Sustaining Hill Agriculture in Changing Climate:

A Compendium of Seminar Papers

SHACC - 2015

December 05-07, 2015

Agartala, Tripura

Indian Association of Hill Farming (IAHF)
&
ICAR Research Complex for NEH Region,
Umiam-793 103, Meghalaya, India

National Seminar on

Sustaining Hill Agriculture in Changing Climate

December 05-07, 2015, Agartala, Tripura

Organized by:

Indian Association of Hill Farming and
ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya, India

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Published by:

The President
Indian Association of Hill Farming,
Umiam, Meghalaya
E-mail: sec.iahf@yahoo.com

Printed at Millennium Graphics, Ambikagirinagar, R.G. Baruah Road, Guwahati 781 024

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Status and strategies for conservation of natural resources in Andaman and Nicobar Islands

B Gangaiah*, S Dam Roy, T Subramani, S Swain and A Velmurgan
ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands
*Correspondence: bandla_gan@hotmail.com

Andaman & Nicobar Islands, is located in the Bay of Bengal between 6-14^0 N latitude and 92-94^0 E longitude as a long (North-South direction spanning over 700 km length) and narrow stretch (average and maximum width of 24 and 58 km) of landmass of rolling topography. These islands, a group of 572 Islands of which only 38 are inhabited, are spread on ~0.825 m ha of geographical area (0.25% of countries area). It has a population of 3, 79,994 (Census 2011). The islands being a popular tourist destination is visited by 1, 95, 396 tourists (that includes 14, 615 foreign tourists) during 2010-11. To support the food requirements of growing population, farming was started by clearing the forests since 18th century that gradually moved towards intensification and commercialization.

Though, history of agriculture reveals plantation of coconut and areca nut in Nicobar group of Islands as early as 7th century, the natives of Andaman lived in isolation in the dense tropical forests obtaining food from forest products, fish and wild animals etc. The first attempt of settled agriculture by clearing forest was made by Archibald Blair in 1779 at Chatham Island and by 1901, 10,198 ha of forest land was cleared of which 4,198 ha was put under cultivation. The establishment of penal settlement during 1857 and with gradual increase of settlers by repatriation, land distribution started in Andaman and Nicobar Islands, providing, each settler about 2 ha paddy land, 2 ha hilly land and 0.4 ha of homestead land has marked the initiation of agriculture in these Islands. After Independence also major stress was given to area expansion up to the end of 4th five year plan (1969-74). The ban on clearing of forests by the Supreme Court of India in 2002 put an end to this act of converting forest into farm lands. The agriculture area that peaked in the early part of this century (50, 000 ha,~6% of geographical area of islands) has lost some farm lands due to 26 December, 2004 Tsunami and at present stands at 42,839 ha area (2014). Thus agriculture through cultivation of crops (21,339 farmers) along with animal husbandry (68,713 households) and marine fishing (14, 839 in 2013-14) provides employment to the islanders.

Natural resources of agriculture and their present status

Success of agriculture (crops Animal husbandry and inland capture fisheries, and logging from forestry), is directly dependent on the health of soil, water, climate, energy (fire) and biodiversity, the five natural resources of mankind. The current status of these natural resources after initiation of farming about 160 years back is as below.

Soil: In general, the island soils with humus on top have 0.20 - 0.95% organic carbon with mild to moderately acidic reaction (In coastal areas prone to tidal floods, acid sulphate and saline soils are found). The island soils in general show deficiency nitrogen, phosphorous (owing to fixation), calcium, magnesium, and sulphur. Though, information is not available about, molybdenum, the acidic nature of soil indirectly indicates its deficiency. In addition, iron and aluminium toxicity (sulphur in acid sulphate soils) are reported. The low water holding capacity (10-20 cm/m) coupled with moderate water intake rate in high intensity rain fall zone of Islands results in medium to very high rates of runoff water. The Tsunami of December 26, 2004 that has resulted in the land subsidence by 1.2 meter in Andaman and Nicobar islands has resulted in accelerated and altered shoreline erosion. Low fertilizer application (1,065 t in 2013-14) to crops as against the estimated requirement of ~8,000 t/annum of primary nutrients (NPK) poses a great challenge to sustainable use of land for farming. Even after discounting the contribution of manures and crop residues to crop nutrition, there lies a huge demand and supply gap in nutrients ultimately resulting in mining of soil nutrients. The fertility depleted soils with poor crop harvest are gradually eroding the farm profits.

Water: The Andaman and Nicobar Islands are blessed with plenty of water resources exclusively from the source of precipitation. Based on the mean annual rain fall (2900.8 mm; 1967-2014), islands have 24.75 billion m^3 (65, 172 m^3/caput/year as per 2011 population). Even for the projected population of 0.53 million by the year 2051 (Population Foundation of India 2007), the water availability (46,698 m^3/caput/year) is going to be on higher and safer side. But the saline ground water under the influence of sea water ingress limits the exploitation of underground water resources for farming. Thus the Islands face severe shortage of water not only for agriculture but even for house hold needs despite of plenty of rain. Though rice crop is grown successfully in *kharif* season (despite of crop flooding and submergence), the perennial crops (plantation crops, spices, fruits) under homestead farming subjected to post-monsoon soil moisture stress (December-April) are encountering enormous yield penalties.

Climate: The Islands with tropical (mean maximum and minimum of 30.2 and 23.3^{0}C; 1949-2014 at Port Blair) humid (77.4 at 8.30 hours and 80.5% relative humidity at 17.50 hours at Port Blair) climate with copious rainfall and moderate winds (9.06 km/hour: 1975-2014) are ideal for year round farming (with protective irrigation in post-monsoon period) though the cloudy weather reducing solar radiation poses a challenge to rice cultivation.

Biodiversity: Islands are bestowed with unique biodiversity that is a mix of both native (with similarities to Indo-Myanmar region in Andaman and Malaysia-Indonesian in Nicobar Islands) and introduced species. The unique germplasm that includes photosensitive 'C-14-8', scented 'black Burma' rice with salinity and aluminium tolerance and beach pea *Vigna marina* for sandy soils. In plantation crops wide variation exists especially in coconut. At Sippighat (South Andaman), World Coconut Garden with 30 germplasm lines (from Asia-Pacific region) is maintained. Wild cashew *(Semecarpus kurzi)* with high vitamin A content, diverse vegetable, flower (orchids) and root crops are available for exploitation. Islands are house for pelagic, demersal and oceanic fishes. Salt tolerant feral goat, Nicobari fowl, Nicobari pig are important livestock endemic resources of the islands.

Energy resources: Farming is least mechanised and thus use of power is low. Din *et al.* (2007) based on 1996 statistics has estimated the farm power availability as 0.40 kW/ha as against the national average of 1.29 kW/ha. There has been substantial improvement in number of power tillers (from 12 to 706) and pump sets (900 to 2243) since then, and thus the current power availability comes to about 0.76 kW/ha. Small holdings limit the use of mechanical power while the minimal contact with outside world limits the availability of simple agricultural tools of farming making the farming a drudgerous one.

Conservation of soil

As tillage on slopy lands (>45^o) accelerates soil erosion up to 120 t/ha/year (Pandey and Venkatesh 2003), no tillage is desirable. Integration of *Gliricidia* as hedgerows with grass cover on ground in vegetables with inter row mulching and cover cropping with *Pueraria phaseoloides* in coconut plantations have contributed to reduce soil erodability to the level of native forest. The agricultural lands are protected from erosion by adopting structural approaches like land shaping through bunding, terracing practices etc.

For fertility management various approaches are adopted. Green leaf manuring (GLM) of rice with 7.5 t/ha *Glyricidia maculata* (Singh *et al.* 1988) was also found promising for improving the rice yields by 0.72 t/ha over control. Green gram residues incorporation @ 2.4 t/ha without N (Singh *et al.* 1988) has improved rice productivity by 0.81 t/ha over no N and no mungbean residue application (2.98 t/ha). Salt tolerant crops (Beach pea *Vigna marina*; Khariphal : *Ardisia solanaceae / andamanica*; Khaarikhajoor : *Phoenix paludosa* Pond apple : *Annona glabra*) and cultivars (black Burma, CST 7-1 of rice) are also explored for farming in saline and other salt affected soils. Effective weed management practices integrating herbicides in rice and other arable crops were evolved for arresting the nutrient and moisture depletion by weeds. In light of organic farming being highlighted in the islands, there is need to evolve suitable non-chemical weed management solutions.

Conservation and management of water

During rainy season, low lands (coastal areas) of islands face the water logging problem limiting crop choices to rice only and sometimes even this crop too fails. To ensure reliable rice cropping while diversifying agriculture towards vegetables and fishes, the concept of *Broad Bed and Furrow (BBF)* system is followed for water stagnant lands. Vegetables are grown on beds while rice + fish are cultured in furrows resulting higher and diversified production. The water collected in furrow providing protective irrigation to vegetable crops, in addition to rice and fish culture bringing in multiple uses of water has increased its productivity. In BBF, beds have also shown reduced salt built up problems (Ambast *et al.* 2010).

For farm landscapes with rolling topographies, topography based runoff water tapping technologies were developed at CIARI. *For hill tops,* silpauline lined tanks (3-5 tanks/ha storing 1500 m^3 water) was evolved and the stored water was successfully used for irrigating areca nut and coconut crops improving their productivity substantially. *In mid-hill areas*, recharge structure (check dams, gabion structures) cum well system was found promising. The check dams constructed in the stream at appropriate sites resulted in storage of 1000 - 5000 m^3 water. This stored water will also recharge shallow aquifer that can be recovered downstream by creating a open dug wells of 4-5 m diameter. The surface storages can provide water for initial period of dry season whereas water from dug well can meet the water requirement in rest of the season.

The precious water collected through above methods was applied through efficient irrigation methods like micro irrigation in capsicum grown in polyhouse at CIARI (Subramani *et al.* 2011) resulting in 4 times increase in water productivity as compared to conventional flooding (Table 1). To overcome the limitations of the farmers' size (small and marginal) induced difficulties in adoption of drip irrigation owing to the high initial costs and economy of scale in its operation, government is encouraging loan cum subsidy schemes. In view of rolling topography, gravity-fed drip irrigation has been developed and successfully demonstrated for small farms (<0.1 ha) with low head availability (< 2.0 m) for which low cost head filter has been designed.

Table 1. Performance of capsicum as influence by irrigation method and schedules

Irrigation method (Schedule : IW/ CPE)	Capsicum fruit yield (t/ha)	Water productivity (kg/m^3)
Surface irrigation (0.75)	13.5	2.3
Drip irrigation (0.25)	15.7	11.5
Drip irrigation (0.50)	18.3	6.7
Drip irrigation (0.75)	20.2	4.9
CD (0.05)	2.1	

Mulching has been adopted by farmers for both soil and water conservation from time immemorial. Coconut and areca nut husk and leaves are used as mulch material around the tree trunks.

Andaman and Nicobar islands are bestowed with enormous water (precipitation) resources. But its tapping for agriculture (others sectors also) is not concomitant with the potential / requirement due to rolling topography aiding in quick drainage. The shallow ground water table (saline water) under influence of sea water ingress are hurdles to the exploitation underground water resources. The low inherent fertility status of arable lands coupled with moderate to severe erosion constraints under the influence of heavy precipitation (including sea erosion) and under fertilization of crops is eroding the productive capacity of land. In light of above soil and water related constraints, a runoff based conservation farming technologies are evolved and adopted in plantation and perennial cropping systems. However, for arable cropping systems of islands revolving round rice (*kharif*) and vegetables, suitable water / moisture conservation technologies are yet to be evolved especially for post rainy season (December-April).

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Rice-based farming systems for food and nutritional security of Indian farmers

UK Behera*
Indian Agricultural Research Institute, New Delhi
**Correspondence: ukb2008@gmail.com*

Farming system research is a multi-disciplinary holistic approach to solve the problems of small and marginal farms. Small and marginal farmers are the core of the Indian rural economy constituting 85% of the total farming community but possessing only 44% of the total operational land. The declining trend of per capita land availability poses a serious challenge to the sustainability and profitability of farming. Under such conditions, it is appropriate to integrate land based enterprises such as dairy, fishery, poultry, duckery, apiary, field and horticultural cropping within the farm, with the objective of generating adequate income and employment for these small and marginal farmers and thereby improved livelihoods. The production system adopted during green revolution has been explorative and the natural resources like soil and water were subjected to immense pressure beyond carrying capacity. As a result sustainability of agricultural production system and the farming system has shaken. This suggests the urgent need of integrated farming system development where the various components of the farming system can be integrated to improve productivity and profitability as well as resource conservation along with maintenance of the environment.

Rice occupies a position of overwhelming importance in Asian agriculture and it constitutes the bulk of the Asian diet. It plays an important role in providing livelihood to the Asian population. Rice farming is the single most important source of employment and income for the majority of rural people in these regions. Among the various farming system options in rice ecologies, rice – fish farming has great potential particularly in eastern India in view of the resources, food habits and other socioeconomic conditions. Rice-fish diversified farming system with the integration of compatible components like improved varieties of rice, fish, prawn, pulses, oilseeds, horticultural crops, agroforestry, mushroom, poultry, duckery, goatery, floriculture, apiculture etc. can increase the farm productivity, besides farm employment over traditional rice farming. There exists a chain of interactions and flow of resources among the different enterprises in an integrated farming system. In order to make farming profitable and improve resource use efficiency at the farm level, the synergy among interacting components of farming system should be exploited.

The impact of climate change are witnessed all over the world, but the countries like India are more vulnerable in view of the huge population dependent on agriculture, excessive pressure on natural resources and poor coping mechanisms. Of late focus of agronomic research has been shifted towards development of climate resilient rice-based farming systems by focusing on adaptation and mitigation strategies to climate change involving conservation agriculture, resource conservation technologies viz. direct seeded rice, reduced/zero tillage, LASER land leveling, system of rice intensification, aerobic rice, crop residue management, site specific nutrient management and real time N management using LCC and SPAD. Research is also directed towards crop diversification/substitution in classical rice – wheat and rice – rice systems.

Fodder production in Uttarakhand with special emphasis on wastelands management

JK Bisht and A Pattanayak
VPKAS, Almora, Uttarakhand, India

Scientific management of land and water resources in hilly areas with the application of proper vegetative measures has become important for getting long-term conservation and production needs. With the over exploitation and improper management of natural resources in the hills, forests are gradually disappearing and grasslands are converted into wastelands causing acute fodder and fuel wood scarcity and danger of soil and water erosion. In this region, irrigated land is very less and cultivation of fodder is restricted to lower hills only. The whole cultivated land which is around 10-13 % of total geographical area is used for cultivation of cereals, pulses and oil seeds. Range lands and forest which are around 50 to 70% of total geographical area are the major sources of forage for sheep, goats, rabbits, cattle and other animals. Productivity and sustenance of livestock closely depend on natural resources and their management, which are fast degrading in the north western Himalayas. Consequently, most of the hills today are barren slopes, with severe soil erosion (>40 t/ha/yr), causing further decline in productivity, floods, and siltation of tanks, river beds and reservoirs.

Therefore, to increase the livestock production, fodder production has to be increased. In hills, cultivation of fodder is rarely practiced and mainly sourced from the non-cultivated agricultural lands, fallow, wastelands, pastures and forest areas. It is imperative to conserve and utilize these finite resources most efficiently so as to meet the growing needs of food, fibre and fuel-wood for human and fodder for livestock consumption.

Methodology

These include management of natural grasslands, production of improved grasses under pine and deodar trees and sloping and degraded lands, utilization of terrace risers by growing erect growing grasses, planting fuel-cum-fodder trees by improved pit methods, fodder production from marshy lands, energy plantation and silvi-pastoral system. Several grasses were tested under these conditions. Hybrid Napier was found to be the best.

Results and Discussion

On the sloping and degraded lands and under pine and deodar trees Hybrid Napier was found to be the best. It produced 20 to 30 t/ha green fodder during first year and 400- 800 q/ha during second year onwards. In degraded steep slopes (30-40% slope or more) and shallow lands, *Grewia optiva, Morus alba, Robinia pseudoacacia* and *Quercus leucotrichophora* can be grown through improved pits. Improved pit planting yielded maximum green forage followed by square pit. Erect growing grasses like *Setaria kazungula, Setaria nandi,, Panicum coloratum*, and *Pennisetum purpureum* can be grown on the field terrace risers. *Pennisetum purpureum* produced the highest green forage yield (30 t/ha) followed by *Setaria* spp. Kudzu vine (*Pureria thumbergiana*), a very hardy and fast growing legume was found extremely suitable for protecting unstable, sensitive and highly degraded sites.

In the marginal and sub-marginal lands of the hills a silvipastoral system including combination of *Digetaria decumbense* with *Bauhinia purpurea, Quercus leucotrichophora*, *Grewia optiva* and combination of *Cenchrus ciliaris* with *Celtis austrelis* produced 1.8 to 2.45 kg/m^2/year green biomass. In silvi horti system turmeric (12 t/ha) and ginger (8 t/ha) produced significantly higher rhizome yield under *Quercus leucotrichophora*. Green forage yield varied from 5.7 kg/tree by *Quercus leucotrichophora* to 7.7 kg/tree by *Bauhinia vereigata.*

In case of grassland management, it was found that two years of effective closure increased forage production up to four folds (3.83 t/ha vs. 0.97 t/ha) in control. Introduction of improved grasses such as *Digetaria decumbense, Cynodon plectortachus, Panicum coloratum, Chloris gyana, Panicum maxicum, Setaria kazungula* can successfully enhance the fodder yields. Stage and frequency of cutting significantly influenced the quantity and quality of forage. *Brachiaria mutica* gave the highest yield 21 t/ha with four cuttings than the single cut (5.6 t/ha).

During winter months green fodder availability is a major problem due to sub-zero temperatures and heavy frosting. *Lolium parene*, *Festuca arundinacea,* and Grassland manawa gave encouraging yields ranging from 21 to 35 t/ha. Among the legumes white and red clover were found promising. Dual purpose varieties of wheat (VL Gehun 829 and 616) developed by VPKAS, Almora are capable of providing substantial quantity of green forage (7 to 8 t/ha) during phase of initial growth without initial growth significant reduction in grain yield (Bisht *et al.2011*).

By adoption of improved planting techniques and management practices degraded and wastelands can be successfully developed for production of forages in mid hills. Thus, the production of fodder from the waste lands will be able to reduce the gap between demand and availability and well fed livestock will help ensure higher productivity and income to hill farmers in addition to ensuring environmental security of the hills.

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Climate resilient farming system for livelihood improvement

AS Panwar*, Hadienlarisa Syiemlieh, Lotika Kalita, Moutusi Tahashildar, Jimmy Y Yumnam
Supriya Bhujel, Anup Das, Ramakrushna GI and Jayanta Layek
ICAR research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: draspanwar@gmail.com

Introduction

Indian Agriculture contributed major role in national economy since independence. The food production increased up to 4.5 times from the base line of 1950-51 due to green revolution. While in Horticulture sector it increased up to 8 times. This has been possible due to technology invention as the cultivated area remain static i.e., 142 million ha for the last 40 years but the production has increased manifold. The pressure on cultivable land continued to incline the Indian agriculture which supports 17 and 11% of world population and livestock, respectively from 2.4 and 4.5% of global land and water resources respectively. The increasing trend in population declining land and water coupled with changing scenario of climate changes has pose a question on the sustainability of Indian Agriculture. The effect of climate change remains an issue of debate for its effect on production and productivity, besides the increasing input cost, the cost of production has increased tremendously. Soils are also the fundamental foundation of food security, economy and environmental equality. The adoption capacity for agriculture is continued to be an outcome of bio-physical, socio-economic and technological factors as per Environmental Protection Agency (EPA), the increase in temperature may lead to lengthening of crop growing season in temperate areas and shortening of crop growing season in tropical and sub-tropical region. It adversely affects crops in areas where summer heat already limit production. The increase in evapo-transpiration and possibility of severe draught are the causes of climate change. Keeping in view the above, Farming System Model was developed for food and nutritional security at household level under mid-hill altitude condition in North Eastern Region.

Methodology

The model was developed at the research farm of ICAR Research Complex for NEH Region, Umiam, Meghalaya. The field is located at the latitude of $25^0$41'23.21" N and longitude $91^0$55'19.27" E with elevation of 956 m asl. One ha area was developed into terraces and terrace risers were planted with guinea grass for soil and water conservation, beside terrace stabilization and green fodder production. The area was allotted to different components of Farming System of which 7000 sqm area was allotted to agriculture/ vegetables based cropping system, 2000 sqm area under horticulture and 500 sqm area under poultry-fish system. The remaining 500 sqm area was kept for vermi-compost unit, threshing floor, livestock and miscellaneous uses. Amongst the livestock, 3 nos. pigs were reared for 270 days for attainment of minimum of 85 kg weight. Poultry was also integrated with IFS model in poultry + fish system in which 660 nos. poultry birds were kept on pond dyke in 6 cycles. At 1st cycle 110 nos. of poultry chicks were kept for 35 -45 days and reared with adoption of improved production technology. The average weight of chicks was recorded to be 2.5 kg during this period. After sale of broiler chicks the shed was cleaned, disinfect and kept fallow for 23-30 days followed by 2nd lot of chicks was introduced. The biomass produced on the farm was recycled through composting/in-situ incorporation into the soil. The production and economics of the system was worked out as per standard procedure.

Results and Discussion

The results revealed that Rice-Toria-Frenchbean system allotted with 2300 sqm area recorded Rs. 46,080.00 with an income potential of Rs. 20.03 per sqm area. The maize based cropping system was adopted for feed production for livestock and pulses for human consumption in 2500 sqm area which recorded income potential of Rs. 14.34 per sqm area. The spices based cropping system grown in 900 sqm area registered highest income potential of Rs.48.75 per sqm area. The vegetables based coping system registered 300% cropping intensity in 700 sqm area with an income potential of Rs. 48.13 per sqm area. The total production in terms of Rice Equivalent Yield (REY) followed the similar trend. The Horticulture components was established during 2009 in 2000 sqm area by planting Assam lemon, Guava, Peach and Orange. The orchard has started fruiting but could not attain the production as desired. Hence, intercropping with pulses, vegetables and spices were undertaken which increase the income from Horticulture components. Amongst the animal husbandry sector 660 broiler chicks were reared in six (6) rotations which showed 10.0% mortality and hence 600 nos. marketable broilers were produced with a total live weight of 1500 kg with average weight of 2.5 kg per bird. Total net profit of Rs. 35,000/- was realized from the broiler production, besides 110 nos. layer birds of Vanaraja breed were maintained on partial excavating system which gave a net return of Rs. 12892/-. The net income was comparatively low with layer poultry due to high cost of chicks and concentrate. Therefore, it was recommended that feed based cropping system with Maize-Soybean so that net income can be increased from the system. Piggery is liked by every community people of North Eastern region. Generally 2-3 nos. of pigs are reared per family, hence, 3 nos. of pigs were reared and integrated with the system which realized the income of Rs. 10,000/- in 270 days. The fishery was also established by rearing 500 fingerlings, these fingerlings were reared with zero input system as the excreta of the poultry birds was transferred to the pond as feed for the fish and zooplankton. The fish recorded a net income of Rs. 3653/- per annum. A total dry matter of 7255.4 kg was generated from the system in the form of excreta from livestock, crop residue and weed biomass which was recycled into the system. The economics of various components worked out separately (Table 1) revealed the component wise cost of cultivation, net return and B:C ratio. The total net return from the system was estimated to be 1.4 lakhs per annum per ha after 5 years of establishment of the model. The crop component registered highest B:C ratio of 1.94 followed by fishery (B:C ratio of 1.80) and Horticulture (1.62). The livestock component although registered the lowest B:C ratio due to high cost of feed but it has contributed significantly in the generation of net return from the system. The study revealed that the adoption of promising cropping system and their integration with livestock hold promises for livelihood improvement of small and marginal farmers under mid-hill altitude of North Eastern region.

Table 1. Cost of cultivation and returns from various components of IFS

Component	Net area (sqm)	Total cost (Rs./unit)	Net return (Rs./unit)	B:C ratio
Crops/ cropping system	7000 sq. m	84,966.95	79,458.05	1.94
Horticulture	2000 sq. m	96,00.00	5,930.00	1.62
Livestock	660 no. broiler, 110 no. layer and 03 no. pigs	2,06,105.20	50,292.50	1.23
Fisheries	500 sq. m	4,563.00	3,653	1.80
Total		3,05,235.15	1,39,333.55	1.45

Comparative evaluation of different farming system models suitable for small and marginal farmers of Nagaland

Rakesh Kumar, Bidyut C Deka, A Thirugnanavel, MK Patra, D Chatterjee, Tasvina R. Borah, K K Barman*, G Rajesha, HD Talang, Manoj Kumar and SV Ngachan

ICAR Research Complex for NEH Region, Nagaland Centre Jharnapani, Medziphema, Nagaland

Introduction

In the North Eastern India, the crop productivity is far below the national average for most of the crops even after having the fertile land and water resources. Due to the failure of monsoon, farmers are forced to mix up of agricultural and allied enterprises like poultry, piggery, fishery judiciously suited to their agro-climatic condition and largely dependent on their farm size. To overcome the problems of resource poor farmers, diverse and risk prone environment has led to the development of more holistic, resource based, client oriented and interacting approach popularly known as intensive integrated farming system (IIFS). This approach requires involvement of agriculture, horticulture, soil conservation, forestry, fisheries, animal husbandry and apiculture. Integrated farming system takes into account the concepts of minimizing the risk, increasing production and profits improving utilization of organic wastes and crop residues (Ansari *et al*. 2013 and Yadav *et al*. 2013). For holistic development of hill agriculture, commodity-based efforts may not be appropriate to tackle the complex socio-economic needs of people Hence, IIFS is a reliable way of obtaining the higher productivity and profitability .

Methodology

To improve the livelihood of small and marginal farmers, based on land availability and topography, the IIFS research was started at ICAR RC for North Eastern Hill Region, Nagaland Centre Jharnapani during 2012-13. A total of 04 nos. of IIFS models have been established involving the crops, poultry, pig, fish, duck and mushroom with the evaluation in different combination to recycle the residues and by-products of one component over others. Each IIFS models were allocated a minimum area of 0.4 ha (1.0 acre).

IIFS Model 1: Horticulture+Fishery+Piggery+Vermicompost: area 4025 m^2 horticulture crops (peach, litchi, mandarin, mosambi, banana and seasonal veg. 3245 m^2); fish pond (780 m^2); piggery unit (2 nos. pig) and vermicompost unit.

IIFS Model 2: Agriculture+Horticulture+Fishery+ Duckery+Vermicompost: area 4000 m^2 major field crops (rice-linseed/toria, 2510 m^2); horticultural crops (mango, guava, pineapple, and seasonal vegetables, 880 m^2); fish pond (600 m^2); duckery unit (50 no.) and vermicompost unit (10 m^2).

IIFS Model 3: Agriculture+Horticulture+Fishery+Piggery+Vermicompost: area 4000 m^2, major field crops (maize- toria-mungbean,1476 m^2); horticultural crops (mango, banana, Assam lemon and seasonal vegetable crops, 1462 m^2); fish pond (1062 m^2) and 05 pig in piggery unit. Drainage channel of piggery unit attached to fish pond for effective utilization of bio-resource flow.

IIFS Model 4: Agriculture+Horticulture+Fishery+Poultry+Mushroom+Azolla+Vermi-compost: area 5710 m^2 major field crops (rice- toria-mungbean, 3805 m^2); horticultural crops (mango, banana, Assam lemon, papaya and seasonal vegetable, 1079 m^2); fish pond (755 m^2), poultry unit, mushroom unit (56 m^2), azolla tank (15 m^2) and vermicompost unit. Litter materials of poultry were allowed to fall in fish pond.

Results and Discussion

Effect of model component for sustainable regular income and employment generation round the year was compared. Results on different combinations revealed that the combinations of agriculture, horticulture, poultry, fishery, mushroom, azolla and vermicompost (IIFS model 4) gave the highest net income of rupees 32,205 followed by IIFS model 3 where piggery was one of the important component among livestock with a net income of rupees 24394 (Table 1). The IIFS model 2 recorded the lowest net income of rupees 11720. Based on the two year evaluation of production and economic efficiency of different components, rice-toria-mungbean system was found to be the best cropping sequence in terms of productivity and profitability in all the IIFS models except in model 1 which was primarily horticulture based (Annual Report 2014-15). The fruit crops in this model were yet to reach in production stage hence, the return was low in the beginning years.

Besides generation of additional income integration of different components in IIFS model has also increased the employment for farmers on yearly basis (Table 1). The employment generation was increased from 60 to 360 man-days / ha / year by integrating agriculture + horticulture + fish + poultry + mushroom + azolla + vermicompost in IIFS model. An extra average employment of 40 to 90 man-days per year was generated from agriculture components due to inclusion of two more crops (toria and mungbean) into the system over the traditional cropping system of rice alone (60 man-days/year).

Similarly, the year round horticulture components like fruits and vegetable also contributes 50 - 150 days depending on its area coverage in these models. The other supportive enterprises (fishery, piggery, poultry, mushroom, azolla and vermin-compost) also generated additional employment of 10 - 85 man days each year by intensification of rice and horti based farming system. Thus, combining of crops with other enterprises in IIFS model would increase the labour requirement and thus provides the scope to employ the more family labours round the year without giving much relaxation during the lean season as in traditional agriculture like growing of rice alone.

Hence, to enhance the productivity, monetary returns, generating employment and maintaining the soil health of farm and farm families, the IIFS model with agriculture, horticulture, fishery, mushroom , azolla, vermicompost combinations with either piggery or poultry could be adopted successfully for small and marginal farmers of the Nagaland. However, the recycling of organic residues in form of animal and plant wastes could be beneficial further in improving the soil health and productivity over a longer period of time. The livelihood of small and marginal farmers could be upgraded by adopting such intensive integrated farming system (IIFS) technologies on a larger scale hilly ecosystem of Nagaland.

Table 1. Economics and employment generation of different IIFS models (Mean data of 3 years)

IIFS Models	IIFS Components	Cost of cultivation (Rs)	Net income (Rs)	Employment generation (man-days/yr)
Model 1	Horticulture	**8200**	**-30**	170 (60*)
	Fishery	600	120	15
	Piggery	21000	8250	45
	Vermicompost	-	-	**10**
	Total	**29800**	**8340**	**240**
Model 2	Agriculture	4100	11925	100 (60*)
	Horticulture	930	1595	50
	Fishery	1650	750	15
	Duckery	8000	-2670	20
	Vermicompost	500	120	10
	Total	**15180**	**11720**	**195** (60*)
Model 3	Agriculture	3900	3500	90(50*)
	Horticulture	1741	10404	150
	Fishery	1000	1040	10
	Piggery	10800	8850	85
	Vermicompost	450	600	15
	Total	**17891**	**24394**	**350 (50*)**
Model 4	Agriculture	5600	15750	150 (60*)
	Horticulture	1055	6755	70
	Fishery	2000	730	15
	Poultry	14000	8360	35
	Mushroom	5640	-3090	70
	Azolla	500	2500	10
	Vermicompost	600	1200	10
	Total	**29395**	**32205**	**360** (60*)

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Fodder promotion in the Western Himalayas: potential and substitutes

JMS Tomar*, Sunil Prasad[1], H Mehta and PK Mishra
[1]*Indian Institute of Soil and Water Conservation, Dehra dun, India,*
[2]*Freelance Consultant - Ecology and Biodiversity, Dehradun, Uttarakhand-India.*

Livestock rearing has been the backbone of Himalaya's economy for centuries and this sector is the primary source of energy for agricultural operation and animal protein for the people. Under present situation, adequate fodder supply is one of the challenges and there is very limited scope of alternative fodder resources throughout the Himalayas due to scarcity of land. Moreover, maximum production of forage is an attempt to tide over unfavourable periods because fodder production is limited by climatic extremes leading to two critical fodder shortage periods, one during winter (Dec. to Jan.) and the other in summer (May to June). Under present situation of ever increasing fodder requirement throughout the Western Himalayas, various alternatives may supplement the existing feed resources for livestock and can help to bridge the wider gap between demand and production of fodder. By improving these alternatives, we can also reduce the chances of women drudgery and these alternatives can also be useful in enrichment of soil, stability of slopes and in some way can definitely show a path to stop migration. Alternative fodder is always a challenge in the western Himalayas due to small land holdings and insufficient supply of crop residue fodder. Although people of the Western Himalayas still depend on the traditional fodder resources i.e. grasses but due to increasing demand of fodder, they must be think about the alternative fodder resource to sustain their livestock cycle. We analysed the significance of various alternatives of fodder in bridging the gap between demand and production of fodder in animal feeding systems. We also evaluated the appropriateness of various alternativeness of fodder under current scenario.

Managing crop germplasm in North East India-prospects and strategies

AK Misra, S Roy, GD Harish and SK Singh
ICAR National Bureau of Plant Genetic Resources Regional Station, Umiam, Meghalaya

The Indian region is very rich in its biological diversity including both flora and fauna. It harbors about 45000 plant species and 65000 species of animals. India, one among the 12 mega bio-diversity hotspot countries of the world having only 2% of world's total land area, accounts for over 11% of the recorded plant species of the world. A larger component of the plant diversity is endemic. The richness in agro-biodiversity of this mountainous region warrants the great concern for its sustainable management and utilization of Plant Genetic Resources (PGR) for the wellbeing of mankind. A total 17000 species of higher plants were described in Indian Gene Center, of these NEH flora comprises 7000 species alone with 43% endemic species.

The declared *in situ* conserved area is 5.53% of the total geographical area of the NEH region. *In situ* conservation is in the form of Biosphere reserve, National Park, Wild life sanctuary and Gene sanctuary. Sacred grove is also a novel method of *in situ* biodiversity conservation, also popular at community level especially in Meghalaya. The Nokrek, Manas, Dibru-Saikhowa, Dihang-Dibang and Kanchenjunga are the declared Biosphere reserve in the region. Besides this 9 National Parks and 37 wild life sanctuaries are exist in this region. Maintenance and continuous cultivation over the generation of various crop landraces in farmer's field is another method of *in-situ* (on farm) conservation in NEH. Apatani plateau (Lower Subansiri district) and Khampti Valley (Lohit district) of Arunachal Pradesh is an example of *in-situ* conservation practice for rice landraces. Habitat preservation, another approach of *in-situ* conservation, is also popular in this region. *Nepenthes khasiana* (in Jaintia hills), *Lilium macklinae* and *Zizania latifolia* (in Manipur) *Coptis teeta* (in Dibang Valley) and *Gymnocladus assamicus* (in Tawang district of Arunachal Pradesh) are examples of such kind of conservation.

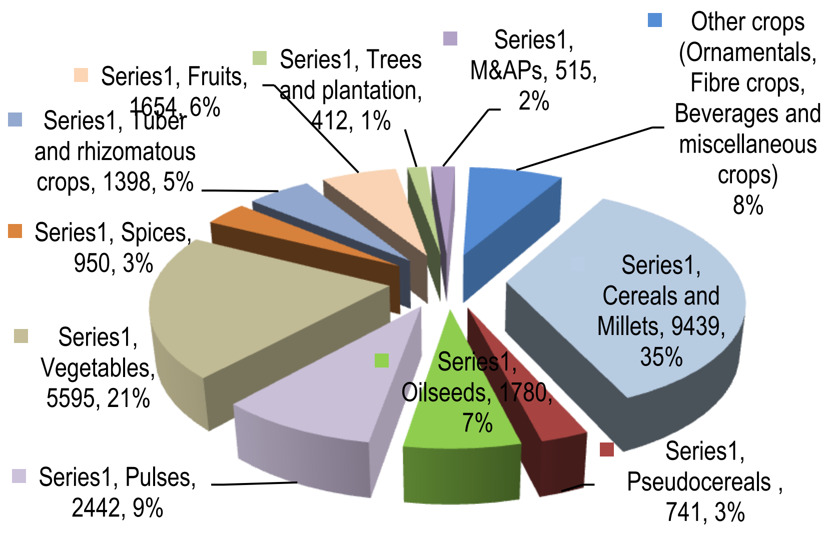
The Station collected 28300 accessions of various agri-horticultural crops from 260 exploration trips so far, including following crops:

Abelmoschus sp	*Dioscorea sp*	*Oryza sp*	*Solanum sp*
Allium sp	*Dolichos sp*	*Perilla sp*	*Sorghum sp*
Alpinia sp	*Eleusine sp*	*Phaseolus sp*	*Terminalia*
Artocarpus sp	*Erianthus sp*	*Phyllanthus sp*	*Trichosanthes sp*
Bambusa sp	*Fagopyrum sp*	*Piper sp*	*Triticum sp*
Benincasa sp	*Glycine sp*	*Pisum sp*	*Vicia sp*
Brassica sp	*Gossypium sp*	*Prunus sp*	*Vigna sp*
Cajanus sp	*Hibiscus sp*	*Pyrus sp*	*Zea sp*
Capsicum sp	*Hordeam sp*	*Raphanus sp*	*Zingiber sp*
Citrus sp	*Ipomoea sp*	*Ricinus sp*	
Coix sp	*Jatropha sp*	*Rosa sp*	
Corchorus sp	*Lathyrus sp*	*Rubus sp*	
Cucumis sp	*Luffa sp*	*Saccharum sp*	
Curcuma sp	*Lycopersicon sp*	*Secale cereale*	
Curcurbita sp	*Momordica sp*	*Sesamum sp*	
Dendrobium sp	*Musa sp*	*Setaria sp*	

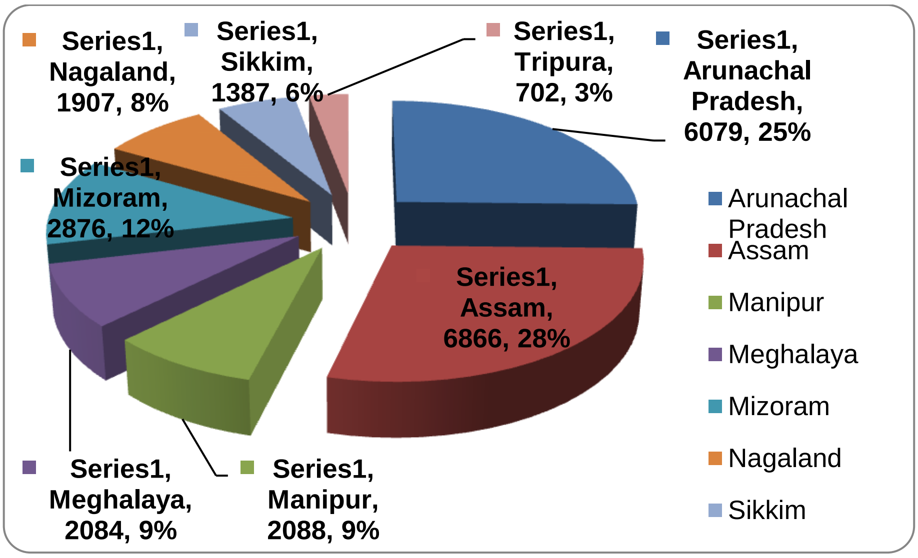
The National Bureau of Plant Genetic Resources (NBPGR) established in 1976 under the auspices of Indian Council of Agricultural Research (ICAR) has the mandate to act as nodal institute at national level for acquisition and management of indigenous and exotic plant genetic resources (PGR) for food and agriculture, and to carry out supportive research and capacity building through human resource development. The Bureau has its main campus at New Delhi with 10 Regional Stations located in different agro-ecological/ phyto-geographical regions of the country. The NBPGR Regional Station- Shillong established in 1978. This station represents the entire North - Eastern region of the country for the purpose of crop germplasm collection. The collection jurisdiction encompasses eight states such as Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura which lays within the geographical boundary in between $21^{o}3'$ N latitude and $87^{o}5'$ and $97^{o}3'$ E longitude. The Station has been entrusted the responsibility of the collection, characterization, documentation, maintenance, conservation and sustainable utilization of agro-biodiversity of NEH Region. The activities of station are as under:

- Collection of local crop diversities, including their wild relatives from North Eastern states through explorations.
- Maintenance and characterization of mandated crops (Field crops: paddy, maize, mustard; Horticultural crops: chilli, zinger, turmetic; Under-utilized crops: *Perilla*, *Coix*, buck wheat, rice bean).
- Conservation of Germplasm at regional level in seed gene bank (under MTS) and maintenance of vegetatively propagated crop Germplasm in field gene bank.
- Introduction and utilization of exotic materials.
- Undertaking various AICRP trials.
- Need based supply of germplasm for research purpose.

The crop diversity collected are as under:



The state wise collection is as follows:



This station is undertaking evaluation and characterization of its mandated crops based on agro-morphological traits. Several promising germplasm were identified for various traits which also being utilized in improvement programme. As many as 568, 266 and 60 accessions of field, under-utilized and horticultural crops, respectively were evaluated in recent past. As many as 1443 germplasm are in medium term storage (MTS) and 381 are under field gene bank (FGB). After field evaluation, the germplasm were sent to National Gene Bank for long term storage. The promising genotypes were also identified. A maize genotype (MCM-11/01, IC0524594) selected by this Station having the characteristic of multiple cobs (3-5) per plant has been registered (INGR 13054) under PGRC of ICAR in 2013.

The horticultural crop germplasm such as citrus, banana, different minor fruits and introduced accessions of guava, passion fruit, *Ziziphus*, *Phyllanthus*, etc. have been maintained in field gene bank (FGB). The banana genotypes (60) those have been collected from this region were sent to NRC Banana, Tiruchirappalli for necessary management and one set of the same have also been maintained in FGB. Most of the citrus (acid group) genotypes available with the station, were characterized and at present 29 genotypes of citrus belonging to both acid group and sweet orange being maintained. The exotic genotypes of guava and passion fruit are performing satisfactorily at

Umiam. Eight guava accessions and nine accessions of other fruits such as passion fruit, *Ziziphus*, *Pyrus pashia*, *Emblica* etc. were under maintenance. Some of the accessions of taro and *Dioscorea* spp. were maintained in FGB. Many important medicinal and aromatic plants (M&APs) which were collected from this region have been maintained at the FGB.

Regeneration of ginger (152 accessions), turmeric (186), chilli (95 accessions) were done in past five years. The chilli accessions were comprised of 86 accessions of *Capsicum chinense* (king chilli) and nine accessions of *C. frutescens* (bird-eye chilli) which were collected mainly from Nagaland. This station has developed agro-techniques for the cultivation of Kulanjan {*Alpinia galangal* (L.) Swartz}, belongs to the family Zingiberaceae.

A total of 1068 germplasm accessions of various agri-horticultural crops were supplied for research purpose in past five years. The categorization of the indenters into respective institute revealed that most of the indenters were from ICAR and CSIR institutes followed by SAUs.

Following are some of the thrust area for effective agro-biodiversity management in NEH region:

1. Accessions from widely distributed habitats are required to be augmented and conserved. Special missions are needed to be undertaken in the area of occurrence of rich diversity to collect and conserve the germplasm using *ex-situ* and *in-situ* approaches.
2. Emphasis needs to be given on targeted collection, conservation and sustainable management of economic germplasm and their wild relatives.
3. Efforts are needed in conservation of some of the hot spot and critical habitats such as *Citrus* Gene Century of Meghalaya.
4. Gaps identified in the management of the PGR should be bridged through appropriate research and development (R & D). Different organizations / institutes engaged in the R & D work should come together and work jointly to conserve the diversity.
5. There is a need of systematic documentation and updating the scientific data base.
6. Awareness generation at various levels through formal and informal education need to be emphasized in conservation of biodiversity.
7. Farmers have played a crucial role in the conservation of biodiversity. It is important that society recognizes and encourages this role through incentives, such as benefit sharing.

Integrated farming systems for enhancing productivity and profitability in hill and mountain ecosystems under changing climate

Anil K Choudhary*
ICAR-Indian Agricultural Research Institute, New Delhi
*Correspondence: anilhpau2010@gmail.com

Introduction

Hill and mountain eco-systems are found throughout the world occupying about 20% of its land area with an estimated one-tenth of human population deriving their life-support directly from mountains. Majority of farmers in hills have small and marginal arable land holdings where they practise integrated farming. Integrated crop-livestock farming system is integral part of hill agricultural production systems. Globally, mountains provide biodiversity, water and other natural resources not only for their inhabitants, but for millions of people down-stream. It is paradoxical that mountain people are mostly resource poor with meagre livelihoods and limited access to food and productive resources everywhere in developing world. Integrated farming system is an economically and environmentally sound diversified production system.

In intensive agricultural production areas, the practice of crop based farming has been the driving force for food security at global and regional level. But, these practices have created various environmental and production vulnerabilities in intensive production systems. Today, integrated farming in confined to small and marginal farmers mostly. Hence, it is pertinent to integrate cropping systems with horticulture, animal rearing, and other suitable farm enterprises to ensure sustainability and factor productivity of these farming systems to bring prosperity and better livelihoods to resource poor rural masses in developing world with reference to hill farming.

Traditional hill and mountain farming systems

Traditionally, integrated crop-livestock farming system has been the major hill agricultural farming system in Indian sub-continent since centuries. Oldest traditional hill farming systems includes animal-pastureland, and shepherd-rangeland production systems.

Integrated farming systems for hill and mountain agro-ecosystems

Many research and developmental organizations are working world-wide for developing economically viable, practically feasible and technically sound IFS models for hill communities to harness the potential of farm enterprises and crops. Choudhary *et al*. (2012) have developed an IFS model for wet temperate North-Western Himalayas (Tables 1). This IFS model developed at Experimental Farm of KVK Sundernagar (HP), India assumes greater significance as an innovative extension tool for hill farmers and extension functionaries in existing production systems because critical farming analysis and agrarian simulation modelling of farm enterprises has been done with technological modifications.

Table 1. Integrated farming system model for wet temperate NW Himalayas.

Component	Net area (m^2)	Remarks
Crop production	2300	On cropping system basis under rainfed conditions
Vegetable production	700	On cropping system basis with transmittent irrigation supply from rain water harvesting unit
Nursery raising	20	Based on demand
Rain water harvesting unit	100	Established in 100 m^2 area with 1 lakh litre water capacity
Fodder production Fruit production	500	Established as an agri-horti-pastoral agro-forestry system model as farm entrepreneurship*
Vermi-composting unit-cum-vermiculture hatchery	150	• Vermi-compost utilised in vegetables and other IFS crops. • Vermiculture for sale as farm entrepreneurship*
Mushroom production	40	As farm entrepreneurship*
Polyhouse cultivation	100	As farm entrepreneurship*
Dairy farming	2 Milch cow	As farm entrepreneurship*

Based on the performance of crop production units (crop production, vegetable production, nursery raising, rain water harvesting unit) of this IFS model it was revealed that from a net sown area of 3020 m^2 hill farmers can earn net returns of Rs. 67483 with B:C ratio of 3.73. Another viable option of vermi-composting unit-cum-vermiculture hatchery, dairy, mushroom production, fruit farming and protected cultivation was also explored in the exiting IFS model. In the existing IFS model, these entrepreneurships raised the overall net returns of the exiting IFS model to Rs. 1,69,913 in net area of 0.4 ha with B:C ratio of 4.24.

In another study in an '*On farm'* IFS model developed at farmer's fields under participatory mode in Mandi district of Himachal Pradesh (Table 2), it was revealed that by adopting different IFS components in an area of 1.0 ha, we can easily earn the net returns of about 2.46 lakhs a year. In Himachal Pradesh, another study undertaken by AICRP-IFS Palampur centre revealed that livestock based farming systems followed by cereals based farming systems were the dominating farming systems in Zone I and II of Himachal Pradesh. In these zones 63.9 and 59.7% of the farmers were dependent on Livestock based farming systems and 33.3 and 36.8% farmers, respectively, were dependent on cereals based farming systems. In Zone III fruit growing was main activity and 72.2% of the households were dependent on fruit based farming systems. This was followed by vegetable based farming systems from which 23.6% of the households earn their livelihood. On an average, livestock based farming system was the major activity for more than 65% marginal farmers, 36% small farmers, 37% medium farmers and 23% large farmers. Cereals based farming systems was the main activity of the small (39.4%), medium (42.6%) and large farmers (44.3%). However, irrespective of the farm size, overall the livestock based farming system (50%) was the main activity followed by cereals based (28.3%), fruit based (15.6%) and vegetable based (5.8%) farming system in that order.

Table 2. Performance of IFS model developed in participatory mode on farmers fields in Mandi district of Himachal Pradesh.

Components	Net area/ units	*Cost of cultivation (Rs./unit)	Net returns (Rs./unit)
Crop/vegetable production unit	1.0 ha	30042	79816
Dairy unit	5 buffalo	118260	76850
Sericulture unit	1 unit	1300	11478
Mushroom production unit	300 bags	25680	41448
Vermi-composting unit	1 small unit	500	4500
Mini-floor mill	1 unit	51600	31920
Total	1.0 ha	227382	246012

**Operational costs*

With technological and infrastructural development, numerous new hill and mountain farming systems have emerged in India. The resultant higher productivity and profitability under IFS models through various crops and farm enterprises to fetch better livelihoods strongly advocate to follow IFS principles and technology in hill production systems so as to transform these less remunerative hill production systems into highly remunerative systems using available farm resources to generate better farm gains, climate resilience, livelihoods and employment on sustainable basis.

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Need of crop diversification in poverty alleviation of small & marginal farmers of Tripura

A Suklabaidya* and M Datta

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura. India

*Correspondence: ashimahorti@gmail.com

Diversification of agriculture refers to the shift from the regional dominance of one crop to regional production of a number of crops, to meet ever increasing demand for cereals, pulses, vegetables, fruits, oilseeds, fibre, fodder and grasses, fuel etc. It aims to improve soil health and a dynamic equilibrium of the agro-ecosystem. Crop diversification takes into account the economic returns from different value-added crops. Agriculture plays a significant role in rural economic development of Tripura whereas, about 52 per cent of total main workers are engaged in agriculture including 28 percent cultivators and 24 percent agricultural labourers. Small and marginal farmers constitute 96 percent of the total farmers in the state against all India 78 percent. The average farm size is only 0.6 hectares. Around 95 per cent of farmers have land holdings smaller than 1 ha and they cultivate nearly 75 percent of the arable land. As Tripura's agriculture is mainly rain-fed in nature, so farming is a risky business. Farmers face risk coming from natural as well as economic factors. The natural factors are difficult to control, but an economic factor related to changes in price commonly occurs and such risks are inevitable. So diversification of products is an important way to reduce both natural and economic uncertainties. In Tripura, agriculture is largely in rice-based cropping system which has been recognized as an effective strategy for achieving the objectives of food security, nutritional security, income growth, poverty alleviation, employment generation, judicious use of land and water resources, sustainable agricultural development and environmental improvement. But, fragmented and small land holdings with inadequate operational resources are predominant and thus, rice-based cropping system approach becomes very much important for improving the productivity, generating additional income, employment and condition of the small and marginal farmers. It is this context, intensification along with better use of resources for remunerative crops in rice ecology through system perspective are essential.

The major driving forces for crop diversification are: 1) Increasing income on small farm holdings. 2) Withstanding price fluctuation. 3) Mitigating ill-effects of aberrant weather. 3) Balancing food demand. 4) Improving fodder for livestock animals. 5) Conservation of natural resources (soil, water, etc.). 6) Minimizing environmental pollution. 7) Reducing dependence on off-farm inputs. 8) Decreasing insect pests, diseases and weed problems. 9) Increasing community food security. At present, total net crop area of the state 1,49,133 ha with in which Gross rice fallow land 143933 ha out of which 84341 ha and 59592 ha pre *kharif* fallow (April-June) and *rabi* fallow (Dec-June)respectively (plan for Agriculture Development in Tripura 2013-17). In case of grain production our requirement gap is 1.32 Lakh tonnes *i.e.* we are not very far away from self-sufficiency in food grain production. But if we look at the production and requirement gaps of pulses & oilseeds, these gaps are 91 and 97.8%, respectively. Therefore, in this area crop diversification can play a significant role for mitigating production & requirement gaps through utilizing more fallow areas of the state. Directly, it can enhance our food basket & indirectly improves farm household income, food and nutritional security and poverty alleviation of small & marginal farmers as well as economy of the state. Diversification in Agriculture 'has tremendous impact on the agro -socio - economic impact and uplifting of resource - poor farming communities of the state. It generates income and employment for rural youth year round for the ultimate benefits of the small and marginal farmers in the state. The success of any diversification programme involves the development of crop - or enterprise - specific technologies, identification and development of market, and provision of economic incentives.

Effect of resource conservation practices on maize –toria cropping systems under terrace land situation

DJ Rajkhowa*, AK Sarma, Anup Das, A Kumar, R Krishnappa and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: djrajkhowa@gmail.com

Introduction

Maize (*Zea mays* L.) is an important cereal crop in North Eastern Hill region of India next to rice. The low productivity of maize in this region is attributed to an array of constraints of which heavy weed infestation during the rainy season is one of the major constraints. Resource conservation practices such as conservation tillage, residue management, intercropping with appropriate crops etc. are some of the options that may help in production enhancement, increasing resource use efficiency (Sainju *et al*. 2008; Mohammad *et al*. 2003) and minimizing weed infestation. Limited information are available on the effect of tillage, intercropping and residue management on maize productivity and weed growth under terrace land situation of NEH region of India. Hence the present study was undertaken.

Methodology

A field experiment was conducted during 2010 to 2014 to evaluate the effect of resource conservation practices on productivity and weed growth (in *kharif*) in maize – *toria* cropping system at ICAR Research Complex for NEH Region, Umiam (Meghalaya). The treatments comprised of two tillage practices *viz*., conventional tillage (CT) and no tillage (NT) and four intercropping systems with residue removal (RR) and residue retention (RT). Maize was grown alone as well as intercropped with different crops like ground nut, soybean and *in situ* green manuring in paired row with or without residue retention (Table 1). Toria was grown under both CT and NT practices. The treatments were arranged in a split plot design with three replications. The recommended dose of 80: 60: 40 kg ha^{-1}and 80: 40: 40 N, P_2O_5, and K_2O kg ha^{-1} for maize and toria respectively along with FYM 5 t ha^{-1}was applied. Data on weed growth and yield were recorded.

Results and Discussion

The weed flora in the experimental field consisted of grasses, broad leaf and sedges. *Paspalum longifolium*, *Ageratum conyzoides*, *Borreria hispida*, *Spilanthesis* spp. and *Digitaria sanguinalis* were the major weed species recorded in maize. Significantly higher weed population (292 No. m^{-2}) and dry weight (61 g m^{-2}) was recorded under NT compared to CT. The weed population and dry weight was significantly lower under intercropping system compared to sole maize. Among the intercropping systems, maize + groundnut along with residue retention significantly lower weed population (197 No. m^{-2}) and dry weight (39 g m^{-2}). Water use efficiency (WUE) in *toria* was also found significantly higher under NT(3.4 kg ha^{-1} mm^{-1}) over CT (3.2 kg ha^{-1} mm^{-1}). Among the intercropping systems, maize + groundnut along with residue retention resulted in significantly higher WUE (4.5 kg ha^{-1} mm^{-1}). Maize yield and maize equivalent yield (MEY) under NT (4.7 and 5.9 t ha^{-1}) were at par with CT (4.6 and 5.6 t ha^{-1}). Significantly higher toria yield was recorded under NT (0.85 t ha^{-1}) over conventional tillage (0.80 t ha^{-1}). Among the intercropping systems, significantly higher maize yield (5.2 t ha^{-1}) and MEY (7.9 t ha^{-1}) and seed yield of toriawere recorded in maize + groundnut intercropping system along with residue retention. Significantly higher carbon stock was recorded under NT (31.9 Mg ha^{-1}) as compared to CT (26.1 Mg ha^{-1}) practices. Among the intercropping practices highest C stock was fund in maize +groundnut intercropping system along with residue retention (32.8 Mg ha^{-1}). Resource conservation practices such as no tillage, residue retention and intercropping of groundnut with maize (paired row) resulted in higher system productivity, reduction in weed growth, improvement in carbon stockand enhancing WUE in toria under terrace land situation.

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Molecular characterization of Leptin in Indian Major Carps

B Bardolai[1], J Parhi[1], TK Maiti[2,] SK Ghosh[2], D Kamilya*

[1] *College of Fisheries, CAU, Lembucherra*

[2] *IIT, Kharagpur, West Bengal*

*Correspondence: jjparhi@gmail.com

Introduction

Leptin, a product of obese (ob) gene and related to food intake and energy balance in mammals was discovered by Zhang *et al* (1994) in mouse. In fish, the leptin-like peptide was first evidenced by immune-cross-reactivity and its existence was demonstrated by sequencing in puffer fish. In some fishes, two leptin isoforms are present. For instance, in common carp (*Cyprinus carpio*), leptin-I and leptin-II have been identified (Huising *et al*. 2006). However, only one type of leptin is found in majority of the fish species. Leptin is produced and secreted by liver, adipocytes, brain, gonads, gastrointestinal track and spleen. Leptin is crucial for short-term as well as long-term body weight regulation by exerting ananorexigenic effect on the appetite centers in the brain (Ahima and Osei 2004), as well as altering peripheralmetabolism mainly by mobilizing lipid stores. It is also one of the metabolic signals that convey nutritional status to the reproductive axis, affecting puberty onset and fertility. Leptin also affect maturation of fish as many literatures cited that matured males had significantly higher leptin mRNA expression level than the immature males. Apart from that, leptin also play important role in immunoregulation. There is no report of molecular characterization of leptin from Indian major carps.

Methodology

The liver of experimental specimens, Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*) was collected aseptically and total RNA isolated using trizol method. cDNA was synthesized using the First Strand cDNA synthesis kit (Fermentas, USA) as per the protocol supplied by the manufacturer. Based on the available sequence of other species, degenerate primers were designed to amplify the leptin gene. The amplified gene was cloned and sequenced. Based on the sequence obtained primers were designed for quantitative PCR and RACE PCR.

Results and Discussion

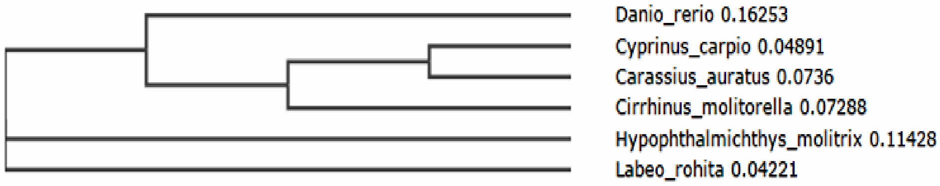
The amplified PCR products with size are

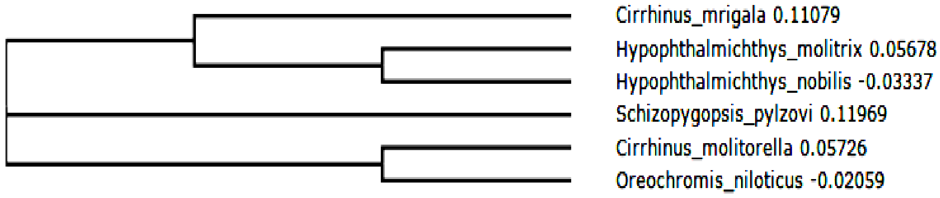
Table 1. PCR Product sizes of partial gene amplification, 3' RACE product and 5' RACE product.

	Primer Used	Size (bp)
Partial amplification	Forward: FW3 Reverse: RV2	~400
	Forward: FW4 Reverse: RV5	~300
5' RACE PCR	Forward: OligodG Reverse: RV2	~500
3' RACE PCR	Forward: FW3 Reverse: Adaptor	~500

From the amplified PCR product we have got the partial sequence of leptin in fish, rohu and mrigal. The sequences were compared with the already available sequence of related species in NCBI.

Phylogenetic tree based on the partial ORF sequence of leptin in rohu and mrigal are given below:





Partial sequence of leptin gene of *L. rohita* using FW3 and RV2 primer set is

AAACTGCAGGCAAAGACCATCATCCTCCGAATCAAGGATCACAATGAGAAGCTGAAACTATCTCCGA AGGTTGTTATTGGGGATCCAGAGCTTCCTGCTGATAAACCCATCCAAGGGCTCAGGTCAATCATGGAC ACCCTAAATACCTTCCAGAAGGTTCTTCAAAAGCTGCCCAATGGGCACGCGAGCCAGATATGCAATG ATTTGTCCACCCTTTTGGGTCACCTGAAGGAAAGAATGACATCTATGCGTTGCACACCTAAGGAGCCA GCCAATGGGAGATCACTGGACACTTTATTAGAAAAGAATGCCACTCACCCTGTTACTTTGGGGTACCT TGTTTTAGACCGACTGAAACAGTTTATGCAAAAGCTGAT

Partial sequence of leptin gene of *C. mrigala* using FW3 and RV2 primer set is

GCTCATGTGTGTTTTCTCTCACAGCTGATATCTTCGAAGGTTGATATTGGGCATCCAGAGCTTTACCCT GAGCTTCCTGCTGATAAACAAGGGCTCATCCAAGCCATCCAAGGGCTCAGGTCTATCATGGACACCCT AACTACCTTCCAGAAGGTTCTTCAAAAGCTGCCTGAGGGGCACGCGGGCCAGATACGCAATGATTTG TCCACCCTTCTGGGT

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Evaluation of chickpea varieties under late sown condition in Tripura

Bhargabi Chakraborty, Debashre Bhattacharjee, Debalina Biswas, Pujaita Ghosh, Papiya saha, Tapas paul and SP Das*
ICAR Research complex for NEH region, Tripura centre, Lembucherra, West Tripura
*Correspondence:drspdas@gmail.com

Introduction

Chickpea [*Cicer arietinum* (L.)] is a self-pollinating, diploid (2n = 2x = 16), annual legume (Arumuganathan and Earle 1991) with a small genome size of 740 Mbp. Chickpea is commonly known as *channa* and *gram*, is the most important pulse crop in India. It is also the largest producer (25%), importer (20%) as well as consumer of global chickpea production (Chavan *et al*. 2011). Chickpea. Chickpea is not an widely grown in north eastern region, however, experiments conducted at ICAR Tripura Centre recorded very good level of productivity for this crop. Keeping the potential yield levels shown by this crop an evaluation trial was conducted to identify the suitable varieties of chickpea for their wide cultivation in Tripura as well as in other north eastern states. One major constraint in chickpea cultivation is the late availability of the land after harvest of the kharif paddy. The study comprised 8 most popular varieties of chickpea in replicated yield trial. Trial was planted in late condition to identify the varieties that can perform well under late sown condition. Results indicated that PUSA 372, followed by JG 11 were the 2 most promising varieties for Tripura under late sown condition

Methodology

The field experiment was conducted during Rabi season at research farm of ICAR NEH region Tripura situated between $22^{0}51^{'}$N latitude and $90^{0}07^{'}$ E longitude the soil experimental site was sandy loam having p^{H} of 5.4,organic carbon (0.81%),available nitrogen of 265.3kg/ha, available phosphorus of 21.5kg/ha and available potash was 119 kg/ha. The experimental material comprises of eight different varieties viz., Rajas,JG 11,KPG-59,PUSA 372,IG 14DCP 92 -3,SUBHRA IPCK 02 -29 and IPC 97-67.

The experiment was laid out in randomized block design (RBD) with five replication. Recommended dose of fertilizers were applied. Data were recorded for yield and yield contributing characters viz. Plant height, branch, pod length, pod bearing length, seeds per pod and pod per plant. The data were statistically analysed following. The standard errors of mean and critical differences at 5% level of significance tables were consulted.

Results and Discussion

Significant differences in respect to plant height, no. of branch, no of seeds per pod, podlength, pod bearing length, pods per plant and yield were observed. Among all the varieties JG11 recorded highest plant height (62 cm), followed by PUSA 372 (61cm) and RAJAS (54cm). Maximum number of branches per plant was recorded for IPC 97-67 (5.4), followed by PUSA 372 (5.2).The highest pod length was observed in PUSA 372 (2.0)which was at par with KPG-59.From the revealed data it was observed that PUSA 372 and KPG-59 had maximum no of pods per plant. Pod bearing length was maximum for DCP 92-3 and for RAJAS it was (34.8).

Table 1. Yield and yield attributing characters observed for different varieties

Entry	DTF50 %	Branches/plant (no)	No of seeds /pod	Pods /plant	Pod length (cm)	Pod on main stem	Yield (kg/ha)
Rajas	68	4.4	2.8	32	2.2	6.2	1264
JG 11	58	3.8	1.4	32	1.9	7.6	1356
KPG-59	71	4.4	2	44.4	2	8.6	858
PUSA 372	58	5.2	2	44.4	2	8.6	1465
IG 14	58	4.4	1	19.6	1.5	6.2	440
DCP 92 -3	60	4.6	1.8	40.4	1.5	7.8	732
SUBHRA IPCK 02 -29	60	3.8	1.2	27.2	2	5.8	611
IPC 97-67	68	5.4	1.4	33.4	1.6	7.8	863
CD (P=0.05)	1.08	1.3	1.0	17.5	0.2	2.2	1657.9

The highest pod length was recorded for Rajas (2.2cm) , followed by KPG-59, PUSA 372and SUBHRA IPCK 02 -29. No of pod on main stem recorded highest for both KPG-59 and PUSA 372 (8.6). RAJAS showed highest no of seeds per pod (2.8), followed by KPG-59 and PUSA 372. Grain yield recorded maximum for PUSA 372 (1465 kg/ ha) followed by JG 11 and RAJAS. The study revealed that variety PUSA 372 produced highest yield (1465kg/ha), followed by JG 11 (1356kg/ha) under late sown condition in Tripura. PUSA 372 also showed highest number of pod/ plant (44.4), which has significantly influenced the yield. These 2 varieties appears to be most promising for wide spread cultivation in the state.

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Recessive epistasis underlies the pericarp colour determination of black rice of Manipur

Bhuvaneswari S* and Sudhir Kumar

ICAR Research Complex for NEH region, Manipur centre, Lamphelpat, Manipur

*Correspondence: bhuvana0284@gmail.com

Introduction

The Black rice, *Chakhao amubi* which turns deep purple on cooking is sticky rice used in community feast as well as in ceremonial purpose as delicacy. Rich in anthocyanin content imparting deep purple colour to perisperm, the landrace is a potential source of dietary antioxidants and has great neutraceutical properties (Das *et al.* 2014). Many studies have demonstrated that the consumption of extracts of black rice bran reduced the oxidative stress (Chung and Shin 2007; Min *et al.* 2011; Sompong *et al.* 2011). There is high local demand and huge potential for scented black sticky rice in South East and East Asian countries for its elite nutritional properties. However due to low productivity, its area and production is restricted to more of a family consumption. In order to improve the yield levels of black rice retaining the original colour and quality, it is important to understand the genetic constituents of perisperm colour for accurate prediction and selection of genotypes. In this regard, a study was taken up to understand the number of genes and gene interaction underlying Chakhao, black rice pericarp color.

Methodology

The material for the present study consisted of *Chakhao amubi*/RCM 23 (MC-52 series) The crossing programme was carried out at ICAR RC NEH region, Lamphelpat during *kharif* 2012 with objective of obtaining useful segregants with quality parameters of *Chakhao amubi* with higher yield traits of RCM 23. The F_1 plants were raised during *kharif* 2013 along with parents in pots and successful crossed ones were identified based on morphological characters of male parent. The F_2 population was grown during *kharif* 2014 along with parents in the transplanted rainfed lowland condition. A total of 411 F_2 plants were selected for recording observation on pericarp color based on visual observation. Chi-square test (χ^2) was used to evaluate the goodness of fit for number of genes segregating in the population based on phenotypic classes.

Results and Discussion

Different variants of pericarp color was observed which included dark purple, dark brown, light brown and white which were distinguishable and clear. The observed number of segregating classes was tested against 9:3:4 ratio considering dark purple and dark brown segregants together. The χ^2 calculated value of 3.87 was lesser than table value of χ^2 = 4.605 at 10% critical value, thus validating the hypothesized recessive epistsis ratio(9:3:4) for pericarp color. The finding indicated that the pericarp colour is under control of two independent genes. Rahman et al.,(2013) investigated on the black rice variety grown in korea 'Heugnambyeo' crossed with three white variants also reported a segregation ratio of 9 purple:3 brown:4 white. The pericarp colour pigmentation of black rice is reported to be under control of two genes Purple pericarp A and Purple pericarp B located on chromosome number 1 & 4, respectively.

The present study indicated the color segregants need to be correlated with the yield parameters for selection of superior black pigmented segregants for effective yield improvement in black scented rice of Manipur.

Table 1. Inheritance pattern of pericarp colour in cross involving black rice Chakhao and RC M 23

Cross	F1 Phenotype	Number	F2 segregation			Total	$\chi2$(9:3:4)	Table $\chi2$
			Black	Brown	White			
Chakhao/RCM 23	White	Observed	219	72	120	411	3.87	5.99
		Expected	231	77	103	411		

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Development of degraded land through agroforestry model under PPP mode

D Daschaudhuri, Gulab Singh Yadav, Mrinmoy Datta, Chandan Debnath, Avijit Haldar and A Shuklabaidya

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra

Introduction

About 2 billion ha in the world is affected by various forms of human induced land degradation with erosion by water being the chief contributor. In India, about 70 percent land degraded due to water. Tripura is predominantly hilly with approximately 60 percent land under forest with high rainfall, humidity and nutrient rich soil. The dependency on forest for food, fodder, housing and an array of marketable forest produces, potentially degrading the forest. Besides, high rainfall and removal of vegetation cover, the soil in the forest is under the threat of erosion. Land Degradation Map (LDM) of Tripura (2007) estimated about 13 percent land degradation due to water and 2.35 percent due to shifting cultivation owing to illicit felling of trees. Among different land use pattern, about 12 percent forest land is under the threat of degradation while only 0.22 percent land under different agricultural activities is facing the problem of degradation. According to the LDM land degradation problems affected mostly north eastern and southern part of the state owing to deforestation and mismanagement of land resources which needs immediate attention for food security as well as maintenance of fragile eco-system.

To mitigate the problem of degradation we need an approach which meets the demand of soil protection, diversification, productivity, profitability and above all sustainability. Agroforestry is an agricultural approach of using the benefits from combining trees and crops and/or livestock and above it is a highly human-dominated land-use systems. The theoretical base for agroforestry comes from ecology, via agro ecology. The efficiency of photosynthesis drops off with increasing light intensity and the rate of photosynthesis hardly increases once the light intensity is over about one tenth that of direct overhead sun. This means that plants under trees can still grow well even though they get less light. By having more than one level of vegetation, it is possible to get more photosynthesis than with a single layer. Agroforestry has two or more plant species in close interaction both provide multiple outputs with single application or inputs, as a consequence, higher overall yields. Agroforestry is also defined as the deliberate land management unit whereby, woody perennials are deliberately grown on same piece of land along with agricultural crop and or livestock in some form of spatial arrangement or temporal sequence.

Methodology

ICAR Research Complex for NEH Region, Tripura Centre and Uttarayan Agricultural Research Society, a society registered under Society Registration Act 1860 has agreed to develop a Fruit Based Agroforestry Model at 2.90ha land under society at Nepalibasti under Lefunga of West Tripura District under Private- Public- Partnership mode. An understanding between the two organisations has been made which include- (i) ICAR, Tripura Centre will provide all technologies to develop Agroforestry model; (ii) farm inputs will either be made available wherever possible or the source of good farm inputs will be shared with the society, (iii) a centre for capacity building and demonstration for the farmers will be developed within the model area by the ICAR, Tripura Centre. In return the society will implement and maintain the farm activities and allow ICAR to collect scientific observations, alter or modify the activities if required. The farm output in any form will be the property of the Society only. Some part of the farm output can be shared with ICAR, Tripura Centre only in case of experimental purposes.

The study area is located at $23^0$53'24"N latitude and $91^0$19'37"E longitude. A GPS survey have been done in the survey area which reveals that the elevation of the area varies from 32.1 m to 53.0 m. The area has further divided as per land classification and planned for different crop cultivation. Agroforestry system with different components is given in table 1.

Table 1. Area allotted under different components

1.	Water harvesting structure with Coconut Plantations around the pond+ vegetables on dyke + Fishery	17% of total land
2.	Pineapple along with spices mostly ginger and/or turmeric (as per the need of farmers and marketability) at sloppy land: about 5000 plants + Forest Trees (Gamahari, Teak, Agar)	30% of total land
3.	High density Banana Crop (Sapri) + seasonal vegetables (pumpkin, watermelon etc): 500 saplings	10% of total land
4.	Arecanut + Lemon at the ridge: 400 saplings	Boundary/ Fencing
5.	Bamboo at natural gulley	As per requirement
6.	High Density Orchard: Amrapali, Papaya- 100 plants	8% of total land
7.	Goat: 5 nos (4 Female & 1 Male) with Grazing land + Jackfruit/ Taprocia + Cover crop (Napier/ Dinanath/ Stylosenthus)	12% of total land
8.	Piggery: 3 nos (2 Female & 1 Male)	1% of total land
9.	Cereals and/ or other agronomical practices as per availability of land	15% of total land
10.	Habitation + other individual usages	7% of total land

Results and Discussion

Agroforestry system developed under ICAR Tripura centre was demonstrated in PPP mode and production and profitability of different components were analysed. Among all the components, fishery, piggery, goatry, mushroom cultivation, tuber crops, field crops, pineapple start to provide the economic return to farmer at from first year onward. Therefore, to recover the establishment cost of agroforestry system, these components found very effective. Fruit crops like papaya and banana gave economic return during second year. It was found during establishment of agroforestry system, that the economic return was more than investment from second year onward. The entire component adopted during the establishment of agroforestry system, maximum cost was incurred for pond construction, but highest return was reported under poultry and pineapple system.

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Phenotyping of Mapping Populations (RILs) of rice against blast disease incidence in upland condition in Tripura.

Debasre Bhattacharjee, Tapas Paul, Jayashree Bhattacharjee, Pujaita Ghosh, Debalina Biswas, Bhargabi Chakraborty, Papiya saha and SP Das*

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura

*Correspondence: drspdas@gmail.com

Introduction

Blast is a major disease in most of the rice growing regions which cause moderate to severe loss in yield. It can affect all above ground parts of a rice plant: leaf, collar, node, neck, parts of panicle, and sometimes leaf sheath. Blast is typically seed borne disease. In upland rice, large day-night temperature differences that cause dew formation on leaves and overall cooler temperatures favour the development of the disease. Blast, caused by *Pyricularia grisea* Sacc., has been a continuous threat to rice production in Tripura. The farmers often transplant blast infected seedlings that might serve as sources of inoculum for further out-breaks of leaf and neck blast disease in the field (Teng *et al*. 1991). Panicles infected near the base (neck) may break and cause complete yield loss. In general, the disease causes 10-20% yield reduction in susceptible varieties, but in severe cases the loss may go up to 80% . For 1% increase in the neck blast, a reduction in grain yield had been estimated between 21 to 51 kg ha-1 in rice cultivar 'Sankharika'.More recently, a grain yield loss of 38.5 and 76.0 kg ha-1 was reported in the rice cultivars: 'Masuli' and'Radha-17', respectively, due to one percent increase in neck blast (Chaudhary 1999).Seed treatments with systemic fungicides and fungicidal foliar sprays had been demonstrated to be effective in minimizing blast disease (Chaudhary and Sah 1998). However, the resource-poor farmers are reluctant to use the chemicals prior to occurrence of the disease. The use of chemical is also neither practical nor environment-friendly. Utilization of host resistance has been the best way to manage the disease. However, blast resistance, especially governed by major genes, is often broken down under field conditions. Therefore, identification of new sources of resistance especially partial resistance and their deployment are necessary for blast management. In this study five mapping population BHALUM X NAVEEN, PHULBADAM X SWARNA, KATAKTARA X NAVEEN, KATAKTARA X SWARNA and PHULBADAM X NAVEEN were evaluated for qualitative and quantitative resistance to blast under field condition.

Methodology

A total no of five mapping populations were evaluated at ICAR RC NEHR, Tripura Centre in upland field conditions. Disease evaluation was started 28 days after sowing. For this study from each Mapping population 200 RILs were scored of Blast incidences following IRRI SES.

Results and Discussion

Among the five mapping populations, Bhalum x Naveen score ranged from (0 to 9 scale) and out of the 200 lines 186 RILs recorded a score of 0 indicating that the RILs having good high level of resistance to blast. Fourteen lines were Moderately Resistant to blast under the field conditions. Among the five mapping populations, Phulbadam x Swarna score ranged from 0 to 9 scale and out of the 200 lines 163 RILs recorded a score of 0 indicating that the RILs having good high level of resistance to blast. Sixteen lines were Moderately Resistant and twenty one lines considered as moderately susceptible to blast. In the mapping populations Kataktara x Naveen disease scoring ranged from 0 to 9 scale and out of the 200 lines 173 RILs recorded a score of 0 indicating that the RILs having good high level of resistance to blast .Fourteen lines were Moderately Resistant, eleven lines considered as moderately susceptible and two lines considered as susceptible to blast under the field conditions. In Kataktara x Swarna disease scoring ranged from 0 to 9 scale and 87 RILs out of the 200 RILs recorded a score of 0 indicating that the RILs having good high level of resistance to blast. Thirty lines were Moderately Resistant to blast, Seventy lines were considered as moderately susceptible and eleven lines considered as susceptible. Two lines were highly susceptible under the field conditions. In Phulbadam x Naveen disease scoring ranged from 0 to 9 scale and 151 RILs out of the 200 RILs recorded a score of 0 indicating that the RILs having good high level of resistance to blast Nineteen lines were found to be moderately resistant, twenty two lines were moderately susceptible and seven lines were screened as susceptible to blast under the field conditions in Tripura. Among the five mapping populations highest tolerance to blast was exhibited in Bhalum X Naveeen follwed by Kataktara x Naveen, Phulbadam x Swarna, Phulbadam x Naveen, Kataktara x Swarna . Kataktara x swarna exhibitied most susceptible to this disease. Hence, it transpires that high yielding breeding lines with resistsnt to reaction blast can be found from all the mapping population. At early stage of crop growth no significant differences were observed of mapping population for disease reaction. However ,over time this disease severity faster in kataktara x swarna followed by Phulbadam x Naveen as compared to other mapping populations. Among RILs in Bhalum x Naveen exhibited higher level of tolerance towards blast disease compare to RILs of other four mapping populations and can be used as a donor parent or resistance genotypes. Hence Bhalum x Naveen appears to be most promising.

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Physiological analysis of tolerance to iron toxicity in rice germplasm of Northeast India

AG Devi[1*], M Datta[2] and SV Ngachan[3]

[1,2]*ICAR Research Complex for NEH Region, Tripura centre*

[3] *Headquarter ICAR Research Complex for NEH Region, Umiam, Meghalaya*

*Correspondence: ganga.ayam@gmail.com

Introduction

Iron is an essential element in plants which plays an important role in many physiological processes; however, excess concentrations of ferrous (Fe^{2+}) ions may lead to Fe toxicity and seen in lowland-rice production also (Dobermann and Fairhurst 2000) causing the discoloration of leaf (Ponnamperuma *et al*. 1955). Hydroxyl radicals (.OH) and other reactive oxygen species (ROS) generated through Fe^{2+} catalysed Fenton reactions cause an irreversible damage to membrane lipids, proteins and nucleic acid. Subsequently, they oxidise chlorophyll and reduce leaf photosynthesis thereby reducing yield about 15-30%. Three types of tolerance mechanism have been proposed through which rice plants adapt to varying Fe toxic conditions (i) root exclusion of Fe^{2+}. This is mainly achieved through oxidation and precipitation of Fe^{2+} on the root surface, referred to as root oxidising potential, thus avoiding excess Fe^{2+} from uptake into rice shoots. (ii) Inclusion but subsequent avoidance of Fe^{2+}*via* internal distribution and storage in a less reactive form. (iii) Refers to inclusion and tolerance to ROS formed in the Fenton reactions. Tolerance is associated with antioxidative capacity of the antioxidants such as ascorbic acid, glutathione and antioxidative enzymes such as superoxide dismutase, catalase, peroxidase etc. which helps in scavenging the ROS and protects the plants from ROS damage. To augment our understanding towards the physiological mechanism for tolerance to Fe toxicity in rice, an investigation was carried out by screening twenty-one rice germplasm from Northeast India under iron pulse stresses (1,000 mg L^{-1} = 17.9 mM Fe^{2+} for 5 days) in hydroponic solution, followed by experiments with selected germplasm to determine whether tolerance attributes were associated with iron exclusion (i.e. root based mechanisms), or iron inclusion (i.e. shoot-based mechanisms).

Methodology

Twenty one rice cultivars Chakhao amubi, Guwahati, Paijam, Mani khamnu, Safed khasa, Kali khasa, Phoujak, KD-2-6-3, Akhanphao, Shahsarang, Arize, Katakchara, Hathia, Mami Reang, Chinari, Chakki Badam, Lalgura, Abhinara, Chandina, Signal and Garumaruti were screened initially for tolerance to Fe pulse stress during the vegetative growth stage at 1,000 ppm Fe^{2+} using $Fe_2SO_4.7H_2O$ as described by Wu et al. (2014). Experiments were conducted in Plant growth chamber facilities of the institute following standard methods described by Wu et al. (2014) with the day/night temperature set at 30/25°C, photosynthetically active radiation (PAR) light of 400 µmol m^{-2} sec^{-1}. Rice seeds were soaked in demineralized water and germinated at 30°C in the dark for 72 hours. Subsequently, germinating seeds were floated in 70.5 mg L^{-1} $CaCl_2$ and 1.625 mg $L^{-1}FeCl_3$ solution in light for another 5 days. Homogenous seedlings were selected and transplanted into 20L tanks filled with half strength nutrient solution. In all experiments, three replicate plants per rice cultivars were used. After 10 days, nutrient solutions were changed to full strength. The pH value during the experimental period was maintained at 5.5 and solutions were exchanged every 10 days. Five weeks after the plant growth, half of the plants were exposed to a pulse stress of 1000 mg L^{-1} for 5 days. To maintain the low redox potential in the solution, N_2 gas was percolated into the culture solutions for 15 minutes every 2 hours. Leaf bronzing scores were measured on the three youngest fully expanded leaves of the main tiller after five days (IRRI, 1976). Plant materials were harvested for Fe distribution, root oxidation and lipid peroxidation studies. Plant shoots of contrasting lines were oven-dried at 60°C until the weight was constant and ground to a fine powder. Fe concentrations in shoots were determined after digesting 250 mg of dry samples with 4 ml 65% HNO_3 at 180°C for 8 hours followed by dilution to 25 ml and filtration. Standard and sample solutions were measured using atomic absorption spectroscopy (AAS, GBC). The redox indicator methylene blue was applied to detect the root oxidizing power (Kotula 2009). The roots of 4 representative plants of each line were carefully placed in 500 ml Erlenmeyer flasks. Gaseous N_2 was applied to remove air from the flasks. Colourless solution containing reduced methylene blue was poured into the flasks to submerge the whole root system. The open surface of flasks was immediately covered with a plastic wrap to avoid air diffusion. Flasks were wrapped with aluminium foil to keep the roots in the dark. The plants were placed in a greenhouse at 30°C for 4 hours. Photographs were taken at every hour to record the colour changes in rhizosphere due to the root oxidizing power. Lipid peroxidation was studied by estimating the malondialdehyde (MDA) content using 200 mg fresh tissue according to the modified method of Hodges *et al.* (1999).

Results and Discussion

The rice cultivars showed varying degrees of leaf bronzing in response to excess iron. Leaf bronzing score ranged from 1.0 to 9.0 in response to iron pulse stress of 1000 mg L^{-1} Fe^{2+}. Among the subjected cultivars, pronounced symptoms were observed in cultivars Paijam, Phoujak, Chandina, Hathia, Signal, Garumaruti, Abhinara, and Mamireang whereas the cultivars Mani khamnu, Kali khasa, Arize, Chakki Badam, Chinari and Lalgura expressed mild symptoms. Relatively low leaf bronzing scores were observed in cultivar Akhanphao, Chakhao amubi, Safed Khasa and Katakchara. On the contrary, leaf symptom expression was not observed in the cultivars KD-2-6-3, Guwahati and Shahsarang. Among the cultivars studied, KD-2-6-3, Guwahati Shahsarang and Arize showed markedly higher relative shoot and root growth. Based on the screening, Guwahati, KD-2-6-3, Shahsarang, Arize showed significantly lower leaf bronzing scores and Paijam and Phoujak which showed pronounced symptoms were chosen for Fe uptake analysis, root oxidation and lipid peroxidation studies. The shoot Fe concentration was significantly lower in cultivars KD-2-6-3 and Arize as compared to Paijam and Phoujak whereas Shahsarang and Guwahati did not differ significantly from these two cultivars. To investigate the physiological basis of low shoot Fe concentration in KD-2-6-3 and Arize, the oxidizing power of roots was investigated. Oxidation of the rhizosphere as indicated by a color change of the Methylene-blue indicator proceeded at a faster pace in KD-2-6-3 and Arize than Guwahati and Shahsarang. While root oxidation in the cultivar Paijam and Phoujak which showed pronounced leaf symptom was relatively slower as compared to KD-2-6-3 and Arize. The MDA level was highly increased in response to iron pulse stress in Paijam and Phoujak as compared to Shahsarang, Guwahati, KD-2-6-3 and Arize.

The present investigation revealed that rice cultivars employ different tolerance mechanism against iron toxicity i.e. shoots- and root- based mechanisms. Based on the Fe uptake into the shoot, while the dominant tolerance mechanism of KD-2-6-3 and Arize was determined to be exclusion with its root architecture being able to oxidize Fe^{2+} through air transport in rhizosphere whereas, the iron tolerance in Guwahati and Shahsarang was attributed mainly to shoot-based mechanisms.

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Intensification and diversification of rice-based farming systems for diversified rural livelihoods of tribal people in Tripura

Gulab Singh Yadav*, Mrinmay Datta, Subhash Babu, H Lembisana Devi, Chandan Debnath, Poulami Saha and Chiranjit Debbarma

ICAR Research Complex for NEH Region, Tripura Centre, West Tripura

*Correspondence: gulab.iari@gmail.com

Introduction

Tripura is one of the seven states in the north eastern part of India, comprising of eight Districts. Though the total area (10,492 km^2) of the state is small, Tripura is considered as one of the twelve bio-diversity rich destinations in the country. The population density of the state has increased from 305 per square km in 2001 to 350. Main occupation of the rural masses is rice based farming. Rice production in the rainfed lowlands faces a number of biotic and abiotic constraints at the farm level, including poor soil fertility, droughts and floods, and various pests and diseases (Das *et al*. 2013). Furthermore, factors beyond the farm boundary, such as rising input costs, fluctuating output prices *etc*., continue to limit farmers' incentive to intensify production beyond that required to achieve household self-sufficiency. The traditional farming system that relied on draught animal power, traditional varieties, and no fertiliser with low productivity is dominant in tribal areas. The intensification and diversification of rice systems with widespread adoption of mechanised land preparation, improved varieties, improved methods of rice production like system of rice intensification (SRI) and integrated crop management (ICM), integrated nutrient management, introduction of maize, lentil, vegetables in rice fallow and integration of fish, pig, poultry etc. may improve the productivity of rice based system and livelihood security of tribal people.

Methodology

Emphasis was given to select the small, marginal tribal farmers and the poorest of the poor tribal farmers. Thus, we selected different number of tribal farm men and women for the interventions on rice based farming system. To implement the programme on large scale, we formed a network with help of KVKs, NGOs, Farmers club, self-help group and state agriculture department officials for monitoring and implementation. We first interact with representative and officials of different areas of above mentions organization and discussed our programme with them. We made a primary visit in some selected tribal villages to understand the existing farming situations and socio- economic conditions of the farmers. We then completed family based micro survey in the selected village with help network partners' for the interventions on rice based farming system. This was not possible to us to personally meet all the farmers at their doorsteps. Therefore, we meet some selected farmers. And network partners' meet all most all the farmers of their respective areas. We then organized meetings in collaboration with respective agency of that area where we explained the benefits and plan of our work in front of the tribal farmers. Based on the existing farming situations, preferences, gender and economic conditions of the farmers, we selected the farmers under activities (Table 1). We then organized hands on trainings both at the village and farm of ICAR Research Complex for NEH Region, Lemucherra, West Tripura to educate the farmers regarding technical know-how of different activities and distributed inputs like seed, fertilizers, farm implements etc. The high yielding varieties of rice *viz.* Ranjit, Gomati, Naveen, MTU – 1010, Rajlakshmi, maize hybrids DMH-849, DMH-117, HQPM-1 and VQPM-9, lentil varieties HUl-57, WBL-77, WBL-58, NDL-01 and Pl-06, quality seed of different vegetables, like pea, chilli, tomato, cowpea *etc*. were distributed among the farmers. Besides that, fertilizers farm implements, sprayer *etc*. were also given to farmers. Thereafter, we offered technical and financial supports for SRI and ICM in rice, for zero and reduced tillage in maize and lentil, making semi- permanent pig shelter with brick-cement (minimum 10 ft long and 5 ft wide) or bamboo- made, low- cost pig shelter (minimum 10 ft long and 5 ft wide)/ bamboo- made, for vermicompost unit. Yield data of crops and performance data of other components were collected time to time through a structured questioner and analyzed through suitable statistical methods.

Table 1. Extent of coverage of village and districts under different activities

Type of activities	Households covered	Villages covered	Name of district covered in Tripura
Diversification of rice based cropping system through rice varietal replacement	4637	92	West, South, Khowai, North, Sipahijala, Gomati, Dhalai
SRI and ICM methods of rice production	500	15	West and Dhalai
Integrated nutrient management	50	2	West
Diversification of rice based farming system through maize	4500	82	West, South, Khowai, North , Sipahijala, Gomati, Dhalai
Diversification of rice based farming system through lentil	222	18	West, South, Khowai, Dhalai
Diversification of rice based farming system through vegetables	50	2	West Tripura
Rice - Fish – Pig – Tuber Crop based IFS	8	2	West Tripura
Rice - Poultry – Kitchen garden based IFS	120	2	West Tripura
Rice – Fish – Poultry – Kitchen garden – Vermicompost based IFS	15	2	West Tripura
Rice – Fish – Poultry – Kitchen garden based IFS	20	3	West Tripura
Total	10122	220	

Results and Discussion

The intensification and diversification of existing rice based farming system through different interventions enhanced the overall income of tribal farmers Rs. 27400 – 211600ha^{-1} (126% - 212%) from Rs. 12200 – 67799ha^{-1}. Different interventions and components had showed variable responses on farmers' field (Yadav *et al*. 2013). The rice yield was increased from 3.1 tonnesha^{-1} to 5.2 tonnesha^{-1} through adoption of high yielding rice varieties (Ranjit, Gomati, Naveen, MTU – 1010, Rajlakshmi) under system of rice intensification (SRI) and integrated crop management (ICM) that led to increase the farmers income from Rs. 12200 ha^{-1} to Rs. 27400 ha^{-1}. Furthermore, diversification of rice fallow land after harvest of rice through lentil, maize and vegetables provide the additional income Rs 26000 – 130000 ha^{-1} to the farmers. Integration of animal, fish and tuber crops component in selected rice based farming system was found more productive, sustainable and remunerative.

Therefore, study suggested the cultivation of rice with high yielding varieties through adoption of improved production technologies (SRI and ICM) and integration and inclusion of animal, poultry, fish, vegetable and other crops for enhancing the system productivity, profitability and livelihood security.

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Genetic diversity of white seeded finger millet genotypes for grain yield

SR Karad*, KS Nagargoje and NY Patil
Zonal Agricultural Research Station, Sub montane Zone, Kolhapur, Maharashtra
*Correspondence: sunil_r_karad@yahoo.co.in

The fifty seven white seeded finger millet diverse genotypes were evaluated for grain yield and yield contributing traits during *kharif* 2014 at ZARS, Kolhapur. The treatment differences were statistically highly significant for all the characters and also the magnitude of genotypic coefficient of variation (G.C.V.) and phenotypic coefficient of variation (P.C.V.) indicated the presence of good amount of variability. The highest heritability (b.s.) was observed for iron content (99.90) followed by plant height (99.70), fodder yield per plant (98.60) and days to 50% flowering (98.30). Calcium content was exhibited highest genetic advance as per cent of mean (126.21) followed by plant height (21.49) and days to maturity (15.31). The grain yield per plant showed highly significant positive correlation with productive tillers per plant, finger length, number of fingers per main ear head, ear heads per plant and 1000 grain weight. The 57 genotypes formed nine clusters. Cluster I, consist of maximum 26 genotypes followed by cluster II with 15 genotypes, cluster V with 6 genotypes, cluster VI with 4, cluster IV with 2 genotypes. However the cluster III, VII, VIII and IX were monogenotypic indicating wide divergence from other clusters. On the basis of inter cluster distances, cluster means, per se performance white seeded finger millet genotypes *viz*., KWFM-43, KWFM-49, KWFM-9 and KWFM-34 were found to be superior genotypes for further breeding program.

Screening and evaluation of stress tolerant summer mungbean rhizobia for their potential PGPR traits and symbiotic efficiency

Moumita Ghosh* and Poonam Sharma
Punjab Agricultural University, Ludhiana
*Correspondence:zina.ghosh@gmail.com

Introduction

Rhizobia are agriculturally important soil bacteria capable of forming root or stem nodules on leguminous plants, in which they can fix atmospheric nitrogen. Inoculation of legumes with rhizobial strains selected for high symbiotic efficiency can improve nitrogen (N) fixation in agriculture, particularly when local rhizobial strains are absent from soils or are ineffective. Due to the reduced need for application of nitrogenous fertilizers, the rhizobia have a great agriculture value and play an important role in improving soil fertility in farming systems. In legume-*Rhizobium* symbiosis the compatibility of the host and the microsymbiont is prerequisite for nodule formation. Rhizobial inoculation increases nodule biomass thus encourages sustainable environmental friendly agriculture by responding perfectly in Biological Nitrogen Fixation (BNF). The present study was done in Department of Plant Breeding and Genetics, Punjab Agricultural University (PAU), Ludhiana.

Methodology

Twelve rhizospheric root nodule samples were collected from different parts of summer mungbean growing areas of Punjab. Isolation of rhizobia from root nodules was done by the method of Vincent 1970. Pure culture of white, translucent, gummy colonies was maintained on Yeast Extract Mannitol Agar (YEMA) medium. PGPR characteristics, stress tolerance and symbiotic efficiency were determined by IAA production, temperature tolerance, ACC deaminase activity followed by pot experiment. IAA production was detected according to Gordon and Weber (1951) by inoculating the rhizobial cultures in YEMB media supplemented with 0.01% tryptophan separately and incubated for 3 days at 28±2ºC. Appearance of pink color confirmed the production of IAA. Isolates were grown on slants containing YEMA medium and maintained at three different temperatures: 35^{o}C, 40^{o}C, and 45^{o}C and kept for 3-5 days. They were examined for presence or absence of growth. Results were categorized as excellent growth +++, good growth++ and poor growth+. For ACC deaminase activity spot inoculation was done on Petri plates containing modified N free Dworkin and Foster medium (DFM) containing 3mM ACC as well as on plates containing 3mM $(NH_4)_2SO_4$. Control plates containing no ACC or $(NH_4)_2SO_4$ were also spotted. The plates were incubated at $30^0C \pm 2^0C$ for 5 days. The ability of culture to grow on ACC plate pointed out the presence of ACC deaminase activity. Pot experiment was conducted by CRBD (Complete Randomized Block Design) method with 4 replications. Sterilized seeds of summer mungbean were inoculated with different promising strains of *Rhizobium* sp. before sowing. Data were recorded of dry weight of shoot, root, and nodule; total N content of shoot and nodule at the time of flowering stage (35 DAS).

Results and Discussion

Out of twelve rhizobial isolates only six showed significant performance as promising strains. IAA is a plant growth hormone produced by rhizobia to promote the plant growth. All the isolates of *Rhizobium* sp. were tested for their ability to produce IAA in the presence of precursor L- tryptophan. Significant amount of IAA was produced by LSMR 5 (15.85μgmL^{-1}) followed by LSMR 1 (14.65μgmL^{-1}). Temperature is one of the most important physical factors affecting growth of microorganisms. All *Rhizobium* sp. were evaluated for tolerance to three temperature regimes 35^oC, 40^oC and 45^oC. At 35^oC, all rhizobia showed excellent growth (+++), while at 40^0C and 45^0C, only LSMR 1 showed excellent growth. Enzyme 1-aminocyclopropane-1-carboxylate (ACC) deaminase which catalyzes the cleavage of ACC to ά-ketobutyrate and ammonia decreases ethylene levels in host roots and there by alleviating stress. In present study all the isolates found ACC deaminase positive. Data presented in Table 1 depicted the effect of potential isolates of *Rhizobium* sp. on growth parameters of summer mungbean. Significantly higher dry weight of shoot was observed in case of LSMR 5 (5.0gPlant^{-1}) followed by LSMR 1 (4.9gPlant^{-1}). Whereas LSMR 1 (25.7 gPlant^{-1}) showed highest dry weight of root followed by LSMR 9 (23.1gPlant^{-1}) than uninoculated (control). Significantly high dry weight of nodules has been noted for LSMR 5(37.4 mgPlant-1) followed by LSMR 1(36.9 mgPlant^{-1}) whereas LSMR 8 (21.3mgPlant^{-1}) recorded non-significant difference over uni-noculated control (23.1 mgPlant^{-1}). Isolates of summer mungbean rhizobia LSMR 1 and LSMR 5 recorded significantly high total N content of shoot and nodule (3.68 and 3.50%; 4.57 and 4.48% respectively) over un-inoculated control treatment (2.90 and 3.03%). Our results agreed with the study of Zahir *et al.* (2010) where it was showed that rhizobial isolates varied widely in increasing levels of L-TRP for improving the growth and yield of mungbean.

Studies also reported significant increase in mungbean growth parameters and yield due to the inoculation of rhizobial isolates (Amir *et al.* 2013). Improvement in nodulation can also be attributed to ACC deaminase activity. Results are well corborrated with the observation of Zahir *et al.* 2011 who reported that rhizobia containing ACC-deaminase activity of rhizobia enhanced the nodule formation in lentil by regulating the ethylene synthesis which subsequently effected nodulation. Out of six promising rhizobia LSMR 1 and LSMR 5 were found to be most efficient for improving growth and symbiotic traits in summer mungbean. To obtain efficient nodulation and nitrogen fixation, it is important to know the predominant types of rhizobial strains present in soil and assess their functionally traits for contributing in symbiotic efficiency and yield improvement in summer mungbean. Thus *Rhizobium* inoculation can be demonstrated in summer mungbean as sustainable, environment friendly agro-technological practice.

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Varietal evaluation of French bean for higher productivity and profitability under Longleng District of Nagaland

Patu Khate Zeliang*, Manoj Kumar, KL Meena, Rakesh Kumar, BC Deka

Krishi Vigyan Kendra, Longleng, Nagaland and
ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani
**Correspondence: patukhate@gmail.com*

Introduction

French bean (*Phaseolus vulgaris*) commonly known as kidney bean, common bean or rajmash is a green vegetable as well as grain pulse. It is an important, highly profitable, early kharif season legume crop and fetches the highest price among all other pulse and is economically a very profitable crop (megapib.nic.in). Thus its commercial cultivation can be an avenue for enhancing farmers' income in the hill ecosystem.Generally, it is cultivated for vegetable purpose round the year except winter months (Oct.-Jan).The tender pods are used as vegetable and mature seeds are consumed as dal. French bean is a highly nutritious crop. Thecomposition of green pod (per 100g) contain, protein=1.7g, carbohydrates= 4.5g, Vit. A= 221 IU, Vit.C= 11 mg and Calcium = 50mg. Dry beans are also rich in protein. The optimum monthly temperature for cultivation of French bean is 15-25°C. It is sensitive to high rainfall, frost and high temperature. The ideal soil PH for growth of French bean is 5.5-6.0. In plains of north India, French bean is sown during two seasons viz., July-Sept and Jan-Feb. In hills, sowing is done from March to May.The district of Longleng has monsoon type of climate with a minimum temperature of 10° C in winter and a maximum of 28° C in summer. The district has a fairly moderate climate where days are warm and nights are cool. Though climate and other natural resources are favourable, farmers are not able to take up vegetable production on a large scale for income generation due to lack of knowledge and high yielding varieties (Zeliang *et al*.2014). On this account, conducting of On Farm Trials (OFTs)to identify location specificity of the agri technologies under various farming systems is one of the important programmes of the Krishi Vigyan Kendra under ICAR Research Institutes. Here we have taken up varietal evaluation of French bean in the pre kharif season of 2015-16, for determining the suitable variety for yield and economic benefit forthe hill areas under Longleng district of Nagaland.

Methodology

Longleng, the tenth district of Nagaland is situated at 26˚26' N latitude and 94˚52' E longitude. The altitude of the district ranges from 260-1306 m above mean sea level. It is bordered by Mon district in the north, Mokokchung district in the west and Tuensang district in the south with its headquarters at Longleng town situated at an altitude of about 1,066 m above sea level. Longleng District is a strip of mountainous territory having no plains with a total area of 885 Sq. KM. Agriculture is the main source of livelihood for the people of Longleng district and Jhum cultivation is the most common form of agriculture (District Contingency Plan, KVK Longleng, Nagaland, 2015). Under the On Farm Trial (OFT) conducted for varietal evaluation of French bean, three different varieties from IIHR (Indian Institute of Horticultural Research), Bangalore, var. Arka Komal, Arka Anoop, Arka Suvidha, were taken up for the trial along with Longleng local-var. Auching as local check. Self-help Groups (SHGs) from two villages *Viz*., Longkam and Pheineu group from Lingtak Village, HD Pangla group from Yongphang village and one individual farmer and his family from Muli ward, Longleng were engaged in the trial. The total area covered was approximately 2 ha in total. Land was ploughed to a fine tilth and divided into randomised block design. Ridges and furrows were prepared by ploughing after a basal dose application of FYM. Seeds were sown under optimum moisture condition on side of the ridges 2 days after two to three showers of rain. The spacing of row to row and plant to plant was maintained at 40X15cm, with a seed rate of 80 Kg/h. The recommended dose of NPK (50:75:75) was followed for cultivation. The whole of phosphorous and potash in the form of Diammonium Phosphate (DAP) and Murate of potash (MOP) were applied as basal dose and Nitrogen in the form of urea in two split doses. Half or 25 kg of the required dose of N was added at the time of sowing and the other half or remaining 25 Kg was added 30 days after sowing.

Results and Discussion

Among the four different varieties of French bean, Arka Anoop and Arka Suvidha were ready for picking in 62 days, whereas Arka Komal and Longleng local were ready in 65 days. In the case of their physical characteristics, Arka Anoop showed the highest plant height (43.97cm) pod weight (11.10g) and pod length (16.64 cm) followed by Arka Komal (40.50cm) pod weight (9.57g) and pod length (16.03 cm), whereas highest number of pod per plant was recorded in Arka Komal (17.77) compared to other varieties (Observation table). Longleng local showed minimum height (28.67 cm), pod weight (6.90g), pod length (12.18 cm), and number of pods per plant (10.80).Maximum green pod yield was recorded 4.38 t/h in Arka Komal followed by Arka Anoop (3.98 t/h), Arka Suvidha (3.70 t/h) and Longleng local (3.26 t/h). In a survey for taste preference among the farmers, Arka Komal was found better in taste followed by Longleng local compared to other varieties. Since the topography is mountainous and steep, it is difficult to find large tract of land in one place. Contour bunding was constructed in one of the fields and the yield was found to be more compared to the other fields. The different varieties performed differently according to the locations of fields and villages, where in some Arka Anoop was best and in others Arka Komal. Arka Anoop was infected with bean anthracnose in one of the fields which greatly affected its yield. Overall Arka Komal was most preferred followed by Arka Suvidha. Arka Anoop was found not only hard and fibrous but tasteless by the village folk's. From the result it has been observed that Arka Komal was found suitable for higher productivity, taste and income. Adoptivity wise; the village folks are impressed with crop yield and the short duration. Many more SHGs and individuals have expressed interest in cultivation of French bean next season.

Table 1. Performance of French bean varieties at Longleng

Variety	Plant ht. (cm)	Pods/Plant	Pod length (cm)	Pod wt (g)	Yield (t/ha)
Arka Komal	40.5	17.8	16.0	9.57	4.38
Arka Anoop	43.9	16.9	16.6	11.10	3.98
Arka Suvidha	37.1	15.5	14.9	9.00	3.70
Longleng local (Auching)	28.7	10.8	12.2	6.90	3.26

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Effect of conservation tillage and live mulch on earth worm population, fresh biomass weight and maize productivity

Poulami Saha*, Gulab Singh Yadav, Mrinmay Datta, Subhash Babu, Chandan Debnath and Chiranjit Debbarma

ICAR Research Complex for NEH Region, Tripura Centre, Tripura

*Correspondence: gpsahapoulami@gmail.com

Introduction

Earthworms play an important role in many soil functions and are affected by soil tillage in agricultural soils. Earthworms affect many soil properties in agricultural land including nutrient availability, soil structure, and organic matter dynamics. Earthworms in turn are influenced by soil moisture, organic matter, texture, pH, and soil management. Tillage systems can affect soil biota through changes in habitat, loss of organic matter, moisture and temperature dynamics and mechanical damage. Earthworm population change due to soil tillage depends on tillage intensity and may be higher under root than cereal crops. Earthworm population is good indicator of soil fertility and soil organic matter. Maize is the most potential and predominant rainy season crop on the hills of NER of India (Das *et al.* 2010). Exhaustive nature, wider spacing and poor ground cover under maize encourage soil loss through erosion and degrade soil. Therefore, a field experiment was conducted to study the effect of conservation tillage and live mulch on earth worm population, live weight and maize yield.

Methodology

The experiments were conducted during 2013-14 at the experimental farm of ICAR Research Complex for North East Region, Tripura Centre, Lembucherra, Tripura (W), India ($23^0$54'24.02" N and $91^0$18'58.35"E) situated at an altitude of 162 m ASL (above mean sea level) The annual rainfall of the region is 2200 mm. The experiment consists of five treatments: no-till (NT), NT + Live mulch (NT+LM), reduced tillage (RT), RT + live mulch (RT+LM) and conventional tillage (CT). The approximate fifty residue of previous crop was left on field as mulch in the entire no-till and reduced tillage plot. In treatments, where live mulch was used, the two rows of cowpea variety Kashi Kanchan were sown in between of two rows of maize. We counted earthworms by digging one 25 cm × 25 cm × 25 cm sample from each treatment. The samples were hand sorted for earthworms. After that earthworms were counted and their fresh biomass weight was taken. Maize kernel yield was measured from net plot. All the data were analyzed following a RBD model. The least significant difference (LSD) test was carried out for the analysis of mean square errors. The procedure provides for a single LSD value at 5% level of significance which serves as a boundary between significant and non-significant differences between any pair of treatment means (Gomez and Gomez 1984).

Results and Discussion

Earthworm population and fresh biomass showed variable response to different tillage and live mulch. Earthworm population was not affected by tillage and mulch treatments.

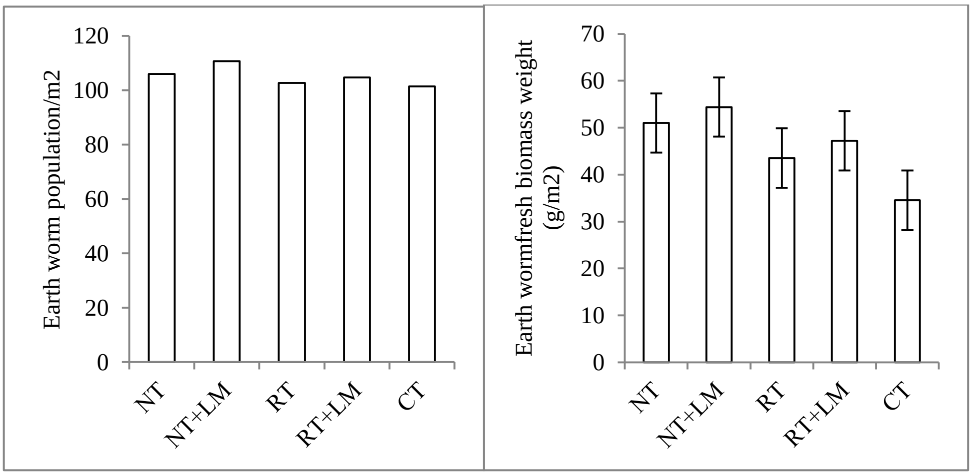

Fig 1. Effect of tillage and live mulch on earthworm population and fresh biomass weight

However, NT+LM recorded maximum number of earthworm/m^2 (Fig 1). Earthworm Fresh biomass weight was significantly higher under NT+LM and NT as compared to CT. The higher live weight of earthworm under NT based plots indicated higher organic matter. However, maize grown under reduced tillage system with live mulch of cowpea produced significantly higher yield as compared to NT, NT+LM, RT and CT. The study suggested that cultivation of maize under reduced tillage and no-till condition with live mulch of cowpea is beneficial to the farmers for enhancing their productivity and income as well as population of earthworms.

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Assessment of genetic variability and diversity in *Jhum* rice lines of Tripura using SSR markers

Pujaita Ghosh, Debashree Bhattacharjee, Debalina Biswas, Bhargabi Chakraborty, Papiya Saha, Tapas paul and SP Das*
ICAR Research Complex for NEH Region, Tripura centre, Lembucherra, Tripura.
*Correspondence: drspdas@gmail.com

Introduction

Oryza sativa, commonly known as Asian rice, is the cereal with the smallest genome, consisting of just 430Mb across 12 chromosomes. Household food and nutritional security of north-eastern states of India predominantly depends on rice occupying 3.51 million hectares which accounts for more than 80% of the total cultivated area of the region and 7.8 per cent of the total rice area in India while its share in national rice production is only 5.9 per cent. Characterization and quantification of genetic diversity has long been a major goal in evolutionary biology studies. Information on the genetic diversity within and among closely related crop varieties is essential for a rational use of genetic resources. Study on genetic variation contributes to monitoring germplasm and can also be used to predict potential genetic gains. Diversity based on phenological and morphological characters usually varies with environments and evaluation of these traits requires growing the plants to full maturity prior to identification. SSRs can be identified in sequence databases and used for SSR marker development (Morgante *et al*. 1993). In the present investigation the following objectives were studied; assessment of genetic variability and diversity at molecular level among 45 traditional jhum rice using SSR markers.

Methodology

Forty five Jhum paddy lines are used for the present study. Young, tender, fully opened and pale green leaves were collected from individual plants. DNA was extracted by following CTAB method reported by Rogers and Bendich 1994. A set of 50 standard SSR primers were used. To standardize and quality assurance we have used the standard SSR primers. The PCR reaction was carried out using DyNAzyme^{TM} II PCR master mix in 20 ml reaction volume containing 0.04U/µl DyNAzyme^{TM} II DNA ploymerase, 20mM Tris-HCL (pH 8.8 at 25°C), 3 mM MgCl2, 100 mM KCL, stabilizers and 400 µM mM of each dNTPs, 5 pmol of forward and reverse each primers and 50 ng genomic DNA. All the genotypes were scored for the presence and absence of the SSR bands. The similarity matrix was employed to construct dendrograms using Sequential Agglomerative Hierarchical Nesting (SAHN) based Unweighted Pair Group Method with Arithmetic Means (UPGMA) to infer genetic relationships and phylogeny.

Table 1. Jhum paddy lines used in the study

Sample ID	Designation	S.NO.	Sample ID	Designation	S.NO.	Sample ID	Designation
JHUM-07	Garua	16	JHUM-36	Galong-1	31	JHUM-64	RCPL-1-80
JHUM-13	Uknown-2	17	JHUM-37	Horipi	32	JHUM-66	RCPL-1-412
JHUM-16	Unknown-1	18	JHUM-38	Mybring-Ha	33	JHUM-68	RCPL-1-93
JHUM-17	Badaiya	19	JHUM-40	Galong-2	34	JHUM-69	RCM-5
JHUM-18	Kataktara	20	JHUM-42	Kaproc	35	JHUM-71	Bhalum-3
JHUM-19	Garomalati	21	JHUM-50	Maivar	36	JHUM-72	RCPL-1-90
JHUM-20	Maidan	22	JHUM-52	Buh Vui Buk	37	JHUM-73	Binny Dhan
JHUM-21	Aduma-1	23	JHUM-53	Farbawr (Tai)	38	JHUM-74	Garo Maitha
JHUM-22	Galong-3	24	JHUM-55	Kung rei	39	JHUM-75	Kataktara
JHUM-23	Berain-6	25	JHUM-56	Buhbam	40	JHUM-76	Adma Kslkak
JHUM-25	Aduma-2	26	JHUM-57	RCPL-1-103	41	JHUM-78	Unknown-3
JHUM-31	Galong-6	27	JHUM-59	RCPL-1-413	42	JHUM-79	Beti-4
JHUM-33	Chinal small	28	JHUM-61	IR 46A	43	JHUM-80	Berain-5
JHUM-34	Chinat-2	29	JHUM-62	RCPL-1-114	44	JHUM-82	Berain-4
JHUM-35	America	30	JHUM-63	RCPL-1-111	45	JHUM-84	Beti-1

In addition, Principal Component Analysis (PCA) based clustering was also done using the subroutine EIGEN. The genomic DNAs were amplified by 50 rice markers for amplification verification for different chromosome positions and for polymorphisim analysis.

Results and Discussions

Assessment of genetic diversity is an essential component in germplasm characterization and conservation. In the present investigation 20 primers showed polymorphism between 45 JHUM cultivars. A total of 4 distinct groups resulted out of analysis of pooled SSR marker data. Rice similarity ratio revealed that high degree of similarity to the extent of 98% exists between JHUM-7 and JHUM- 16 whereas very low level of similarity of 15% exists between JHUM- 07 and JHUM- 64. Thus the JHUM- 69 and JHUM- 73 genotypes are different from other JHUM genotype included in the study. Cluster analysis was used to group the varieties and to construct a dendogram. The similarity matrix representing the DICE Co-efficient was used to cluster the data using the UPGMA algorithm. The UPGMA based dendogram obtained from the binary data deduced from the DNA profiles of the samples analysed adds a new dimension to the genetic similarity perspectives generated. A total of 4 distinct groupsor clusters resulted out of analysis of pooled SSR marker data. This dendogram revealed that the genotypes that are derivatives of genetically similar type clustered more together. There are 4 groups in the sample:

Table 2. Categorization of the Jhum Paddy Lines based on cluster analysis

GROUP-A	JHUM-7, JHUM-16, JHUM-61, JHUM-78, JHUM-17, JHUM-55, JHUM-66, JHUM-79, JHUM-18, JHUM-35, JHUM-33, JHUM-22, JHUM-42, JHUM-63, JHUM-80, JHUM-68, JHUM-34, JHUM-25, JHUM-37, JHUM-40, JHUM-23, JHUM-75, JHUM-76, JHUM-13, JHUM-20, JHUM-53, JHUM-74, JHUM-71, JHUM-57, JHUM- 64
GROUP-B	JHUM-19, JHUM-82, JHUM-84, JHUM-21, JHUM-38, JHUM-31, JHUM-52, JHUM-50, JHUM-59, JHUM-72, JHUM-36, JHUM-62, JHUM-56
GROUP-C	JHUM-69
GROUP-D	JHUM-73

Principle component analysis was also done to visualize genetic relationships among the elite breeding lines. The results were similar to UPGMA results. This indicates that probably there was an intercrossing between JHUM rice and *Oryza rufipogon* at some point of evolutionary time. However, this phenomenon appeared not in the recent past as there were no heterozygous bands for this marker. Based on study the large range of similarity values for related cultivars using microsatellites provides greater confidence for the assessment of genetic diversity and relationships.

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Social dimension of shifting cultivation – cross cultural reflections

P Punitha[1], A Sarkar [2] and D K Pandey[3]

[1]*College of P.G studies, Umiam, Meghalaya*
[2]*College of Fisheries, Tripura*
[3]*College of P.G Studies, Umiam, Meghalaya*
Correspondence: kppunithaa@rediffmail.com

Introduction

The shifting cultivation is an indigenous land use system widely distributed and practiced in North East India. The majorities of the people who are practicing shifting cultivation belong to ethnic groups and are referred as ethnic minorities, tribal people, hill tribes or aboriginal people or increasingly call themselves as indigenous people (AIPP and IWGIA, 2014). Around the globe, the tropical countries experience this form of land use called commonly as shifting cultivation or swidden or slash and burn agriculture. The nomenclature of shifting cultivation varies from place to place. It is called as Jhum in India and Bangladesh. These apart, different tribes in India also call it by their own names. The word shifting cultivation is unique to this North Eastern Region as it occupies 83 percent of the shifting cultivation in India. The total estimated area under the shifting cultivation in India is 0.9 million ha which includes both current Jhum (53%) and abandon Jhum (47%) (DOLR and NRSC 2011). The people who practice this form of land use are called as Jhumias. Being one of the dominant land use systems, shifting cultivation calls for exploration of it's by the interested researchers and academicians.

Methodology

Systematic approach has been adopted to collect review from electronic databases, open access repositories, research gate, academia.edu and e-libraries of CAU. Online books and printed articles were deeply perused. Scientists, state government officials like Director, Department of Agriculture Manipur, and Joint director of Horticulture were contacted to discuss about the status of shifting cultivation in Manipur. Manipur university library has been accessed for collecting secondary literature. The objective is to analyse the basic social dimensions of shifting cultivation, to comprehend the dynamics of such ethno-agricultural system through reflections getting accumulated across different cultural milieu basically through analyses of secondary information. The reviews lay focus on shifting cultivation in India and blending the accumulated experiences with those of other countries. The revelations have got classified under the sub heads of i) the social characteristics of the shifting cultivation ii) the trend in the pattern of shifting cultivation, iii) the Government of India initiatives to control the shifting cultivation, iv) the issues of sustainability, food security and livelihood aspects of the shifting cultivation, and v) the shifting trends in shifting cultivation and the SWOT of shifting cultivation.

Results and Discussion

The various researchers' analysis and cross cultural reflections reveals that the shifting cultivators have an intricate relationship with the land and have a strong affinity and respect towards the land as it is a way of life. The causes of shifting cultivation revealed by researchers are traditional customs and the shifting cultivation as a way of life but these causes have to be explored inform of the attachment they have towards continuance of shifting cultivation in the present context especially in the North East India. The reason being, the FAO has declared in 1950s as a destructive form of land use (Kherkhoff and Sharma 2006) but still the shifting cultivation is continuing in varied trends in the North East India. Since 1950s, Government of India along with the state government collaboration in the North East India implemented various schemes implemented since 1950s and the latest being Watershed Development Project in Shifting Cultivation Area (WDPSCA) which completed in 2012. The trends in shifting cultivation though depict some patterns of change but the data are highly varied from government records, wasteland atlas and various researchers' data. From the literature, it is observed that there is a transition taking place in the various countries but in varied form from subsistence based system to dual economy in which both shifting cultivation and settled cultivation practices are done. The factors responsible for change are either due to choice or compulsion from laws, government programmes, population pressure, market integration, infrastructural facilities improvement etc. However, the systematic and detailed study need to be conducted in the North Eastern Region about the transition any taking place in the Jhum characteristics, the supporting and hindrance factors responsible for the transition, the Jhumias perception on the technology for Jhum land and their matching initiatives taken by the research organization, the possible policies to support for the requirement, youths perception on Jhum and the detailed livelihood analysis of the Jhumias are the areas need to be explored for the future research in the social dimension of shifting cultivation.

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Assessment of productivity enhancement by self-sustainable integrated farming system through crop, livestock and tree integrations under rainfed conditions in Meghalaya

JJ Rajappa*, A Venkatesh, Puran chandra and KP Mohapatra
ICAR Research complex for NEH Region, Umiam, Meghalaya
*Correspondence: rajappajj@gmail.com

Introduction

Hilly regions of Northeast India are inhabited by various ethnic groups who depend largely on agriculture for their subsistence. From the ages *Jhum* (Shifting cultivation) is a major source of economy in its traditional and cultural integrated form. However due to time factor and high population pressure, *jhum* has caused drastic decline in crops yield, loss of forest wealth and environmental degradation. Therefore, it is essential to have farming systems approach. The emergence of Integrated Farming Systems (IFS) has enabled us to develop a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones (Rana 2015). With this aspiration to explicate strategies for agricultural development in this region with an objective to assess the productivity of the whole system, productivity of five different Intensive Integrated Farming System models was estimated.

Methodology

A study site was farm of ICAR Research complex for NEH region, Umiam In 1.77 hectare area of integrated farming system, an area allotted to different component is shown in (Table 1). Observations on the productivity and economics of individual components of 5 subsystems (models) of IIFS along with one unit as a control (no integration) were recorded.

Table 1. Productivity and stocking density of animal/birds and fishes of different IIFS

IIFS model	Productivity/yr	Stocking density of animals/birds and fishes	BC ratio	Net returns (Rs/ha/y)
Chicken-crop-fish-duckhorticulture along with hedgerow on contour bunds.	Duck: 24 Nos.	Duck- 38 nos./ha	1.58	65,306
	Eggs: 13.5 kg, Fish: 6.43 q/ha	Fish-9000 fingerlings/ha		
Crop-fish-poultry-multipurpose trees	Live chicken: 6.43q	Broiler birds 200/batch	1.51	31,573
	Fish: 4.25 q/ha	Fish-9000 fingerlings/ha		
Crop-fish-goat-multipurpose trees	Meat: 116 kg	Goat- 12 nos./ha	1.55	33,735
	Fish: 4.29 q/ha	Fish-9000 fingerlings/ha		
Crop-fish-pig-vermicompost bamboo-multipurpose trees hedgerow-broom	Pork: 0 .78 q/ pig	Pigs- 2 nos./ha	1.42	34,276
	Pond underwent repairing and hence fish yield not obtained	Fish-9000 fingerlings/ha		
Crop- fish-dairy-vermicompost-horticulture-hedgerow	Milk: 1634 liters	Cattle- 3 nos./ha	1.76	1,21,634
	Fish: 16.22 q/ha	Fish-9000 fingerlings/ha		
Upland crops, and fish farming without integration (control)	=	=	1.09	13,965

Results and Discussion

Compared to control, net income from Integrated farming system showed more than one fold increase in poultry, goat and pig based systems. Whereas broiler based and dairy based systems showed 4-fold and 8-fold increased productivity respectively. Among the cropping sequences, turmeric-groundnut system yielded the maximum closely followed by vegetables. Productivity of fish was recorded highest in Crop-fish-dairy-vermicompost-horticulture-hedgerow system (1.62 t/ha). Among the animal components daily weight gain was recorded highest in pig (0.28 kg/day). Highest meat production was from crop-fish-poultry-multipurpose trees (0.64 t/ha). Crop-fish-poultry-multipurpose trees model was the most profitable with cost benefit ratio (Table 2). Dairy based model recorded the highest benefit cost ratio (1.76) followed by Broiler-duck (1.58) based systems. This was followed by goat based (1.55), poultry based (1.51) and pig based system at ratio 1.42. Results discussed revealed that IFS enables the agricultural production system sustainable, profitable and productive. On an average profit margin on account of IFS varied from Rs 17,000 to Rs 1, 20,000/ha/annum. The overall premise of IIFS is to put in place a process for increasing the productivity and promote crop-livestock synergies effectively with careful land use, raise the productivity of specific mixed crop-livestock systems, facilitate expansion of food and feed production and simultaneously safeguard the environment with efficient use of natural resources.

Table 2. Productivity of various IIFS models

IIFS models	Area (ha)		Components	Var./Breed	Area (ha)	Productivity
Duck-fish-hedge row-vegetables-annual crops	Pond	0.150	Duck (24 nos.)	Indian runner	0.166	
	Pond dyke	0.030	Egg			145 nos.
	Duck shed	0.016	Soya bean	JS-335	0.051	2.45 t/ha
	Crop area	0.360	Maize	DMH-849	0.19	2.15 t/ha
	Hedgerow	0.300	Up land Paddy	Bhalum-1	0.032	1.39 t/ha
	Total area	**0.856**	Low land paddy	Shasarang	0.12	2.61 t/ha
			Turmeric	Lakadong	0.05	25.6 t/ha
			Ginger	Nadia	0.03	15.9 t/ha
			Lentil	PL126 ,L-4147	0.10	0.7 t/ha
			Mustard	M-27	0.03	0.4 t/ha
			Rapeseed	TS-36, Varuna	0.063	0.79 t/ha
			Vegetables:		0.14	0.62 t/ha
Poultry-fish	Pond	0.12	Poultry birds (200 per batch)	Kroiler/Broiler	0.13	
	Pond dyke	0.04				
	Poultry shed	0.01	Eggs		157 nos.	
	Total area		Meat		1100 kg/yr	
		0.24	Poultry dropping		800 kg/yr	
Goat-fish	Pond	0.10	Meat (17 nos.)		0.11	190 kg/yr
	Pond dyke	0.035				
	Goat shed	0.008	Goat manure			1700 kg/yr
	Total area	**0.143**				
Pig-fish-MPTs-crops	Pond	0.120	Pig Meat (4 nos.)		0.121	340 kg
	Pond dyke	0.035	Paddy	Bhalum-1	0.10	1.2 t/ha
	Pig shed	0.001	Groundnut	ICGS-76	0.05	1.25 t/ha
	Crop area	0.15				
	Total area	**0.306**				
Cattle-fish-MPTs-crops-vermicompost	Pond	0.120	Milk			3561 ltr/yr
	Pond dyke	0.060				
	Dairy shed	0.016	FYM		0.001	18 t/yr
	Crop area	0.03	Vermicompost			900 kg/yr
	Total area	**0.226**				

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Prospects of white grain finger millet breeding

RK Khulbe*, Salej Sood, Lakshmi Kant and A Pattanayak
ICAR-Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand, India
*Correspondence: rkkhulbe@gmail.com

Finger millet (*Eleusine coracana*) is an important coarse cereal of Indian Subcontinent and Africa and is cultivated in over 40 countries globally. In India, a sizable population particularly in arid, hilly and tribal regions is dependent mainly on small millets for their food and nutritional security. Finger millet grains exhibit a variety of colour ranging from deep brown/red to ivory/white. The colour is determined by the amount of tannins present in the seed coat and is associated with its nutritional quality and consumer preference. The white seeds have been found to have higher protein content and lower tannin content compared to most brown/red seeded types. The tannins impart an astringent taste to the grains and reduce their nutritional quality and palatability, besides reducing their consumer appeal. There is, therefore, increased emphasis lately on development of high yielding white-seeded finger millet cultivars to augment its base particularly among non-traditional consumers and enhance it acceptance by the food industry. Genetic studies on grain colour in finger millet have revealed dominance of brown grain colour over white grain colour and suggested oligogenic mode of its inheritance. The wild progenitor of finger millet (*E. coracana* susbsp. *africana*) has brown seeds, suggesting the brown-seeded cultivated forms as its direct descendants from which the white-grain types may have arisen subsequently following mutational event(s).

The relatively small proportion of white-seeded types in global finger millet collections indicates cultivation of white finger millet on small scale in limited pockets historically compared to the brown-seeded types. Their low prevalence suggests that the initial white-seeded types may not have offered any additional agronomic advantage over the brown-seeded types or may have suffered from drawbacks (such high disease susceptibility), therefore, may not have been the primary target of selection during the process of finger millet domestication. The susceptibility of native white-seeded types to blast disease suggests that the white seed may have arisen in blast-susceptible background causing all or most white-seeded descendants to be susceptible; a genetic linkage between the two traits may be non-existent though. White-seeded types do not seem to have originated/existed in India and the fact is evidenced by the absence of indigenous white-seeded germplasm accessions in the national gene bank. Most of the existing white-grain Indian varieties have been bred using white-seeded donors from Africa. The African material in general is late especially under temperate conditions. The present Indian white material which is late as well as susceptible belongs to the first generation of white x brown derivates intended chiefly to recover the white-grain trait in Indian material. Recent efforts involving the Indian bred white material and early and blast-resistant donors have begun yielding derivatives which combine white seed with earliness and blast resistance. Further, white grain is not genetically associated with low yield is attested to by the fact that white-seeded genotypes as high yielding as or even higher yielding than popular brown-seeded varieties have been developed and released for cultivation. Increased acceptance by consumers and food industry, and availability of white grain trait in improved agronomic background presents a promising prospect for white grain finger millet.

Evaluation of finger millet fixed breeding lines for stability using parametric and non-parametric methods

Salej Sood[1]*, TSSK Patro[2], Sunil Karad[3] and Abhinav Sao[4]
[1]*ICAR-Vivekananda Institute of Hill Agriculture, Almora, Uttarakhand, India*
[2] *Agricultural Research Station,Vizianagram, Andhrapradesh, India*
[3]*Zonal Agricultural Research Station, Kolhapur*
[4]*IGKV, S.G. College of Agriculture and Research Station, Jagdalpur, Chhattisgarh, India*
*Correspondence: salej1plp@gmail.com

Finger millet (*Eleucine coracana* L. Gaertn), a member of the *Poaceae* family, is one of the most important subsistence crop in semi-arid, marginal and hilly areas. It is highly adaptable crop and even grown in higher elevations up to 2400 m above mean sea level in the Himalayan States. The yield levels in finger millet are lower in comparison to major cereal crops and require attention of plant breeders for concerted efforts towards development of high yielding stable varieties. This field experiment was conducted to measure genotype environment interaction (GEI) and compare different parametric and non-parametric stability statistics to identify stable genotypes.

Thirteen genotypes of early and medium maturity duration of advanced varietal trial were evaluated in a randomized complete block design with 3 replications at four diverse locations across India in the year 2013. Genotypes (G), environments (E) main effects and GEI were significant at $P < 0.01$. The relative magnitudes of G, E and GEI variances accounted for 10.64, 66.23 and 23.13 per cent, respectively. All four parametric stability measures (σi^2, s^2, Wi^2, ASV) identified similar stable genotypes namely PPR 2773, KOPN 942, TNAU 1214, KRI 007-01, VL 368, VL 352 and GPU 45. Among four non parametric statistics ($Si^{(1)}$, $Si^{(2)}$, Ysi and YSI), only two statistical measures (Ysi and YSI) could differentiate the genotypes for stability. The rank correlation matrix indicated that both non-parametric measures were significantly inter-correlated with parametric measures and therefore can be used as alternatives. However, only two stability measures (Ysi and YSI) showed significant association with mean grain yield and were important in identification of stable genotypes without compromise for grain yield. Among these two, simultaneous selection for yield and stability (Ysi) was found to be the better choice for screening of genotypes for both yield and stability. The stable high yielding genotypes PPR 2773, VL 368, KOPN 942, VR 988, TNAU 1214 and GPU 45 can be deployed or included in breeding program for enhancing the finger millet productivity.

Diversity of *Perilla frutescens* (Linn.) Britt., a potential oil seed crop of NEH Region of India

SK Singh[1*], PC Kole[2], AK Misra[1], S Roy[1], R Bhardwaj[3], P Suneja[3] and Sangita Yadav[4]

[1]*ICAR-National Bureau of Plant Genetic Resources, Regional Station, Umiam – 793 103, Meghalaya.*
[2]*Palli Siksha Bhavana,Visva Bharti, Sriniketan, West Bengal- 721 235*
[3] *ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi, 110 012.*
[4] *ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi, 110 012.*
*Correspondence: sanjeevs99@rediffmail.com

Perilla [*Perilla frutescens* (Linn.) Britt., Lamiaceae] is considered to be a commercial oilseed crop in Asia. The agro-climatic heterogeneity of this region offers a great deal of diversity in agro-morphology of perilla germplasm. The experimental material comprised of a total of 62 landraces and 4 checks which were collected in various exploration trips from diverse agro ecological areas of Northeastern hill region of India and characterized for 22 morphological and 8 biochemical characters. Frequency distribution for qualitative traits were observed and large variation found for early plant vigour, plant shape, leaf colour, seed colour and seed size, whereas variation was small for inflorescence structure and secondary branches. The accessions exhibited large variation for inflorescence/plant, yield/plant, 1000 seed weight, inflorescence length, stearic acid and plant height as shown by their coefficients of variation while lowest variation observed for characters days to 80% maturity, days to 50% flowering and oil%. The analysis of variance found significant for all the quantitative characters studied. The highest estimates of genotypic coefficient of variation (GCV) were observed in case of inflorescence per plant, plant height, 1000-seed weight, inflorescence length per plant and yield per plant. While the highest estimates of phenotypic coefficient of variation (PCV) were observed in case of yield per plant, inflorescence per plant, inflorescence length, 1000-seed weight, plant height, petiole length, leaf length, and primary branches per plant. The high heritability (>50%) estimates were recorded for the characters plant height, days to 50% flowering, leaf length, seed size, inflorescence per plant, days to 80% maturity and 1000 seed weight. The value of genetic advance in per cent of mean (GA) recorded highest for inflorescence per plant and lowest for days to maturity.

The biochemical analysis revealed that accessions exhibited large variation for stearic acid, total phenol and oleic acid. However, other characters *viz.* oil, protein, linoleic acid, palmitic acid and linolenic acid exhibited less variation. Seed oil contents determined at 4% moisture level ranged between 41 to 55.44% with a mean of 46.86%. The average individual fatty acid values as established for the present accessions were palmitic acid 7.75,

stearic acid 3.66, oleic acid 14.85, linoleic acid 18.32 and linolenic acid 51.74. Among all the fatty acids linolenic acid (omega 3 fatty acid) predominated in the seed oil and contributed 35.3 to 65.2%. Average protein content was 19.25% with a range of 16.75 to 22.74% while total phenol average 14.72 with a range of 7.00 to 21.00.
Hierachical clustering using wards method assembled accession into two major clusters, which was designated cluster A and cluster B, based on 29 traits. Cluster A include a total of 12 accessions (Meghalaya 2; Arunachal Pradesh 5 and Nagaland 5) higher number of inflorescence/plant, inflorescence length, 1000 seed weight, yield/plant and oil yield/plant. Cluster B was further divided in cluster B-I, B-II and B-III. The accessions from cluster B-I (Mizoram 5; Manipur 1; Arunachal Pradesh 1 and Shillong check) displayed days to maturity and linolanic acid. Maximum accessions 36 including three numbers of checks are comprised in Cluster B-II (Arunachal Pradesh 4; Mizoram 11; Manipur 2; Nagaland 16; check Jaintia, Local III and Local IV). Maximum number of accessions collected from Nagaland and Mizoram were also comprised in this cluster B-II. This cluster having primary branches per plant, days to 50% flowering, Total phenol, oil and protein percentage. Cluster B-III consisted a total of 10 accessions (Arunachal Pradesh 6; Sikkim 1; Mizoram 2; and Meghalaya 1). Based on the oil content accessions namely, IC524554, IC524504, IC52445, IC422885, IC275959, IC016443, IC006444, IC06442 and IC599246 found superior, having more than 50% oil. The promising accessions IC599238, IC599235 and IC599246 found superior for oil yield/plant percent. This study will facilitate in planning *in situ* management of this potential oil seed crop of this region and in selecting diverse parents in breeding programmes based on agro-morphological and biochemical traits.

Exploration, conservation and documentation of allied genera of large Ccardamom at Spices Board, ICRI farm in Sikkim

Sreekrishna Bhat*, AK Vijayan, BA Gudade and SS Bora
Indian Cardamom Research Institute, Regional Research Station, Spices Board, Tadong, Gangtok, Sikkim
*Correspondence: sk9bhat@yahoo.co.in

Introduction

India is the largest producer of large cardamom in the World with 54% share, followed by Nepal (33%) and Bhutan (13%). Large cardamom (*Amomum subulatum* Roxb.), a member of zingiberaceae family under the order Scitaminae is one of the main cash crop cultivated in the sub-Himalayan state of Sikkim and Darjeeling district of West Bengal covering an area of about 26000 ha with an annual production of ranges from 4000 to 5500 metric tonnes (Anon. 2013). The presence of several wild relatives and the tremendous variability within the cultivated species support the view of its origin in Sikkim (Subba 1984). In Sikkim total area under large cardamom was 15500 ha with production of 3681 tonnes and productivity of 235 kg/ha (Anon. 2011) primarily for want of high yielding genotypes suitable for different agro-climatic conditions of Sikkim. Therefore it is highly essential to identify the genotypes suitable in different agro-climatic situations and to replace the local unproductive large cardamom by crossing large cardamom cultivars with wild cardamom to combine yield contributing characters to the existing cultivars through hybridization.

Methodology

An expedition was conducted by Spices Board, ICRI, scientists for the collection of allied genera of large cardamom in Aalo, Siang, East Siang, West Siang districts of Arunachal Pradesh during July 2015. Six allied genera were collected during the year 2015 and conserved at ICRI farm, Sikkim.

Results and Discussion

ICRI gene bank already collected and conserved four allied genera of large cardamom *viz*; *Amomum kingie***,** *A. Aromatium, A. delbatum, A. linguiforme*. Six wild large cardamom genotypes *viz*; Belak, Bebo, Tali, Rengka, Jaker and Tajee were collected from Arunachal Pradesh during July 2015 and conserved at ICRI, Spices Board farm (Table 1). Jaker showing robust growth with more height (365 cm) followed by Tali (360 cm). Jaker produced bold fruits and each fruit weighed 10 gm followed by the fruits of Rengka (5 gm). No. of seeds were more in Belak (250 seeds) followed by Jaker (60) (Table 2). ***Belak:*** Medium tall plant (2-2.5 m) with about 10-12 leaves/ tiller and robust growth. Flowers white in colour and capsules are white brown and looks like garlic. Number of seeds/capsules is much more in comparison to other types (250 numbers) and seeds are very small in size. ***Bebo:*** This cultivar is grown in Siang district of Arunachal Pradesh. Plant medium tall in height (2.0 m) with 10-11 leaves/ tillers. The plant has unique features of rhizome and tillering. The rhizome rises above the ground level with roots penetrating deep into the soil and the young tillers are covered under thick leafy sheath. It is supposed to be tolerant to foorkey disease. ***Tali:*** Plants are tall, maroon in colour, 3.5-4 m in height with long (125 cm) and broad (23 cm) leaves. Flowers white in colour and capsules are brown. An inflorescence contains 20-24 capsules and naked (without sheath). ***Rengka (Hotum Tari):*** Medium height (2-2.5 m) with more tillers/plant. Leaves are broad (120 X 25 cm). Capsules (3.8 X 2.2 cm). Sold as large cardamom in the market. ***Jaker:*** Plants are similar to Tali, tall (3-4 m) with 8-10 leaves (125 cm X 24 cm) per tiller. Flowers white in colour and capsules are light brown at maturity. An inflorescence contains 20 capsules and capsules tapers towards the apex. ***Tajee:*** Plant medium tall in height (2.5 m) with 10 leaves per tillers. The size of the mature leaf is 75 X 15 cm. Flowers yellowish red in colour. Fruit is deep brown in colour and average capsule size is 2.0 X 1.6 cm. The germplasm collections with wider genetic base, helps the breeders in the development of improved crop varieties through crossing and by combine high yield potential with superior quality, resistance to disease and pests, and also better adaptation to a biotic stress environments.

Table 1. Collection of allied genera large cardamom from Arunachal Pradesh at ICRI Farm.

Name of the cultivar	Location	Cultivated/Allied genera	Remark
Belak	Sirki, East Siang district	Allied genera	Robust growth. Capsules looks like garlic
Bebo	Darka, West Siang district	Wild/Cultivated	Robust growth. The capsules are sold in the market for less price. Spikes found in the middle of the tiller also. This is considered as a cultivar of large cardamom
Tali	Ralung village, West Siang Dist.	Allied genera	Tall and robust growth with broad and hard leaves. Tillers very green in colour
Rengka (Local name Hotum Tari)	Patum, Aalo, West Siang district	Cultivated/Allied genera	Capsules and seeds bigger in size, seeds are more in number. Sold as large cardamom
Jaker	Upper colony, Aalo, West Siang Dist.	Allied genera	Plants are similar to Tali. Robust growth. Capsules are curved.
Tajee	Sissen village, P.O. Pangin, Siang district	Allied genera	Immature capsules used as vegetable. The mature capsules are sold in the market for less price.

Table 2. Morphological and Physical characteristics of fruits of allied genera of large cardamom from Arunachal Pradesh.

Name of the cultivar	Plant height (cm)	Fresh weight (g/fruit)	No. of seeds/fruit	Size of fruit (cm)
Belak	21 0	2.8	250	3.8x1.6
Bebo	195	3.5	55	2.4x1.9
Tali	360	4.8	42	2.8x2.2
Rengka (Hotum Tari)	200	5.0	48	3.2 x2.8
Jaker	365	10.0	60	4.4x2.6
Tajee	240	4.5	45	2.3x2.0

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Estimation of genetic variability, heritability and genetic advance in short duration rice genotypes of Manipur.

Sudhir Kumar*, S Bhuvaneswari, I Meghachandra Singh, SK Sharma, Narendra Prakash and Y Rajen
ICAR Research Complex for NEH Region Manipur Centre, Lamphelpat, Imphal
*Correspondence: sudhiraaidu2006@gmail.com

Introduction

Rice (*Oryza sativa*) is one of the important cereal crops of Manipur occupying maximum agricultural land. The state is enriched by tremendous amount of genetic variability of rice in form of local landraces and wild rice. Developing of short duration rice cultivars is considered to be one of the most sustainable and effective strategies to achieve high rice productivity in state, because it promotes double cropping (*Pre-kharif/kharif*) in lowland valley condition, escape most of the disease, insect pest and suitable for moisture stress upland rainfed conditions. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are useful in detecting the amount of variability present in the germplasm (Idris *et al*. 2012).

Methodology

Field experiment was conducted at Lamphelpat farm of ICAR RC Manipur Centre in *kharif* season, 2011. The experimental materials comprised of nine short duration rice genotypes that include seven advance lines generated by pedigree method of breeding of a cross of Leimaphou (KD-2-6-3) x Akhanphou and two rice varieties (RCM-8, Ginaphou). Data were recorded on plant height, days to 50% flowering, days to maturity, number of effective tillers per plant, panicle size (cm), number of spikelets per panicle, number of filled grains per panicle, spikelet fertility (%) and grain yield per plant (g) on five randomly selected plants in each entry.

Results and Discussion

The results showed that PCV in general was higher than GCV for various characters but difference between GCV and PCV was low for most of the characters indicating less degree of environment influence in expression of the characters. The magnitude of PCV and GCV was moderate to high for number of effective tillers per plant (23.42, 21.96%), grain yield per plant (21.69, 20.55%, plant height (15.72, 15.47%), days to 50 % flowering (15.97, 15.755) number of grains per panicle (12.54, 11.83%), number of spikelet's per panicle (12.36, 11.61%), and 1000-grain weight (13.94, 13.70%). The results in agreement with finding Shanthakumar *et al*. 1998. High heritability coupled with high genetic advance as percent of mean was observed in plant height (96.78, 32.13 %), days to 50% flowering (97.27, 26.67 %), days to maturity (97.40, 22.72 %) number of spikelets per panicle (88.26, 28.81%) and for number of grains per panicle (89.01, 24.06 %), indicating the role of additive gene in expressing of these traits and revealed better scope for improvement of these traits through direct selection. Similar with present finding Tiwari *et al*. 2014 recorded high heritability as well as moderate to high genetic advance in plant height etc. On the basis of mean performance and various genetic parameters attributes, advance line namely, MC-34-1-10-6-1-26 was observed to be promising culture because it is of short duration (days to 50% flowring-63.67) nature , and yielded significantly higher (17.10 g) than the short duration check RCM-8 (12.75 g).

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Prospect of fodder cultivation in sustainable livestock management under upland ecosystem of Tripura

Sujan Acharjee[1, 2*] and Nihar Ranjan Chakraborty[3]
[1]*Visvabharati, Bolpur, Birbhum, West Bengal*
[2]*Animal Resources Development officer, Govt. of Tripura, Agartala, Tripura*
[3]*Visvabharati, Bolpur, Birbhum, West Bengal*
*Correspondence: acharjeesujan@rediffmail.com

Introduction

Sustainable livestock production in Tripura suffers from a lot of constrains owning to its diverse physiographical and climatic condition. The substantial gap between the demand and availability of green fodder has become a matter of concern in Tripura. Most of the cultivated area is under rain fed ecosystem, further a large portion of the total cultivated area is under production of different food and cash crops. In the current scenario, where competing demands on land renders even expansion of food/cash crops a difficult proposition, the probability of increasing area under fodder crops is nearly impossible, so it has become essential to adopt a multi-pronged strategy for adequate availability of fodder in order to provide a buffer to the farmer even in adverse climatic condition. Considering the above the Department of Animal Resources Development, Govt. of Tripura has taken an initiative on Intensive Fodder Development programme from 2012-13 to till date.

Methodology

The implementation of the fodder cultivation programme has been initiated in the monsoon season of the year 2012-13 to 2015-16 under the component of MGNREGA as well as through the provision of other programmes of State / Central Government like National Livestock Mission, Rashtriya Krishi Vikas Yojana etc. Eight districts of the state were covered under this approach. Strategies were to extract maximum benefit from the unused barren land of the hilly areas of the State. Soil and water conservation, drought proofing , enhancing the soil fertility by means of cultivation of appropriate fodder crops species also got due gravity.

To bring maximum available uncultivable land of the farmers or community under the umbrella of this approach - existing cattle rearers, milk producers' society, pig rearers, self-help groups and other interested farmers of the state has been identified as target groups. Different capacity building programme, training, and field demonstration at farm level were conducted as integral parts of the programme. Different approaches like cultivation of perennial fodder, seasonal fodder, dual purpose fodder, tuber crops and Azolla were implemented in the farmers' field and community land. Planting materials of different perennial grasses like Cumbo Napier–CO-CN-4 (*Pennisetum pupureum*), Congo Signal (*Brachiaria decumbens*), Stylo (*Stylosanthes hamata*) as well as Seasonal leguminous or dual purposes fodder seeds like maize (*Zea mays*), Oat (*Avena sativa*) Cowpea (*Vigna unguiculata*), Black gram (*Vigna mungo*) were distributed to the field level at free of cost.

Results and Discussion

A significant decrease in the cultivated area and production of the green fodder as well as in tuber production has been experienced within this period. A clear cut diversion of the farmer's interest towards the cash crop like Rubber plantation, vegetable production has also been observed. However, farmer's preference in adopting the fodder species varies depending upon the topography and livestock present over there. Interest towards cultivation of Tapioca crop was noticed in North Tripura district, where the tribal farmers rear pig in large scale under hill based ecosystem. Tendency towards short duration fodder crop has been noticed in the vegetable growing area of West Tripura and South Tripura district.

The declining coverage of area and repugnance of farmer's interest towards fodder cultivation may be analyzed under the following points: Fragmentation of land holding; farmer's interest towards food and cash crops; Mind set up of the marginal farmers towards livestock farming and poor management practices in hilly areas**.** Tree leaf fodder is the major feed resource during lean periods. Over exploitation and unscientific management of fodder trees like Subabul (*Leucaena leucocephala)*, Bokphul *(Sesbania grandiflora)*, Jackfruit (*Artocarpus heterophyllus)* etc. has depleted this resource at huge environmental cost.

Importance of fodder production in maintaining food security as well as nutritional security of the animal has been felt since long. The gap between the demand and availability of green fodder in the state is very alarming and corrective measures have to be taken to improve this problem giving due importance to the changing climatic scenario. Though, in the monsoon period, green fodder is surplus in the state, still the animal rearers face an acute shortage of fodder in the lean period. Thus comprehensive measures may be taken for ensuring maximum availability of green fodder in a regular manner for sustaining livestock production of the state.

Fodder production is a component of farming system, hence; efforts are needed for increasing forage production in a farming system approach. The holistic approach of integrated resource management will be based on maintaining the fragile balance between productivity functions and conservation practices for ecological sustainability.

Acknowledgement: This research paper is made possible through the co-operation of all the faculties of Animal Resources Development Department, Govt. of Tripura, P.N. Complex, Agartala, West Tripura -799001, India

Yield as affected by planting pattern and weed management in field pea and baby corn intercropping system

Moirangthem Thoithoi Devi[1*], SB Singh[1], VK Singh[2], A Ratankumar Singh[1], Aruna Beemrote[1] and Bagish Kumar[3]

[1]*ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram,*

[2]*G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand,*

[3]*Agricultural Technology Application Research Institute, Zone-III, Umiam, Meghalaya*

[*]Correspondence: thoiagri@gmail.com

Introduction

Field pea (*Pisum sativum*), one of the important pulse crop of winter season has great potential to contribute to the pulse basket in India. During the recent past, Maize, the queen of cereals has been used as vegetable where unfertilized young cob is used for cooking purpose, popularly known as baby corn (*Zea mays* L.) (Barod *et al*. 2012). Maintenance of adequate crop cover turns the competition in favour of crop. Intercropping itself has been found helpful in limiting weed population by way of cutting light to them. So field pea may be introduced between the rows of baby corn. Development of feasible and economically viable intercropping system depends largely on adoption of proper planting pattern as well as weed management. Appropriation of suitable planting pattern is, necessary to bring the competition to the minimum level. Weeds are one of the major obstacles that severely affect the productivity and quality of the component crops. Keeping the above points in view, the experiment was conducted to see the response of field pea and baby corn to planting pattern and weed management in field pea + baby corn intercropping system.

Methodology

The experiment was conducted during *rabi* seasons of 2011-12 and 2012-13 in, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experiment was laid out in split-plot design with three replications. Main plot consisted of four planting patterns *viz.* field pea sole (30 cm), baby corn sole (45 cm), planting of maize + field pea (1:1) and paired planting of maize (30/60 cm) + field pea (2:2) and sub-plot consisted of four weed management practices *viz.* weedy check, hand weeding at 30 DAS, pre emergence (PE) application of pendimethalin 1 kg/ha and post emergence (POE) application of imazethapyr 50 g/ha at 30 DAS. Maize crop was fertilized with 120, 60 and 40 kg/ha of N, P_2O_5 and K_2O through urea, single super phosphate and muriate of potash respectively. Half dose of nitrogen and full dose of P_2O_5 and K_2O were applied as basal in all the plots and remaining dose of N was applied at knee high stage of the crop as top dressing. A dose of 18 kg N, 48 kg P_2O_5 and 24 kg K_2O /ha was applied to field pea sole through NPK mixture (12:32:16) applied @150 kg/ha as basal. No additional dose of fertilizer to pea was given to intercropping system. The field pea was harvested manually with sickle when more than 80 per cent pods in all plots turned completely brown in colour. The harvested crop after sun drying for a period of about 3-4 days was threshed by beating the plant material with sticks. After threshing, grains were separated by winnowing and grain yield was recorded. Picking of baby corn cobs were done three days after silking of the cobs with hand. The fresh weight of baby corn after removing the husk per picking for each net plot was summed up to get total weight of baby corn per plot.

Results and Discussion

During 2011-12, sole planting of field pea (30 cm) produced the highest grain yield (2264 kg ha^{-1}) which was followed by paired planting of maize (30/60 cm) + field pea (2:2) (1528 kg ha^{-1}) and planting of maize + field pea (1:1) (1108 kg ha^{-1}). All these treatments differed significantly from one another. During 2012-13, field pea sole (30 cm) produced significantly higher grain yield (1435 kg ha^{-1}) than planting of maize + field pea (1:1) (888 kg ha^{-1}) and paired planting of maize (30/60 cm) + field pea (2:2) (764 kg ha^{-1}). On an average, sole planting of field pea yielded 85.3 and 61.4 per cent more grain yield over planting of maize + field pea (1:1) and paired planting of maize (30/60 cm) + field pea (2:2) respectively. Higher yield of field pea in the treatments where it was grown alone might be due to higher planting density, plant height and higher values of yield attributing characters. The results of present investigation are in conformity with those of Das *et al.* (2013). On an average, hand weeding (30 DAS), PE application of pendimethalin 1 kg ha^{-1} and POE application of imazethapyr 50 g ha^{-1} (30 DAS) yielded 50.8, 31.6 and 24.0 per cent higher yield over weedy check respectively. Similar findings were reported by Mundra *et al.* (2003). On an average, increased in straw yield in sole planting of field pea than planting of maize + field pea (1:1) and paired planting of maize (30/60 cm) + field pea (2:2) was 18.0 and 27.9 per cent respectively. This was mainly due to higher plant population in sole planting of field pea. Similar results were reported by Mandal *et al.* (2014). On an average, hand weeding (30 DAS), pre emergence application of pendimethalin 1 kg ha^{-1} and post emergence application of imazethapyr 50 g ha^{-1} (30 DAS) yielded 12.6, 5.0 and 6.1 per cent higher straw yield over weedy check respectively. The yield of baby corn under different planting patterns was statistically similar during both the years (Table 1). On an average, hand weeding (30 DAS), PE application of pendimethalin 1 kg ha^{-1}and POE application of imazethapyr 50 g ha^{-1} (30 DAS) yielded 72.6, 67.2 and 45.5 per cent higher baby corn yield over weedy check respectively. The higher baby corn yield in hand weeding (30 DAS) and herbicide treated plots were due to better growth and development of baby corn plants as a result of less competition from weeds for light, water, nutrients, carbon dioxide etc. as a result of better control of weeds. On an average, sole planting of baby corn yielded 123.1 and 97.3 per cent more stover yield over planting of maize + field pea (1:1) and paired planting of maize (30/60 cm) + field pea (2:2) respectively. On an average, hand weeding (30 DAS), PE application of pendimethalin 1 kg ha^{-1} and POE application of imazethapyr 50 g ha^{-1} (30 DAS) yielded 33.3, 39.2 and 3.5 per cent higher stover yield over weedy check respectively.

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Effect of intercropping in pigeonpea in the tilla lands of Tripura

Biman De*, Subrata Ray, Sujoy Hazari, Partha Das and Debashish Sen

All India Coordinated Research Project on Pigeonpea- Tripura Centre
College of Agriculture Tripura, Lembucherra, Tripura

*Correspondence: biman_de@rediffmail.com

Introduction

Among the pulses pigeonpea [*Cajanus cajan* (L.) Millsp.] is a promising rainy-season crop for rainfed uplands. Intercropping, under rainfed ecosystem, ensures stability in yield and minimizes risk of crop loss due to weather aberrations. Short duration pigeonpea are performing well in foot and mid-hills of northeast. Pulses and oilseed cultivation in some districts is also very popular among the farmers. Crops are grown as a sole or mixed in haphazard manner under rainfed conditions in less fertile soil during rainy season resulting in its low yield (Prakash *et al*. 2005). Intercropping can play a significant role to enhance the productivity and profitability per unit area and time through more efficient use of land, water and solar energy besides assuring insurance against crop failure due to failure of one or the other crop due to vagaries of weather or disease/pest epidemics in rainfed agriculture.

Methodology

The field experiment was conducted during two consecutive *kharif* seasons of 2012-13 and 2013-14 at the research farm of College of Agriculture, Lembucherra, Tripura. The soil of the experimental site was sandy loam having *p*H of 5.5, organic carbon (0.47%), available phosphorus 8.30 kg/ha, available potash 176.0 kg/ ha and available sulphur 12.0 kg/ha. The bulk density of soil was 1.36 mg/m^3 and pore space was 34.9%. The treatment comprised of sole cropping of pigeon pea cv. UPAS 120 and 8 combinations of single row and double row intercropping with cowpea (cv. local), sesame (cv. B-67), black ram (cv. Azad Urd-2), green gram (cv. PDM-5) and groundnut (cv. TAG-24). Recommended doses of fertilizers were applied to each crop in sole stand whereas in intercropping systems no supplementary fertilizers were given to intercrops. Crops were sown at first week of July as per treatment and for comparison between the systems, their yields were converted into pigeonpea-equivalent on price basis (Yadav and Newaj 1990).

Results and Discussion

From the pooled data of two years, higher number of plant stand (92.06%) was recorded in pigeon pea-cowpea intercropping (1:2). Pigeonpea + black gram (1:1) proved superior thereby giving significantly higher pigeonpea yield (2089.91Kg/ha) compared to pigeonpea + blackgram paired rows (1558.23 Kg/ha) and pigeonpea sole crop. It might be due to less crop competition for nutrient owing to 50% less plant population of blackgram in former and indirectly to higher number of pods per plant and 100 seed weight (Prakash *et al.* 2005). Intercropping combinations of pigeonpea and black gram/ green gram being at par recorded significantly higher pigeonpea equivalent yield compared with the sole Pigeonpea crop. This might be due to fairly good yield of pigeonpea in intercropping system and an extra yield of urdbean/mungbean as bonus in intercropping system (Sharma and Rajput 1996; Jat and Ahlawat 2003). Intercropping of one row of pigeonpea + one row of black gram registered highest pigeonpea equivalent yield (2503.76 Kg/ha) closely followed by pigeonpea + green gram in 1:1 row proportion (2494.01 Kg/ha) which were 48.68% and 48.10% higher respectively than the sole pigeonpea (1683.95 kg/ha). Pigeonpea intercropping treatments exhibited variable LER values (1.17-1.85). Pigeonpea + green gram (1:1) registered highest values of land equivalent ratio (1.85) followed by pigeonpea + sesame (1:2). Higher land equivalent ratio due to intercropping of pigeonpea was also similarly reported by Jat and Ahlawat (2004). The pooled value of net returns revealed significant variation in different intercropping system. The significant reduction in net returns to sole cropping compared with the intercropping of pigeonpea. The maximum grain yield was found in pigeonpea + blackgram (1:1) i.e. 84114.93 Rs/ha and the minimum grain yield was recorded in sole cropping of pigeonpea (48527.15 Rs/ha). Benefit cost ratio of different systems under study ranged from 1.90 in pigeonpea- ground nut (1:1) to 3.39 in pigeonpea- black gram (1:1). In respect to per day return, 1:1pigeonpea+ green gram (534.78 Rs/ha/day) was followed by 1:1 pigeonpea+ black gram (527.73 Rs/ha/day), which might be due to lower maturity days of pigeonpea + green gram intercropping though higher productivity was registered under pigeonpea + blackgram intercropping.

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Under-utilized crops of North East India: potential conventional foods of the future

Kohima Noopur*
College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh
*Correspondence: draspanwar@gmail.com

Mankind depends on a number of food crops to meet the needs of staple diets and non-food crops to meet associated needs. Very few crops occupy large areas for these cultivated species. Nevertheless in the past human was depend on a much wider range of species for food, fibre, health security and other needs. About 30 crops are known to provide 95% of the world's food energy while over 7000 species have been known to be used for food and are either partly domesticated. This large array of plant species have been recognized to be underutilized lately known as important minor crops. However, with modernization of agricultural practices many crops species have become neglected. The advent in climate change and greater ecosystem instability has resulted into crop failure. In addition to these, increase in population has tremendous pressure on crop production. Successful crop production depends on the correct choice of cultivars and precise application of production inputs that will sustain the environment as well as agricultural production. And as the demand for plant and crop attributes changes (reappraisal or discovery of nutritional traits, culinary value, adaptation to climate change etc.), the under-utilized crops can overcome the constraints to the wider production and use. The underutilized crops are species that are used traditionally for food, fibers, fodder, oil or medicinal properties, but their importances have been reduced over time owning to particular supply and constraints in use. They have an underexploited potential to contribute to food security, nutrition, health, income generation and environmental services and play a vital role in rural economy (Sajem *et al.* 2008). They are the cheap source of nutrients and could be useful in formulating balance diets (Murthy and Rao 2009). These crop plants now constitute an increasingly important resource for improving agricultural production and for maintaining sustainable agro-ecosystems and thus, potential to become conventional foods of the future – using them in breeding programs; and will be convenient sources of income and the vehicles for improved nutrition and increased food supply (Toledo and Burlingame 2006). North Eastern Region of India is one of the richest reservoirs of different underutilized crops. Rice bean, job's tears, buck wheat, winged bean, faba bean, adzuki bean, broad bean, perilla, plantago, amaranthus, allium, tree bean, wild coriander, arrow root, dioscorea etc are some potential crops of the region. These crop plants have been supplementing/ providing food and other secondary products of metabolism such as alkaloids, essential oils and phenolics from time immemorial (Heywood 1999). To facilitate effective utilization of these plant genetic resources, it is important that these are evaluated for productivity, crop duration, resistance to biotic and abiotic stress, quality of produce etc. Once these objectives are achieved, these underutilized crops may become the most important emerging crop in North Eastern Region and these can be produced throughout the region under diverse/different agro-climatic environment paving to become the conventional foods of the future.

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Identification of field pea genotypes for *rabi* cultivation in Tripura

Papiya Saha, Bhargabi Chakraborty, Debashre Bhattacharjee, Debalina Biswas, Pujaita Ghosh, Tapas Paul and SP Das*

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura- 799210

*Correspondence: drspdas@gmail.com

Introduction

Pulses have been given the status of wonder crop, a unique gift bestowed by nature to mankind for number of reasons. They are important and excellent crop for natural resource management, environment security, crop diversification and consequently for viable agriculture. This is inexpensive source of protein for millions of people. Despite being the largest producer in the world, the country is short in supply of pulses. Production and productivity of most of the pulse crops have either declined or at best stagnated resulting in a sharp reduction in the per capita availability of pulses. Field pea (*Pisum sativum* L. arvense) is the most important legume crops of India, belongs to leguminoseae family, largely confined to cooler temperate zone between the tropic of cancer and mediterranean region. . Pea is rich in protein, carbohydrates, vitamin A and C, calcium and phosphorus. The majority of pea plants exhibit an indeterminate growth habit (Cousin 1997). Field pea has a benefit over many it has the ability to fix its own nitrogen. This makes it useful not only as an alternative crop but also adds rotational benefits. Yields of grain legumes are smaller and generally more variable than those of many other crop species. In developed countries, grain yields of legumes have not increased as rapidly as those of cereal crops. Inception of the genetic improvement programme for seed yield and its component traits in any crop requires identification of suitable and adaptable genotypes for a particular agro climatic zone for using directly and also as base material for further improvement in order to break the existing yield plateau.

Methodology

Thirteen pea germplasm accessions including two checks (HUDP15 and PRAKASH) were evaluated in RCBD design in 3 replications for different quantitative characters. The experiment was conducted at the ICAR research farm situated between $22^{0}51^{'}$N latitude and $90^{0}07^{'}$E longitude and the soil of experimental site was sandy loam having p^{H} of 5.4. The above materials were screened under natural condition with all recommended agronomic practices. Data on yield and yield attributing components were recorded to sort out the best suitable genotypes which can perform well in this region. Data were recorded on three randomly selected plants for each genotype for Days to 50% flowering, Plant height (cm), Clusters per plant, Pods per cluster, Pods per plant, Pod length (cm), Seeds per pod and Seed yield per plant.

Results and Discussion

Among the field pea varieties evaluated most of the quantitative characters shown significant difference for yield and yield attributing characters The data regarding 50% flowering, plant height (cm), Clusters per plant, Pods per plant, Pod length (cm), Seeds per pod and Grain yield of field pea varieties are presented in Table 1. Number of pods per plant showed the highest direct correlation with yield per plant. Days to 50% flowering ranged from a minimum of 69 days to a maximum of 81 days .The flowering commenced at the earliest in genotype RFP 2009-3(69) followed by PRAKASH(71), HUDP-1301(72) and PANT P223(72) respectively. For plant height range observed from 45cm to 76 cm, whereas cluster per plant ranged from 1 (KPMR928) to 7(IPFD13-2). Significant difference has been observed for pod per plant in all the genotypes under study. Number of pods per plant ranged between 5(HUDP 13-01) to 17(IPFD13-2). For Number of pods per plant the most superior genotypes observed are IPFD13-2(17), IPFD13-4(12), VL202(11), HFP 530 B(9) , PRAKASH (7) respectively. For pod length there is no significance difference occurred and the character ranged between 5(KFP12-04) to 7(IPFD 13-2). In case of number of seed per pod the range is observed between 3 (PANT P 222) to 5(IPFD 13-2). All the genotypes differ variably for seed yield per plant. The range for total seed yield found a minimum 166.6 kg/ha (HUDP1302) to a maximum of 2510.9 kg/ha (IPFD13-4). On the basis of yield the top five varieties are IPFD13-4(2510.9 kg/ha), IPFD13-2(2394.3 kg/ha), HFP 530 B(2311 kg/ha), PANT P 223(2069 kg/ha) and VL202(1561 kg/ha) respectively.

Table 1. Yield and yield attributing characters in different variety under study.

Entries	50% DTF	Plant height (cm)	Cluster/ plant	Pods/ plant	Pod length (cm)	Seed/Pod	Plot yield (kg/ha)
KPMR 928	74	45	1	3	6	4	770.3
HUDP15 (Ch)	79	50	2	5	6	4	637.1
HUDP1302	81	47	2	5	6	4	166.6
PRAKASH(Ch)	71	68	2	7	6	4	1657.3
IPFD13-2	74	76	7	17	7	5	2394.3
HFP530B	74	68	3	9	6	4	2311.0
PANT P 222	72	62	3	7	6	3	1478.2
KFP 12-04	73	54	3	7	5	3	678.7
VL 202	74	50	3	11	7	4	1561.5
RFP 2009-3	69	35	2	7	5	3	312.3
IPFD 13-4	73	62	5	12	7	5	2510.9
HUDP 1301	72	69	1	5	6	4	1157.6
PANT P 223	72	67	2	7	6	4	2069.5

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Effect of residue management practices on productivity and soil health in lentil grown in lowland rice fallow

Anup Das*, Utpal Dey, Ramkrushna GI, Jayanta Layek, R Krishnappa, AS Panwar and SV Ngachan

ICAR Research complex for NEH Region, Umiam, Meghalaya, India

*Correspondence: anup_icar@yahoo.com

Introduction

In North Eastern Himalayan region, where a large part area remains fallow after *kharif* rice, lentil has a very good potential for increasing farm income as well as cropping intensity. Crop residues in rice fallows increase the soil hydraulic conductivity and infiltration by modifying mainly soil structure, proportion of macropores, and aggregate stability (Mando *et al*. 1996). So, if crop residues are retained on the soil surface in combination with suitable planting techniques, it may conserve soil moisture and alleviate drought condition in pulses. Apart from this, productivity and profitability of rice-lentil cropping system can be improved with efficient utilization of residual soil moisture. Three is also need of suitable short duration lentil variety to fit in the cropping system. Thus, present research experiment has been undertaken with the objectives to find out sustainable and profitable rice-lentil cropping system.

Methodology

Field experiments under rainfed conditions were conducted for two consecutive years (2011-12 and 2012-13), in the lowland rice field at the Agronomy farm of the Indian Council of Agricultural Research (ICAR) Research Complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya, India. The experiment consisted of two lentil cultivars (DPL 81, IPL 406) and three residue management practices (residue removal, 20 cm standing rice stubble, 40 cm standing rice stubble) in rice fellow land. Rice seedlings were transplanted in 20 X 20 cm spacing. After harvesting of rice, lentil was sown under no-till system. The rice fields were drained at physiological maturity (one week before harvesting) to get a suitable soil condition to cultivate the *rabi* crop lentil. Lentil was sown by opening a narrow furrow in between two rows of rice using a manual furrow opener. The experiments were designed in factorial randomized block design and replicated thrice. The net plot size was 4.0 m x 3.0 m. A recommended dose of 30 kg N, 60 kg P_2 O_5 and 40 kg K_2 O/ha were applied in furrows before sowing of lentil seeds and covered the seed with soil and FYM mixture (2:1 ratio) to give a good seed-soil contact. The initial as well as post-harvest soil samples were collected at 0–15 cm depth for analyzing the physico-biological properties of soil. Soil infiltration rate (IR) was measured by double-ring infiltrometer. Soil BD was measured by core method. The yield parameters of lentil were measured at harvest after sun drying, threshing and cleaning. Yield of lentil was estimated from weight of sun dried seeds obtained from each net plot after threshing and cleaning. The experimental data pertaining to each parameter of study were subjected to statistical analysis by using the technique of analysis of variance and their significance was tested by "F" test.

Results and Discussion

The lentil variety and conservation practices have significant impact on lentil yield. The results on the average (pooled) seed yield ranged from 1.48 tones/ha (IPL 406) to 1.72 tones/ha (DPL 81). The data for seed yield was found to be significant and maximum in 40 cm standing stubble (1.84 tones/ha) followed by 20 cm standing stubble (1.60 tones/ha) as compare to control (1.36 tones/ha). Soil chemical property like soil organic carbon (SOC) was higher in IPL 406 (2.41%) than DPL 81 (2.31%). Residue management practices had significant impact on SOC. The dehydrogenase activity (DHA) and soil microbial biomass carbon (SMBC) were significantly affected by rice stubble management practices. Among the different residue management practices, maximum DHA and SMBC was recorded with 40 cm standing stubble (2.09 µg/g/hr and 160.41µg C/g dry soil 2) followed by 20 cm standing stubble as compare to residue removal. These may be due to the enhancement of the pool sizes of microbial biomass. The dehydrogenase enzyme has been related with the oxidative capacity of soil microorganisms (Madejón *et al*. 2009). Rice residue management practices had significant impact on soil physical parameters i.e. Bulk density (BD), water holding capacity (WHC) and infiltration rate (IR). Least BD was recorded with 40 cm standing stubble followed by 20 cm standing stubble and residue removal at 0-15 cm soil depth. The 40 cm standing stubble recoded higher WHC and IR as compare to 20 cm standing stubble and residue removal in both years. Recycling of natural resources like rice residues improves the soil physical properties (Mandal *et al*. 2004). These may be due to succession of barriers and reducing the runoff and improved pore space, hydraulic conductivity resulting more WHC and IR.

Table 1. Soil health parameters and yield of lentil (pooled data of year 2011-12 & 2012-13)

Treatments	SOC (%)	DHA (µg/g/hr)	SMBC (µg C/g dry soil)	BD (g/cm^3)	WHC (%)	IR (cm/hr)	Yield (t/ha)
	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	
Lentil variety							
DPL 81	2.31	2.00	155.18	1.11	27.48	2.24	1.72
IPL 406	2.41	2.05	159.55	1.10	26.90	2.26	1.48
SEm (±)	0.04	0.02	1.21	0.01	0.30	0.03	0.03
CD (p=0.05)	0.08	NS	3.92	NS	NS	NS	0.10
Residue management practices							
Residue removal	2.24	1.99	152.09	1.11	25.46	2.09	1.36
20 cm standing rice stubble	2.44	1.99	159.60	1.08	27.09	2.28	1.60
40 cm standing rice stubble	2.40	2.09	160.41	1.12	29.02	2.38	1.84
SEm (±)	0.05	0.03	1.48	0.02	0.37	0.04	0.04
CD (p=0.05)	0.14	0.05	4.35	NS	1.07	0.11	0.12

SOC- Soil Organic Carbon, DHA-Dehydrogenase Activity, SMBC-Soil Microbial Biomass Carbon, BD-Bulk Density, WHC-Water Holding Capacity, IR-Infiltration Rate.

Rice residue management (40 cm standing stubble) improves the soil health. This study also showed the positive impact of crop residue management on crop yield in rice-lentil system. Use of *in-situ* crop residue (40 cm standing stubble) and short duration lentil variety (IPL 406) may be a sustainable tool for enhancing cropping intensity, productivity and sustainable soil health in rice based cropping system

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Performance of field pea varieties under late sown condition in Tripura

Bhargabi Chakraborty, Debashre Bhattacharjee, Debalina Biswas, Pujaita Ghosh, Papiya Saha, Tapas Paul, SPDas*

ICAR Research complex for NEH region, Tripura centre, Lembucherra, Tripura.

*Correspondence:drspdas@gmail.com

Introduction

Field pea (*Pisumsativum*) a commercially important crop for food and feed belongs to family Fabaceae (formerly Leguminosae), subfamily Papilionoideae. Field pea is a cool-season legume crop that is grown on over 25 million acres worldwide. Field pea or "dry pea" is marketed as a dry, shelled product for either human or livestock food. Field pea differs from fresh or succulent pea, which is marketed as a fresh or canned vegetable.Greenpeas, eaten immature and fresh, were an innovative luxury of Early Modern Europe. In England, the distinction between as "field peas" and "garden peas" dated from the early 17th century. Pea is one of the most important grain legumes traditionally cultivated in many regions of the world. The agronomical importance of pea (*Pisumsativum* L.) is based on its high concentration of protein, complex carbohydrates, dietary fiber, vitamins and minerals for the human and animal diet (Nikolopoulou *et al*. 2007).Little attention has been given to varietal improvement of peas outside the temperate regions of developed countries. Most cultivars of pea produce white or reddish-purple flowers, which are self-pollinated. Each flower produces a pod containing four to nine seeds (Zohary and Hopf 2002). Indeterminate cultivars mature in 90-100 days while determinate types have a shorter maturity time, usually 80-90 days in western Canada and northern USA. The production of field pea on the Canadian prairies in 2005 was 3.2 million tonnes (Statistics Canada 2005), accounting for approximately 6% of all grain production and 40% of legume production in Canada. In recent years, pea production has decreased in Manitoba (by 64%) and also in Alberta (by 9%). At the same time, Saskatchewan reached record seeded area (1.1 million hectares) and production (3.4 million tonnes) (Statistics Canada 2005).

Methodology

The field experiment was conducted during Rabi season at research farm of ICAR NEH region Tripura situated between $22^0 51'$N latitude and $90^0 07'$E longitude the soil experimental site was sandy loam having p^H of 5.4,organic carbon (0.81%),available nitrogen of 265.3kg/ha,available phosphorus of 21.5kg/ha and available potash was 119 kg/ha. The experiment was carried out during Rabi season where climate of hilly zone is sub-tropical in nature with distinctive characteristics of high rainfall, high humidity and prolonged winter. The experimental material comprises of ninepopular varieties viz., PRAKASH IPFD-1-3.-10, ADARSH IPF-99-25, TRCP-8, VIKASH IPFD-99-13, VL-42, TRCP-9, AMAN-IPF-5-19, HUDP-15 and IPFD-6. The experiment was laid out in randomized block design(RBD)with five replication. Recommended dose of fertilizers were applied. The data collected from field and laboratory was subjected to statistical analysis appropriate to the design and the treatment variation was tested for significance by f-test (Gomez and Gomez 1983). The standard errors of mean and critical differences at 5% level of significance(Fisher and Yates, 1963) tables were consulted. Prior to harvest 5 plants were selected randomly from each plot and uprooted carefully for collecting data on yield contributing characters. Seed yield data collected from individual plots were converted to per hectare of yield

Results and Discussion

The results with respect to plant height, branch, cluster, pod length and pod bearing length were significant. Among the nine varieties highest plant height (138 cm) was observed in VL-42, followed by TRCP-8 (126.80 cm) and TRCP-9 (109.40 cm). In considering the number of branches per plant was recorded maximum in case of TRCP-8 (4.80) ,followed by ADARSH IPF-99-25 (4.0) and VL-42 (3.60). The highest pod length was observed in PRAKASH IPFD-1-10 (6.0) followed by ADARSH IPF-99-25 and AMAN-IPF-5-19. Among different treatments,HUDP-15 observed maximum number of pod per cluster i.e. 2.20 followed by IPFD-6-3 and PRAKASH IPFD-1-10. From the revealed data it was observed that the varietyTRCP-8 recorded highest (16.40) number of pod per plant which was significantly influenced by the yield. The highest grain yield (kg/ha) was recorded for TRCP-8, followed by TRCP-9 and VL-42.Among the fieldpea varieties evaluated TRCP-8 produced highest yield 1973 kg/ha, followed by TRCP 9 (1842 kg/ha)) and VL-42 (1766.00 kg/ha). TRCP 8 also recorded highest number of pods/plant highest (16.40). The study indicated suitability TRCP-8, TRCP-9 and VL-42 under late sown condition in Tripura for higher productivity.

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Nutrient cycling phenomena in fish-pig-tuber crop based farming system

Chandan Debnath*, Lopamudra Sahoo, Rekha Das, Gulab Singh Yadav, Mrinmoy Datta and SV Ngachan

ICAR Research Complex for NEH Region, Tripura Centre, West Tripura, Tripura

*Correspondence: chandannath23@gmail.com

Introduction

Economically feasible integrated farming system requires efficient utilization of nutrients flow from one component to another component. Organic fertilizers are added to the fish ponds to boost fish yields by increasing primary productivity through the release of inorganic nutrients. Fish-pig- tuber crops based integrated farming system now is under popularization in the state of Tripura and other NE states. The stem and leaves of the tuber crops are very raw matter to incorporate in the pig feed and pig excreta contribute excellently during the course of pond fertilization for fish production. In the presently, the potential of tuber crops in pig mash and excreta generated from pig after feeding with tuber crops on fish was assessed so that the flow of nutrient optimized while producing fish.

Methodology

The experiment was conducted in the FSR II model developed at the ICAR, Tripura Centre. Two tuber crops viz., elephant foot yam and sweet potato were grown and their composition were studied for N, P, K, Ca, Fe, Mn, Cu and Zn contents. The nutrient composition of sweet potato was found higher than elephant yam irrespective of seasons. Total nutrient removal by both the crops was estimated which showed total removal of all the nutrients is higher in elephant yam than sweet potato. The above ground biomass of both the tuber crops (stem + leaf) was used in conventional pig feed at 25% and 50% level of replacement. N level of the feed improved slightly with the incorporation of sweet potato (3.3% at 25% replacement and 3.4% at 50% replacement) but with elephant foot yam, it decreased (3.1% at 25% replacement and 3.0% at 50% replacement) compared to conventional feed (3.25%

N). The levels of other nutrients were showed increased with the incorporation of tuber crops except Zn. These feeds were fed to the animals (pigs) and their body weights and voids were calculated over a period of 6-months.

Results and Discussion

Avg. body weight gain in pig was found 47.5 kg with these feeds which found voids 57 kg. Nutrient accumulation in pig excreta was estimated. Amount of nutrient provided by pig was highest at 50% replacement followed by 25% with sweet potato, whereas, with yam it was highest at 25% followed by 50% level. These animals were stocked @ 40, 50 and 60 no. ha^{-1} of pond and excreta collected from them was used in fertilization of pond stocked with fingerlings at the rate of 5000 no. ha^{-1}. Nutrient analysis and accumulation was calculated in fish, water and pond sediment. Nutrients obtained from 40 pigs were found sufficient to fertilize 1 ha of pond with a production of 1750 kg fish and 70% survival. Increasing the stocking of pigs above 40 no. ha^{-1} cause eutrophication and deterioration of water quality parameters of the culture system; hence not recommended.

The study concluded that the leftover of tuber crops are good to recycle in pond fertilization for fish production through pig farming.

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Screening of mungbean genotypes for resistance to mungbean yellow mosaic virus under Tripura condition

Debashre Bhattacharjee, Jayashree Bhattacharjee, Tapas paul, Debalina Biswas, Pujaita Ghosh, Bhargabi Chakraborty, Papiya Saha and SP Das*.

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura

*Correspondence: drspdas@gmail.com

Introduction

Mungbean (*Vigna radiata* L. Wilczek) is one of the important pulse crops in India. Among several constraints for mungbean production, Mungbean Yellow Mosaic Virus (MYMV) disease occupies prime position and is the most destructive and devastating viral disease. It is transmitted through whitefly (*Bemisia tabaci*). Spread of MYMV incidence is only possible by way of controlling the vector viz., whitefly population using insecticides which are ineffective under severe infestations. Use of virus resistant variety is the only solution to avoid occurrence of MYMV disease. The present investigation aimed to identify stable MYMV resistant lines through screening under natural condition. The experimental material consisted of 101 stable advanced breeding lines developed at ICAR Research Complex for NEH Region, Tripura Centre, following pedigree selection from different crosses. The screening was carried out under normal field condition at two locations during *kharif*, 2015. Infected rows with most susceptible variety were planted along with the test entries. Results revealed that most of the developed breeding lines were moderately resistant to resistant in reaction to MYMV . In spite of the variable response to MYMV, the genotypes TRCM 415-1-1, TRCM 2-4-2, TRCM 86-2-3, TRCM 1-3-1, TRCM 1-6-5-4, TRCM 7-8-12, TRCM 3-5-1, TRCM 3-3-5, TRCM 7-1-1exhibited resistance in both the locations and gives highest yield. These genotypes would be utilized as donors to develop MYMV resistant lines.

Methodology

The experimental material in the present study consisted of 101 mungbean germplasm lines collected from ICAR Tripura centre. The above materials were screened under natural condition to yellow mosaic virus. Each entry is sown in two lines of three meter length with the spacing of 25× 10 cm in two replications. All the recommended agronomic practices were followed. No insecticidal spray was given in order to allow the whitefly population to spread the disease. Disease incidence was recorded periodically. Breeding lines were graded as no Infection/ highly resistant (1/R), 1-5% plants tissue infection (3/MR), highly moderately resistant (5/MS), susceptible (7/S) and highly susceptible (9/HS) reaction, respectively.

Results and Discussion

The study revealed that maximum number of entries was grouped under Resistant to Moderately resistant categories in both the locations. Out of 101breeding lines tested, 72 exhibited resistant, 26 moderately resistant, and only 3 moderately susceptible disease reaction. Both the resistant check varieties Samrat and IPM-02-03 exhibited resistant reaction. The genotypes grouped under resistant category with higher yield will be advanced for multi-locational yield trial for selection as promising variety. Other lines with resistant reaction to MYMV will be utilized in further improvement. For additional collaboration, these genotypes will be screened through artificial screening methods like forced feeding method, agro-inoculation method, etc., to confirm resistance against MYMV.

Evaluation of rice bean germplasm for quality green fodder production

Hadienlarisa Syiemlieh, AS Panwar*, Ramakrushna GI, Lotika Kalita, Moutusi Tahashildar, Jimmy Y Yumnam, Supriya Bhujel, Anup Das and Jayanta Layek

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: draspanwar@gmail.com

Introduction

Rice bean is a multipurpose crop. It is mainly used for human dietary uptake, with a smaller proportion used for fodder and green manuring (Joshi *et al*. 2006). Rice bean (*Vigna umbellata*) in spite of its grain yield potential comparable to major pulse crops and excellent nutritional qualities, failed to emerge as an important pulse crop. However, by virtue of its high potential for quality fodder production even up to 35 tonnes per hectare, it is now attracting as a leguminous fodder crop but there is no rice bean variety which can be used as green fodder crop for livestock production. Keeping in view, the present investigation was carried out to evaluate the promising rice bean variety for quality fodder production under mid hill altitude of NEH region.

Methodology

A field experiment was conducted at the research farm of Farming System Research Project, ICAR Research Complex, Umiam, Meghalaya during 2015. The field is located at the latitude of $25^0$41'23.21" N and longitude $91^0$55'19.27" E with elevation of 956 m asl. Ten varieties of rice bean namely, IVTRB - 1, IVTRB - 2, IVTRB - 3, IVTRB - 4, IVTRB - 5, IVTRB - 6, IVTRB - 7, IVTRB - 8, IVTRB - 9 and IVTRB - 10 were tested in randomized block design (RBD) with three replications. Nutrients recommendations were 20: 40: 20 NPK respectively were supplied through urea, SSP and MOP at the time of sowing. Agronomic parameters namely, plant height, number of leaves per plant, root length, fresh weight of the stem, leaf, stem dry weight, leaves dry weight and green fodder yield were recorded at 50 % flowering as per standard procedure.

Results and Discussion

There was significant variation in plant height in all the varieties of rice bean. Among them, IVTRB - 9 recorded the tallest plant of 276.2 cm (table 1) while the lowest plant height was recorded with IVTRB - 1 (158.1 cm). The remaining varieties were statistically at par with each other. Maximum number of leaves was recorded with IVTRB - 8 (36.5) which were statistically at par with IVTRB - 5 (30.1). Leaf fresh weight was highest with IVTRB - 6 and IVTRB - 5 which was significantly higher than the rest of the rice bean varieties. This may be due to larger size of leaf area even though the number of leaves in IVTRB - 6 was minimum. The fresh weight of stem was maximum with IVTRB - 8 (395.5 kg/ha) and minimum value was with IVTRB - 2 (156.1 kg/ha). There was significant difference in root length of all the ten rice bean varieties. IVTRB - 9 revealed the highest value (45.4 cm) in root length and the lowest value by IVTRB - 5 (17.6 cm). The trend for dry weight of leaf and stem was also significant where IVTRB - 6 and IVTRB - 4 showed the significantly higher values in an array of 20.1 and 100.6 kg /ha, respectively. The highest total dry matter was observed with IVTRB - 7 and IVTRB - 8 while the lowest value was obtained with IVTRB - 2. A cumulative effect of growth parameters was observed in total yield of green fodder which was highest with IVTRB - 7 (412.0 q/ha) followed by IVTRB - 8 (411.2 q/ha) whereas the lowest yield was observed in IVTRB - 10.

Table 1. Different agronomic parameters during 50% flowering stage of rice bean

Treatments (Rice bean varieties)	Plant height (cm)	No. of leaves	Fresh weight leaf (kg/ha)	Fresh weight stem (kg/ha)	Root length (cm)	Dry weight leaf (kg/ha)	Dry weight stem (kg/ha)	Total dry matter (g/plot)	Green fodder yield (q/ha)
IVTRB -1	158.1	23.0	33.3	197.1	18.3	9.8	41.6	16.2	296.8
IVTRB -2	180.4	12.5	25.7	156.1	24.7	7.7	33.7	15.4	355.1
IVTRB -3	254.8	26.2	35.6	348.9	23.0	11.3	78.6	32.0	344.9
IVTRB -4	215.6	26.6	38.0	301.3	18.4	13.3	100.6	35.3	349.6
IVTRB -5	214.8	30.1	60.4	347.7	17.6	14.5	69.9	32.1	365.6
IVTRB -6	240.9	28.4	66.3	311.3	18.2	20.1	97.0	39.2	280.4
IVTRB -7	259.4	18.5	34.2	327.2	31.1	9.3	74.2	41.0	412.0
IVTRB -8	225.7	36.5	55.9	395.5	19.9	13.5	92.2	43.0	411.2
IVTRB -9	276.2	18.0	35.6	290.1	45.4	9.1	79.0	31.8	298.6
IVTRB -10	234.6	19.2	36.2	330.0	20.9	13.1	94.8	27.6	263.9
CD ($p=0.05$)	42.91	4.27	15.74	78.64	4.49	2.60	7.50	9.63	63.79

Thus, the varieties IVTRB - 7 and IVTRB - 8 hold promise for higher quality fodder production under mid hill altitude of NEH region. The study demonstrated that growing rice bean serve as a good source of fodder mainly during the lean period for livestocks production and maintains soil fertility.

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Stability performance of promising genotypes of little millet for grain yield

SR Karad*, RD Nigade and NY Patil

Zonal Agricultural Research Station, Sub-montane Zone, Kolhapur, Maharashtra

*Correspondence: sunil_r_karad@yahoo.co.in

The local landraces of little millet (*Panicum sumatrense* R.) collected from different parts of Maharshtra state were evaluated during *kharif* 2009 and 2010. Among them nine promising genotypes were evaluated in the station trial during *kharif* 2011. The local genotype KOPLM 83 (13.35 q ha^{-1}) recorded highest grain yield followed by KOPLM 20 (11.58 q ha^{-1}) and KOPLM 53 (10.52 q ha^{-1}). These promising all nine genotypes of little millet again evaluated at 4 different agro-climatic zones of Maharshtra state during *kharif* 2013 and 2014 along with one check. These were evaluated at four locations viz. Zonal Agril. Research Station, Kolhapur (E1), ARS Karad (E2), ARS Vadgaon Maval (E3) and ARS Radhanagari (E4). Significant differences were observed for genotypes, environments and G x E interactions. On the basis of means of four locations over the two years, the genotype KOPLM 83 (12.75 q ha^{-1} with 1.14 Bi and 1.49 S^2di value) followed by IGPLM 08-116 (11.83 q ha^{-1}), IGPLM 08-2 (11.69 q ha^{-1}), KOPLM 53 (11.20 q ha^{-1}), KOPLM 76 (11.12 q ha^{-1}) and KOPLM 41 (10.98 q ha^{-1}) recorded the higher grain yield over the check OLM 203 (10.00 q ha^{-1}). The stability of genotype was measured as per Eberhart and Russell's model. The local genotype KOPLM 83 found to be more stable at all these environments for grain yield over the mean of two year and showed low interactions. The genotype KOPLM 83 having more earlength (21.5 cm) and tillers (5.0) resulted in higher grain yield. These characters needs to be consider in selection of superior genotypes in little millet.

Relation of yield and yield contributing characters in white seeded finger millet genotypes

SR Karad* and KSNagargoje
Zonal Agricultural Research Station, Sub-montane Zone, Kolhapur, Maharashtra
*Correspondence: sunil_r_karad@yahoo.co.in

The relation of yield and yield contributing characters in white seeded finger millet (*Eleusine coracana* L.) was studied. The correlation and path coefficient analysis recorded for fourteen characters in 57 white seeded finger millet (*Eleusine coracana* L.) genotypes during *kharif* 2014 at ZARS, Kolhapur. In this study, genotypic correlations were higher than the corresponding phenotypic correlation for all fourteen characters. Grain yield per plant exhibited significant and positive correlation with ear head per plant (0.570), productive tillers per plant (0.566), finger length (0.490) and 1000 grain weight (0.468) indicating dependency of yield on these characters. Path analysis revealed that effect of productive tillers per plant (14.978) had the highest positive direct effect towards grain yield indicating true and perfect relationship between them suggesting direct selection based on this character would help in selecting the high yielding genotypes in white seeded finger millet. The characters days to 50 percent flowering (2.974), fingers per head (0.288), protein content (0.263) also showed high positive direct effect on seed yield. These traits were good indicators of grain yield in white seeded finger millet and can be used for making direct selection.

Crop diversification in North Eastern Region of India

Monika Aheibam[1]*, Ram Singh[2], Pallab Debnath[3] and Punitha P[4]
[1, 3 & 4]*College of Post-Graduate Studies, (Central Agricultural University), Umiam, Meghalaya*
[2]*College of Post-Graduate Studies, (Central Agricultural University), Umiam, Meghalaya*
*Correspondence: monika.agecon@gmail.com

Introduction

Agriculture is an important economic sector in India without exception of the North Eastern Region (NER) even though the region lags behind the rest of the country in economic development. Hill agriculture in the region has considerable potential to grow and contribute towards improving farm incomes, enhancing food and nutrition security, reducing rural poverty and accelerating the overall economic growth of the region (Asati and Yadav 2004). But the region is circumscribed by the dominance of marginal and small farmers in terms of numbers and the area cultivated, rural poverty, seasonal and pseudo-employment, non-mechanized farms, poor rural infrastructure, monsoon dependency *etc*. From this perspective of improving incomes, generating gainful and year round employment, stabilizing the flow of incomes over the seasons and conservation and augmentation of natural resources, crop diversification comes out as a major strategy (Vyas 1996) Hence, the study has been undertaken to examine whether there is crop diversification in the region and how much is the extent.

Methodology

Time series secondary data for the study were collected for the period of 2000-01 to 2012-13 from various published and unpublished sources *viz*., Basic Statistics of NER, North East Data Bank, India stat, National Horticulture Board, Directorate of Economics and Statistics *etc*. To measure the extent of diversification, Simpson index of crop diversification was employed. It provides a clear dispersion of commodities in a geographical region. The index ranges between 0 and 1. In case of complete specialization, the index moves towards 0.

$$SID = 1 - \sum_{i=1}^{n} P_i^2$$

Where,

SID = the Simpson Index of Diversity, P_i = the proportionate area of i^{th} crop in the gross cropped area.

Results and Discussions

Cereals are the major crops grown in North-East India with a share of 67 per cent of total cropped area of the region during the year 2012-13 which is a clear decline from 72 per cent during the year 2000-01 (Table 1). Next to cereals, oilseeds and vegetables occupy second highest share in total cropped area of the region. The share of vegetables has been increasing over the years from 6 per cent in the year 2000-01 to 9 per cent in 2012-13 but the share of oilseeds has been constant over the period *i.e.* about 9 per cent. Fluctuating and low rate of increased in area under spices has been observed over the years. Acreage share under fruits has also been increased to about 8 per cent during the year 2012-13 in comparison to about 6 per cent during the year 2000-01. Share of pulses in total cropped area has increased from 3 per cent to 4 per cent in between 2000-01 to 2012-13. Over the years, the values of SID have increased with 0.47 in 2000-01 to 0.55 in 2012-13 which implies presence of diversification. The region has moved towards greater diversification during the past years as the value SID has increased over the years. Saha 2013 also reported in his study that Meghalaya and Nagaland show moderate levels of crop diversification.

Table 1. Year wise area (%) under major crop groups and extent of diversity in NER

Years	Cereals	Pulses	Vegetables	Spices	Fruits	Oilseeds	Total	SID
2000-01	71.58	3.46	6.38	4.18	5.57	8.83	100	0.47
2001-02	71.23	3.11	7.27	4.6	5.62	8.18	100	0.47
2002-03	69.97	3.37	8.94	4.37	4.84	8.51	100	0.49
2003-04	68.81	3.47	8.98	4.51	5.8	8.43	100	0.5
2004-05	69.47	3.42	7.73	4.85	6.07	8.46	100	0.5
2005-06	70.77	3.44	6.95	4.69	6.24	7.92	100	0.48
2006-07	67	3.61	9.69	4.65	6.57	8.48	100	0.53
2007-08	67.39	3.79	9.53	4.39	6.67	8.23	100	0.52
2008-09	69.29	3.68	7.65	4.58	6.59	8.21	100	0.5
2009-10	68.3	3.7	8.07	4.6	7.17	8.16	100	0.51
2010-11	66.07	3.89	8.45	5.26	7.72	8.61	100	0.54
2011-12	67.02	3.69	8.64	4.31	7.8	8.54	100	0.53
2012-13	66.81	3.73	8.77	4.27	7.77	8.66	100	0.55

Compound annual growth rates of different crops reveals that all the crops registered positive growth except wheat and highest growth can be seen in case of fruits (Fig 1). The results of the study show that crop sector of NER are gradually diversifying towards high value crops, *viz.* fruits, vegetables, pulses and spices. However, the speed of diversification is rather slow and is much less than that of the country as a whole. Still a silent revolution is taking place and area coverage of fruits, vegetables and spices has increased substantially during the last few years. Thus, the region has the potential to uplift from the existing subsistence agriculture to a commercial one through crop diversification.

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Evaluation of recombinant inbreed lines from CT 9993-5-10-1-M/2* Sambha Mahsuri for identification of major QTL for drought tolerance in rice

Pujaita Ghosh, Debasre Bhattacharjee, Tapas Paul, Debalina Biswas, Bhargabi Chakraborty, Papiya Saha, SP Das*
ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura
*Correspondence: drspdas@gmail.com

Introduction

Drought is one of the major stresses encountered by rice under both lowland as well as upland rainfed cultivation, which severely hampers rice productivity. In built drought tolerance is the only way to protect the crops from severe yield losses. The conventional approaches for developing crop varieties with effective inbuilt drought tolerance mechanism has been slow due to very low heritability of yield under drought stress, gains from phenotypic selection are low and breeding trials in field nurseries or greenhouse are very expensive and need a lot of facilities. Molecular marker technology is a powerful tool for selecting the genotypes with the desired trait by facilitate the identification and genomic locations of genes controlling traits related to drought tolerance using quantitative trait loci (QTL) analysis (Kamoshita *et al*. 2002). The goal of this research is to extract segregating materials directly from breeding programs and convert them into advanced genetic stocks that can serve the dual purposes of QTL/gene identification and breeding.

Methodology

A mapping population was developed at IRRI by crossing CT 9993-5-10-1-M/2 and SAMBHA MAHSURI. This mapping population was phenotyped under both lowland and upland conditions in 2014-2015 in the experimental fields of ICAR Research Centre for NEH Regions, Tripura. This population has yielded selections which are high yielding, early duration and fine grain quality even combined with high level of drought tolerance. Presently the mapping population has 311 RILs. The trials were sown under normal recommended fertilizer dose and package of practice. Stress was induced by withholding irrigation ten days before flowering. The entire trial was then continued without irrigation. In case of rainfall, the water was drained out as soon as possible. Grain yield was recorded as the primary trait for selection in breeding programs for drought-prone environments (Fischer *et al*. 2012). Other important traits days to 50% flowering, spikelet fertility, etc were also recorded. Drought sensitivity was recorded in Leaf rolling and tip drying during reproductive phase, twice daily at 6 am and 2 pm.

Result and Discussion

Among the 311 RILs, ten most promising ones are selected in the upland cultivation and ten in lowland cultivation based on their yield, since the ultimate goal is to obtain high and stable yield (Fukai *et al*. 1999). Rice RILs grown in lowland stress condition produced higher yield as compared to upland condition (Table 1). In case of upland condition almost all entries showed high scores of leaf rolling and tip drying after 10 days of moisture stress. However, under severe drought stress also the entry IR 90257-B-19 produced highly significant yield (36 g/plant). Entries such as IR 90257-B-133, IR 90257-B-140, IR 90257-B-223, IR 90257-B-376 also produced significantly higher yield in comparison to parents as well as other RILs. Days to flowering ranged from 74-134 days with the mean of 104.

Table 1. Most promising RILs under upland stress

Selected entries	Days to 50% flowering (days)	Yield per plant (gm)	Leaf rolling		Tip drying	
			Morning	Afternoon	Morning	Afternoon
IR 90257-B-19	96	36.50	3	5	5	5
IR 90257-B-140	113	21.60	3	5	5	7
IR 90257-B-108	78	20.80	3	5	5	7
IR 90257-B-124	101	20.40	1	3	3	3
IR 90257-B-428	78	16.40	3	7	5	9
IR 90257-B-133	103	16.00	7	7	7	9
IR 90257-B-189	91	11.60	3	3	5	5
IR 90257-B-223	80	11.60	5	7	7	7
IR 90257-B-376	84	11.60	5	7	7	9
IR 90257-B-196	85	11.20	3	3	5	7

The yield of the RILs ranged from 0-36.50g with the mean of 18.25. The severity score of leaf rolling and tip drying ranged from 1-7 and 3-9 respectively with the mean of 3 and 7 respectively. In case of lowland the entry IR 90257-B-304 showed highest yield/plant (60.8g) and exhibited good level of drought tolerance. The following RILs IR 90257-B-383, IR 90257-B-453, IR 90257-B-324, IR 90257-B-152, IR 90257-B-322 etc. also showed high level of moisture stress tolerance and recorded significantly higher yield levels under drought stress. Days to flowering ranged from 80-113 days with the mean of 96.50. The yield of the RILs ranged from 0-60.80g with the mean of 30. The severity score of leaf rolling and tip drying ranged from 1-9 and 3-9 respectively with the mean of 5 and 7 respectively.

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Study on productivity potential, monetary advantage and resources utilization in maize-based intercropping system under young jhum of Mizoram

Y Ramakrishna[1*], SB Singh, T Boopathi, BK Singh[2], AR Singh, Lungmuana and R Singh[3]

ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram.

[1]*Krishi Vigyan Kendra, Ukhrul, Manipur*

[2]*Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India*

[3]*ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar, Arunachal Pradesh.*

[*]Correspondence: ramakrishna_iari@rediffmail.com

The practice of shifting cultivation had shifted to short fallow period as a result of enormous pressure for land utilization. A field experiment was conducted during *kharif* season of 2011 at ICAR Research Complex for NEH Region, Mizoram Centre;Kolasib; Mizoram to evaluate the production potential of maize based intercropping systems in young jhum condition. The treatments consisted of sole maize (*Zea mays* L.), sole soybean (*Glycine max*), sole rice bean (*Vignaumbellata*), sole pole type French bean (*Phaseolus vulgaris*), sole pole type cowpea (*Vignaunguiculata*), sole red gram (*Cajanuscajan*), sole sweet potato (*Ipomoea batatas*), sole sesamum (*Sesamumindicum*), maize + soybean (1: 1), maize + rice bean (2:1), maize + French bean (2:1), maize + cowpea (2:1), maize + red gram (2:1), maize + sweet potato (2:1) and maize + sesamum (1:1). Maximum yield of maize was observed with maize intercropped with rice bean, while maximum maize equivalent yield was observed with maize + cowpea followed by maize + French bean. The highest rain water-use efficiency was recorded under maize + cowpea intercropping system (2.42 kg grain/ha/mm) followed by maize + French bean (2.26 kg grain/ha/mm). Maximum land equivalent ratio of 1.94 was observed in maize + rice bean followed equally by maize + soybean, maize + red gram and maize + sweet potato (1.71). Maize + sweet potato was recorded the highest aggressively index (3.58) followed by both maize + red gram (2.56). Maize + redgram intercropping recorded higher area time equivalent ratio value (1.74). Maize intercropping with rice bean, sweet potato, soyabean and redgram better utilization of natural resources than sole maize in young jhum.

Potentialities of Horticulture in Hill Farming

- Fruits and vegetables
- Floriculture and landscaping
- Spices and plantation crops
- Medicinal and aromatic plants

Prospects of orchid cultivation in north eastern states of India

DR Singh and Ram Pal
National Research Centre for Orchids, Pakyong, East Sikkim

Introduction

Dr. M. S. Swaminathan, renowned Indian scientist described the region as cultural and genetic paradise and granary of mega-diversity in terms flora and fauna. Despite of richness natural resources and climatic diversity, the economic development in north-eastern states of India is poorest from the rest of country. The change in climate, decreasing crop productivity, poverty and unemployment are creating pressure on. Among floriculture crops, high value and low volume crops hold good promise for these areas. The orchids are one of them. The region has abundant orchid genetic diversity resource and nearly 900 species of orchids are concentrated in this region. Orchids in this region can be grown on unused/wastelands since these are grown in containers. A few success stories of commercialization of orchids have already been written in states like Sikkim, Arunachal Pradesh, Tripura, Assam and Meghalaya. However, concerted efforts are required in planning, promotion and mitigating the problems of orchid growers for sustainable development of orchid industry in the region.

Indian orchid production scenario

After liberalisation the Government of India identified floriculture as a sunrise industry and gave it to 100 percent export oriented status. The annual domestic demand for the flowers is growing at a rate of over 25% whereas the international demand of flowers is around Rs 90,000 crore. The share of India in international market of flowers is negligible. Agricultural and Processed Food Products Export Development Authority (APEDA), helps in promotion of export and development of floriculture in India. It grants subsidies for establishing cold storage, precooling units, refrigerated vans and green houses, and air freight subsidy to exports. Total area under flower crops is estimated around 34,000 hectares, of which 24,000 hectares is under traditional flowers like marigold, jasmine, aster, rose, chrysanthemum, tuberose and only 10,000 hectares under modern flowers like cornation, rose, gerbera, gladiolous, anthurium. The returns from floricultural products were estimated at Rs.205 Crores, which included Rs.105 crores from traditional and Rs. 100 crores from modern flowers.

Orchid cultivation in India started very early but it remained as hobby of affluent people and nurserymen. During sixties and seventies of last century, commercial cultivars of orchids were introduced by leading nurserymen in Kalimpong. However, they remained as hobby or meager income earner for small nurserymen of the region. The first step towards the commercialization of orchids in Kerala was made by AV Thomas and Co. in 1972 by organizing households to take commercial production under the contract. It did well for few years but could not continue. However, these efforts have created wide spread demand for orchids and added interest among the entrepreneurs. In case of temperate orchids, the leading nurserymen took keen interest for commercializing Cymbidium, Cattleyas and Oncidiums. The efforts made during last few decades have motivated entrepreneurs in the country to take up the orchid ventures for large scale cultivation of orchids. Many new ventures have come up for cultivation of orchids particularly in Kerala, Goa, Karnataka, Maharashtra and Tamil Nadu. Progressive farmers of Sirsi in Uttara Kannada district of Karnataka organized into a Society (KANFLORA) have now more than thirty farmers with Orchid units of a minimum of 1000 plants each, Natural Synergies in Chennai, Himalayan Orchids and Mainam Garden, in Sikkim, ICL Flora Exotica, in Assam Nana-Koo Agro Pvt. Ltd. at Zero-Hapoli, in Arunachal Pradesh, Oriental Orchids Ltd. in Imphal are some of the entrepreneurs. National Research Centre for Orchids has also taken a lead for commercialization of Cymbidiums in Sikkim. Fifty five beneficiaries under five groups have been selected in five different locations. Each beneficiary have been given 1000 tissue cultured Cymbidiums and a hardening house to each group. The growers are being provided with the technical guidance by the centre for production of quality cut flowers.

Status of technological backup

Technology development is the key factor for the growth and development of an industry. The brief advancement made technological front is provided as under-

Genetic enhancement

Orchids comprise one of the largest family of flowering plants with 25,000 to 35000 species belonging to 600-800 genera. At present the cultivation of orchids in the country is based on the hybrids developed outside the country like New Zealand, Australia, Netherlands, Thailand, and Japan. India is very rich in orchid genetic resource and nearly 1300 species of orchids have been reported to occur in various parts of the country ranging from Himalayas to seashore of Kerala. The *Ex situ* conservation of orchids have resulted in collection of large number of species in various Govt. institutions like, Orchid Research and Development Centre of State Forest Research Institute (SFRI), Arunachal Pradesh; NRC for Orchids, Sikkim and Darjeeling; IHBT, Palampur (HP); Orchid Laboratory, Chandigarh; Orchidaria under BSI Shillong and Ooty; and TBGRI, Trivandrum. The collected species need to be utilized for production of hybrids, which suits to national and international market. A little progress has been made by SFRI, Arunachal Pradesh, private growers in Sikkim and Darjeeling and NRC orchids Sikkim. Therefore efforts are needed to be expedited and pragmatic breeding programme predicting the trends for next 10 years need to be initiated.

Mericloning for quality planting material

The quality planting material elite clones is either not available or available in very limited quantity. If available, it is very costly. Most of our research efforts are directed to development of protocols for mass propagation of indigenous species which have very little value in commercial orchid cultivation. A very few efforts are being made to develop the propagation protocols for commercially cultivated orchids. There is immediate need to develop reliable protocols for mass propagation of selected commercial orchids with an emphasis to reduce the cost of planting material. The orchids are infected by a number of viral diseases. Cymbidium Mosaic Virus (CymMV) and Odontoglossum ring spot virus (ORSV) are most serious. Productivity of plants is severely reduced if both these viruses are present together. The establishment clean laboratories producing disease free planting material needs to be promoted. In Thailand, orchid tissue culture is a house hold industry and they have been able to export tissue cultured plants to several other countries like Hawaii, USA as the plants produced by them are highly cost competitive.

Orchid production system management

Standardization of product specific packages of practices is required for large scale production of orchids. The package of practices should include artificial growing media, temperature and light requirement, fertigation requirement, protection from disease and pests. Promotion of organic fertilizers and biological control of pests would reduce the cost of cultivation. The production technology package should be such that it enhances confidence of growers and bring them good returns from the market. Several institutes in the country have been working on this direction e.g. Kerala Agriculture University, Tamil Nadu Agriculture University, Tropical Botanical Garden on tropical orchids; NRC for Orchids on both tropical and temperate orchids, some work has also been done under AICRP.

Orchid health management

Several diseases and pests cause losses to their vigor, production capacity and affect their market value considerably. Orchids are known to be attacked by about 130 plant diseases affecting one or more orchid genera. These are caused by fungi, bacteria, nematode and viruses. Generally, orchids are less affected by pests in their natural habitat but can give way to number of diseases and pests when grown under protected conditions. The important fungal diseases causing damage to orchids include black rot, anthracnose, orchid wilt and leaf spots. Bacterial soft rot and nematode also cause severe losses to orchids. The viral diseases particularly Cymbidium mosaic *potexvirus* (CymMV), Odontoglossum ringspot *tobamovirus* (ORSV), and Orchid fleck *rhabdovirus* (OFV) cause serious problem in orchids. For commercial cultivation of orchids, the orchids are masspropagated in laboratories and planting materials move across international borders, and thus, risk of introduction of exotic pathogens is severe. It requires strict vigil on imported materials to avoid entry of exotic pathogens. Rapid and highly sensitive diagnostic tools are required to diagnose pathogens.The biocontrol method in recent years has gained momentum in disease management of many fungal pathogens. Biocontrol with *Trichoderma viridae, T.*

harzianum and *T. virens* have proved successful in controling many important fungal pathogens. Bacterial antagonists like *Pseudomonas florescence, Bacillus subtilis* and *Streptomyces* spp. are also used against several important bacterial pathogens. In addition to diseases, there are number of pests such as mites, scales, aphids, mealy bugs, caterpillars, snails and slugs etc. that affect the overall growth of orchids and deteriorate the quality of flowers. Strict sanitation practices are essential for reducing losses caused by disease and pests.

Post-harvest & marketing management

Commercially valuable genera of orchids are *Cymbidium, Cattleya, Dendrobium, Phalaenopsis, Vanda* and *Paphiopedilum*. Cymbidium, Dendrobium and Vandas are grown for cut flower production whereas Phalaenopsis, Cattleya, and Paphiopedilums are grown for potted flowering plant production. There are minimum prescribed quality standards for the export of different cut orchids. Post –harvest life of orchid cut flowers is influenced by pre-harvest and post-harvest factors. The pre harvest factors like genotype, light intensity, sugar level in cut stem, temperature, rate of water loss determine the life of cut orchids. However harvest and post-harvest factors *viz*., time and harvesting stage ethylene production, pre-cooling, pulsing, packaging material and storage temperature also affect the post-harvest life of cut orchids. The studies conducted at NRCO have shown that post-harvest life of cut Cymbidiums dependant on genotype and found to be up to 58 days. However, the hybrids of Dendrobium, Vanda and Mokara remain fresh 7 to 30 days.

Strategies for promotion of orchid cultivation in northeastern states

Northeastern states of India are situated away from the big domestic markets like Delhi, Kolkata, Bombay and Chennai. Thus, high value and low volume crops hold good promise for cultivation in the region. The domestic floriculture market is estimated to be about Rs. 5000 million and growing by 25 % annually. The preference of domestic market is shifting from traditional cut flowers to exotic flowers. It is good sign for orchids and other exotic flowers. The shift from traditional to exotic flowers offers good scope for orchids due to their variety in colour and long shelf life. The Delhi market alone is estimated to be about of Rs. 1000 million.

Determining product specific zones

Northeastern states of India are endowed with diverse ecological zones, making it feasible to cultivate almost all kinds of orchids ranging from tropical to temperate. The modern cultivars are combination of several species and thus suitable climatic conditions need to be ascertained before taking up large scale production. There is need to earmark the production zones for each product of cultivated genera like Cymbidium, Dendrobium, Oncidium, Paphiopedilum etc. The work done in past may be useful in assessing potential areas. The Cymbidiums have been suggested to be grown in Upper Shillong (Meghalaya), Ziro-Hapoli, Dirang, Bomdila, Twang, Namsai (Arunachal Pradesh), Kohima, Wokha, Mokakchung (Nagaland) whereas for Dendrobiums, Guwahati (Assam), Agartala (Tripura), Itanagar Pasighat (Arunachal Pradesh) and Imphal (Manipur) have been suggested as promising production zones. The Vandas could be grown in Itanagar in Arunachal Pradesh.

Human resource development

In India competitive priced manpower is the major advantage in floriculture and orchids in particular. However, there is shortage of trained/technical managers required for operation of commercial units. The human resource could be developed through training of entrepreneurs in selected institutions of the country and a backward linkage with the institutes specializing in the area needs to be created for technical support and advice of entrepreneurs. There is need to start a diploma course in cultivation of orchids as well as tissue culture so that these people may become future orchids entrepreneurs or contribute significantly by getting employed in companies engaged in production of orchids. The Indian growers also need to be provided an orientation on conforming International Union for the Protection of New Varieties of Plants and Breeders Rights. This could be done by APEDA in association with state agencies.

Infrastructural support

The infrastructure is basic requirement for the development of commercial floriculture. Both, on farm or off farm infrastructure facilities would require to be created for safe delivery of quality products.

The on farm facilities like pack house, refrigerated van, and cool store may be owned by individual or a group of growers. The off farm facilities can be created by APEDA. Northeastern states lack both on-farm and off-farm facilities required for commercial floriculture. The rail connectivity is available up to Guwahati in Assam. Though each state capital is connected with the highway but conditions of the roads is not very good. There are 12 airports; 6 of them are located in Assam. The airport only in Guwhati has night landing facility. The region does not have integrated post-harvest facility, collection centers auction centers, and cold storage facility. However, an Agri Export Zone for promotion of orchids is being setup in Sikkim with an investment of Rs. 32.21 crores which could be very useful for the orchid industry.

Supply of inputs and quality planting materials

Northeastern states comparatively disadvantageous position with regard to infrastructural facilities which delay the supplies of inputs. However, the emphasis should be laid on the locally the development locally available farm inputs and least support is required from the outside. The quality planting material of orchids is either not available or very costly. Most of the material is imported from other countries. The protocols for propagation of orchids are available now and the sufficient infrastructure has been developed under TMNE which needs to be utilized for production of quality planting material for utilization in northeastern states of India. The National Research Centre for Orchids (NRCO) in collaboration with Department of Biotechnology Govt. of India has established five demonstration units for Cymbidiums cut flower production in Sikkim. Apart from NRCO, Govt. of Sikkim is also propagating Cymbidium for promotion of orchid cultivation in Sikkim.

Northeastern States of India has suitable climate, richness of genetic resources, supportive government policies, and large scientific and technical expertise in the field of orchids. However, the great emphasis is to be laid on creation of on-farm and off-farm infrastructural facilities. The geographical location of Guwahati surrounded by other northeastern states and its connectivity with major national markets with rail/road and air and proximity with South Asian Region would add to the advantage of development of sustainable orchid industry in the region. In globalised economy easing of trade barriers, it is obvious that orchids from other countries would likely dominate our markets and it is required to protect the interests of our growers.

Genetic divergence and character association study in tomato under polyhouse in Uttarakhand

Raj Narayan[1*], Mukesh S Mer[1], Anil Kumar[1], BL Attri[1], DB Singh[2], and Anand S Jeena[3]

[1]*ICAR-Central Institute of Temperate Horticulture Regional Station, Mukteshwar, Nainital*

[2]*ICAR-Central Institute of Temperate Horticulture Regional Station, Srinagar*

[3]*G. B. Pant University of Agriculture and Technology- Pantnagar, U.S. Nagar*

*Correspondence: rajnarayan882013@gmail.com

The exploration of genetic diversity is a pre-requisite in any breading programme for effective selection of superior genotype(s) to breed an improved variety and/or to develop hybrid(s) of tomato (*Solanum lycopersicum* L.). Hence, the present experiment was conducted using 25 diverse tomato germplasm lines during summer 2014 under naturally ventilated polyhouse at ICAR-Central Institute of Temperate Horticulture-Regional Station, Mukteshwar, Nainital (UK). The experimental material was planted at 60×45 cm plant spacing in Randomized Block Design with three replications to study the growth, yield and quality parameters performance of the genotypes. Genetical components like coefficients of genotypic and phenotypic variabilities, correlation coefficients, and genetic divergence (D^2) for quantitative and qualitative traits of the tomato genotypes were worked out. Most of the genotypes exhibited significant differences for various traits as well as sufficient ranges of mean for all the characters. The traits viz, fruits yield per plant (22.36 to 956.62), number of fruits per plant (22.80-268.20), fruit firmness (0.46-4.50), average fruits weight (10.76-103.63), acidity content (0.20-1.55), reducing sugars (1.42-7.76), total sugars (2.16-10.99) and ascorbic acid content (23.40-106.83) exhibited good ranges of mean, which is indicative of presence of sufficient variability in such traits, thus, have a greater scope for selection of better genotype(s) from the existing germplasm pool. A wide range of variability alongwith high estimates of genotypic

and phenotypic coefficients of variabilities were recorded for average fruit yield per plant (60.20 and 60.21%), average fruit weight (55.62 and 56.63%), fruits firmness (46.64 and 47.78%), total sugars (47.16 and 47.85%) and reducing sugars (45.00 and 45.04%). All the traits under observation exhibited high broad sense heritability ranging from 92.12% in total sugar content to 99.96% in average fruit yield per plant, indicating that large proportion of phenotypic variance was due to genotypic variance and therefore reliable selection could be made for these characters on the basis of phenotype of the plants.

The correlation studies revealed that the genotypic correlation coefficients were higher than corresponding phenotypic correlation coefficients in general. Economic traits i.e. total fruit yield per hectare exhibited significant and positive association with fruit yield per plant, total sugars, fruit diameter, fruit weight and fruit length at both genotypic and phenotypic levels, whereas it showed negative and significant correlation with plant height and fruit acidity. The quality trait viz., ascorbic acid content exhibited positive and significant inter relationship with fruit length, fruit diameter, fruit weight and fruit acidity content. Total sugar and reducing sugar content of fruit also had positive and significant association with each other. The magnitude of genetic divergence of 25 genotypes of different geographical origin was studied using the Mahalanobis D^2 statistics. A wide genetic diversity was observed among the genotypes and they grouped into three clusters by Tocher's method based on D^2 values. The clustering pattern indicated that the geographical diversity need not necessarily be related to genetic diversity. The cluster I possessed maximum number of genotypes i.e. 16 genotypes and cluster II had 8 genotypes, whereas only one genotype was in cluster III. Maximum inter cluster distance was recorded within cluster II (32.350). Based on the mean performance the cluster III with single genotype ranked first and to contain the potential genotype in respect of ascorbic acid content. The maximum inter cluster distance was observed between cluster II and III (36.933) followed by cluster I and III (31.102). Therefore, selection of divergent parents based on their cluster distance would be useful in selecting the batter genotype for hybridization and formulating a comprehensive strategy to develop superior hybrid and/or sergeants in tomato.

Effect of shoot pruning and foliar feeding of nutrients on flowering, fruit set and fruit quality of litchi under Tripura Condition

Biswajit Das*, H Lembisana Devi and M Datta
ICAR Research Complex for NEH Region, Tripura Centre, Tripura
*Correspondence: biswajitsom_dr@yahoo.co.in

Introduction

Litchi (*Litchi chinensis* Sonn) is an important sub-tropical fruit crop and is very much specific to its climatic requirement. Total production (NHB, 2013) of litchi is 580 Thousand MT over and area of 83.0 Thousand Ha and productivity is 7.0 MT/ha. The major Litchi producing states are Bihar, West Bengal, Assam, Jharkhand, Punjab, Chhattisgarh Odissa, Uttarakhand and Tripura. In Tripura, large area old plantations under litchi is in the upland hilly areas such as Jumerdepa orchard, Belbari, Ompi and Panisagar. Otherwise, small scale plantations ranging from 1-5 plants are found in every village household. Litchi is cultivated over an area of 2.9 Thousand ha in the state with total production of 16.6 Thousand MT and productivity is 5.6 MT/ha. Production share is 3.3% at National level, whereas, Bihar contributes around 45.6%, followed by West Bengal with 17.1%. Apart from climatic suitability for Litchi cultivation in Tripura, another advantage is the early maturity and harvesting of the fruit. Tripura being situated at North Eastern part of India, flowering takes place in the month of February and fruit are ready during April-May and continues upto first week of June in comparison to North Indian States. However, litchi cultivation is suffering from many problems such low production, poor fruit quality, fruit cracking, poor colour development and fruit dropping. Majority of the plantations are more than 50 years old and have become unproductive and unmanageable. Fruits are inferior in quality as well as infested with fruit borer and unharvestable due to very tall tree height. Moreover, many of the young orchards are also not giving higher yield and good quality fruits due to poor management. Fruits are available only for short duration in the market due to improper post-harvest handling. All these factors playing a vital role for slower rate of area expansion under litchi in the state. To expand the area and revive the potential of litchi cultivation in the state, large quantities of quality planting materials have been distributed over the last 6-7 years under different projects. There is an argent need for technological intervention so that litchi cultivation can be sustained on profitable scale in the state. Scientific management of the newly established orchards, rejuvenation of old trees and area expansion by distribution of quality planting materials and planation in the selected areas as well as pre and post-harvest management of the fruits for improving quality are the main priority areas of technology intervention.

Methodology

An experiment was carried out on the young bearing trees of litchi cv. Shahi to standardize the combination of shoot pruning intensity and foliar feeding of nutrient under Tripura Condition with the purpose to induce proper shoot maturity for higher flowering and better fruit growth and fruit quality.

Results and Discussion

Shoot pruning treatments of 20 cm in combination with single spray of zinc (0.1%) at one month before panicle emergence followed by boron (0.5%) at one week before flowering was effective for better flowering and fruit set and single spray of urea (1%) at green fruit stage, again boron (0.1%) at fruit maturity stage was effective for fruit growth and quality. Sprays gave better response in terms of early shoot emergence in 25-29th June, 2014 and shoot maturity in comparison to tree without pruning as well as only the shoot tip removal treatments. Similarly, this treatment combination was also found to be effective for higher shoot length (56.5-61.4 cm) and diameter (19.8-21.8 mm), panicle length (41.0-46.4 mm) and fruit set (16.5-17.9%). Fruit chemical parameters show that fruit weight ranged from 16.8-18.6g, length 3.3-3.8mm, diameter 2.4-2.8mm, pulp 73.6-74.8% and TSS 19.6-21.5%. Foliar sprays of zinc, boron and urea significantly reduced fruit cracking (5.1-5.6) and increased yield/tree (34.6-37.8kg). Recommended fertilizer and irrigation schedule was followed. Along with this experiment, rejuvenation of old litchi trees was also carried out with the objective to apply the pruning and foliar feeding of nutrients treatments at the bearing stage of the rejuvenated trees. Technological interventions with the shoot pruning schedule and foliar feeding of nutrients and rejuvenation of old litchi tree accompanied with recommended fertilizer and irrigation with be very much helpful for increasing production of quality litchi fruits in the state.

Augmenting fruit productivity in north-eastern region through modern techniques

RK Patel[*], NA Deshmukh and Bidyut C Deka

ICAR Research Complex for NEH Region, Umiam, Meghalaya

**ICAR- NRC on Litchi, Mushahari, Muzaffarpur, Bihar*

Correspondence: rkpatelicar@gmail.com

Introduction

North-eastern region of India, is generally represented by the hilly terrain with varying topography and climatic conditions covering more than 65% of the geographical area. It has immense potential for horticultural development. It is well known that soil and climatic condition of NEH region of the country offers a great scope of growing large varieties of horticultural crops. The variation of altitude, soil and climatic conditions provide ample scope for the cultivation of a wide variety of fruits (Patel *et al.* 2010). The important fruit crops currently grown in the state are banana, oranges, pineapple, papaya, strawberry, passion fruit, jackfruit, litchi, guava, plum, peach and pear under various farming systems traditionally practiced in the region.

Challenges in augmenting fruit production

Though the NE region has high potential for the development of fruit crops, very less efforts have been made to develop it as a commercial venture. Fruit productivity continues to be low in NEH region and a significant gap of about 2-5 t/ha exists between current NE fruit productivity and national productivity.

The major fruit production challenges in NE India have been identified as prevalence of shifting cultivation, poor cultivation practices and low yield, lack of desirable planting material and inputs, lack of marketing facilities, scarcity of trained manpower and extension support, land tenure system or land ownership system, problems of processing, financial constraints.

Enhancing fruit production through modern technologies

The ICAR Research Complex for NEh Region, Umiam, Meghalaya has identified/developed and refined some of the varieties and technologies for improved fruit production.

A. Adoption of suitable cultivars

The following cultivars of different fruits crops have been identified:

Crop	Varieties/hybrids	Remarks
Citrus	Khasi mandarin & Kinnow (Orange), Valencia (Sweet orange), Assam Lemom (Lemon), ARL-1 (lime)	High yield
Guava	L-49, Allahabad Safeda, RCG-11, RCGH-1, RCGH-7, RCGH-4	High yield
Pineapple	Kew and Queen	High yield
Peach	Partap, Flordasun, Shan-e-Punjab	Low chilling, early maturing
Plum	Santa Rosa, Satluj Purple, Kala Amritsari	Low chilling
Strawberry	Festival, Ofra, Camarosa, Chandler, Sweet Charlie	High yield

(Patel *et al.* 2008)

B. Technological interventions

1. Multiplication of quality planting material

Propagation techniques: Propagation techniques for raising the quality planting materials of various fruit crops have been standardized.

Fruits	Methods	Season
Khasi mandarin	Soft wood grafting	July-Aug
	'T' budding	July-Aug, Feb-March
Sweet orange	'T' budding	Jan-Feb
Pineapple	Sucker, Slip	July -August
Guava	Wedge grafting, Patch budding	Feb.-March
	Air layering, Mound layering	June-July
Peach	Tongue grafting	Nov.-Dec.
	Wedge grafting	July-Aug
Pear	Tongue grafting	Nov.-Dec.
Plum	Tongue grafting	Nov.-Dec.
Kiwifruits	Tongue grafting, Semi hard wood cutting	Dec-Jan.
Assam lemon	Semi hard wood cutting	June-July
Passion fruit	Semi hard wood cutting	June-July
Sohiong	Tongue/wedge grafting	Mid October

(Patel *et al.* 2008)

2. Planting season and recommended spacing

Fruits	Pit size	Spacing	Planting time
Khasi mandarin, Guava	75x75x75 cm	5x5 m	June-July
Assam lemon	45x45x45 cm	3.5x3.5	June-July
Pineapple	-	30x60x90cm, double row	July to Sept.
Peach, Pear & Plum	75x75x75 cm	5x5 m	June-July, Dec-Jan.
Banana	30x30x30 cm	2x2 m	March to May
Papaya	60x60x60 cm	2x2 m	June-July
Passion fruit	45x45x45 cm	3x5 m	June – July
Kiwifruits	60x60x60 cm	5x6 m	Dec.-Jan.
Strawberry	-	20x30x90 cm, double row	Mid Sept-Mid Oct.
Sohiong	75x75x75 cm	7x7 m	Aug-Sept.

3. Nutrition

Fruits	Manure and fertilizers	Application schedule
Khasi mandarin	N-480g, P_2O_5-290g and K_2O-540g along with 25kg FYM per tree per year. 2-3 spraying of Zinc Sulphate (0.4%) + Magnesium Sulphate (0.2%) + Copper Sulphate (0.3%) or Multiplex (mixture of multi micronutrients) @ 2.5ml/litre during flushing period.	Feb-March, June-July and September-October.
Assam lemon	FYM: 20 kg, 100:100:100 g N: P_2O_5: K_2O/plant /year	Feb-March and October-November
Guava	Urea: 1430 g, SSP: 1250g, MOP: 500 g and FYM: 25 kg/tree/year	March-April and September
Pineapple	FYM @ 500 g/pit, 12 g each of N & K_2O and 4 g of P_2O_5/plant	First dose of nitrogen at two months after planting and last dose at 12 months after planting. Entire phosphorus and half dose of potash is given at the time of planting and the remaining potash 6 months after planting.
Peach, Pear & Plum	Urea: 1200 g, SSP: 1250g, MOP: 500 g and FYM: 25 kg/tree/year	FYM, SSP and MOP during December-January and urea at 15 days before bud break.
Banana	8-10 kg FYM, 180 g N + 100 g P_2O_5 + 250 g K_2O per plant/year	The full dose of FYM, phosphorus and half dose of potassium is applied at the time of planting while nitrogen is given in 3 split doses at 2, 4 and 6 months after planting.
Papaya	200g each of N, P, K and 25 kg FYM/plant	First, third, fifth and seventh month after planting.
Passion fruit	FYM @ 15 kg and 100: 50:100 g as N: P_2O_5: K_2O per vine annually are to be given in 2 splits during the month of	February-March and July-August.
Kiwifruits	800g N, 500g P_2O_5 and 800g K along with FYM 20 kg per vine/ year.	The N fertilizer should be applied in 2 equal doses, half to two third in January-February and the rest after fruit set in April-May.
Strawberry	70-80 t/ha FYM, 100:60:140kg NPK/ha. Foliar application of Urea (2%), Zinc Sulphate (0.5%), Calcium Sulphate (0.5%) and Boric acid (0.2%).	FYM during land preparation and fertilizers in three split doses.

4. Rejuvenation of old declining orchard

Technology for rejuvenation of old and senile orchards orange, guava, peach, litchi, mango etc. is available. Therefore, adoption of these techniques with little modification can bring the changes in production of fruits in the region.

5. Integrated pest and disease management for managing weeds, insects and diseases.

Strategies to improve fruit productivity

Short-term strategies

- Canopy management in bearing trees
- Rejuvenation of senile/unproductive orchards
- Integrated crop management
- Post-harvest handling

Medium term strategies

- Modernization of nurseries and mass multiplication of quality planting material
- New plantation of improved varieties

Long-term strategy

- Breeding of ideal varieties

The NE region is bestowed with altitudinal variation, diverse topography, varied and abundant rainfall, soil and climatic conditions, which provide an ample scope for cultivation of a wide variety of fruit crops. In spite of this, only few crops like orange, pineapple, areca nut and cashew nut are being grown commercially and most of the fruit crops are restricted to homestead garden. However, there is great scope to enhance the production and productivity of the fruits crops in the region. To achieve this, promotion and adoption of scientific orchard management practices along with intensification of fruit crop based multi-tire farming system model is step ahead for achieving sustainable livelihood.

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Effect of climate change on productivity and quality of vegetable crops and their mitigation strategy

RK Yadav*

IARI, New Delhi

*Correspondence: rkyadav@iari.res.in

Introduction

India is the second largest producer of vegetable in world after China with total production of 162.9 million tonnes from 9.4 million hectare area. The productivity of vegetables has increased up to 17.3 t/ha in 2013-14 from 10.5 t/ha in 1991-92. Though more than sixty vegetable crops are grown commercially, potato, onion, tomato, chilli, okra, brinjal, garden pea, cabbage, cauliflower occupy larger area in India. The leading vegetable producing states are West Bengal (14.1%), Uttar Pradesh (11.4%), Bihar (9.3%), Madhya Pradesh (8%) and Gujrat (7.1%) (NHB, 2014). Most vegetables prefer mild temperatures, thus productivity is low in the hot and humid areas of India. Vegetables are generally sensitive to environmental extremes, and thus high temperatures and limited soil moisture are the major causes of low yields and will be further magnified by climate change. Crop yields in Asia are expected to decline by 2.5-10% from 2020 onwards and by 5-30% after 2050, with declines worst in South and Central Asia (Cruz *et al*. 2007). The paper reviews the effect of climate on different quality aspects/bioactive compounds of vegetable crops that may occur under changed climate.

Mitigation strategies to climate change

The strategies for mitigation in vegetable cultivation would be to reduce nitrous oxide emission through site-specific, efficient nutrient management. The emission could also be reduced by nitrification inhibitors such as nitrapyrin and dicyandiamide (DCD). Mitigation of CO_2 emission from agriculture can be achieved by increasing carbon sequestration in soil through manipulation of soil moisture and temperature, setting aside surplus agricultural land, and restoration of soil carbon on degraded lands.

Adaptation strategies to climate change

To deal with the impact of climate change, the potential adaptation strategies are: developing cultivars tolerant to heat and salinity stress and resistant to flood and drought, modifying crop management practices, improving water management, adopting new farm techniques such as resource conserving technologies (RCTs), crop diversification, improving pest management, better weather forecasting and crop insurance and harnessing the indigenous technical knowledge of farmers.

High temperature

This problem can be minimized by the improvement of cultural practices and breeding approaches. There are different types of traits which help for heat tolerance in conventional breeding approaches. Some of them are - long root length which has good ability to uptake water and nutrients from the soil surface; hairiness which provide partial shade to cell wall, cell membrane and repel sun rays; with the improvement through conventional breeding two cultivars which both desire characters i.e. heat tolerance and high yielded genes are selected and hybridized for selection of desirable plants from segregating generation; use of genetic engineering for transfer of heat tolerant.

Low tolerance

Many vegetable viz. broccoli, Brussels sprout, cabbage, kale, knol-khol, onion, mustard, parsley, spinach, turnip which can tolerate very low temperature can be grown in frost /chilling sensitive area successfully. Unlike cultivated tomatoes, wild tomato species such as *Solanum habrochaites* S. Knapp & D.M. Spooner, *S. chilense*

(Dunal) Reiche and *S. peruvianum* L., recover rapidly after exposure to sub-optimal temperatures. These genotypes can be grown at low temperature at high elevation where temperature remains below 10^{o}C. Physiological traits of chilling tolerance in tomato are: Thin stem, short dense glandular hairs and narrow leaflets (*L.peruvianum*); Densely hairy stem, leaves and fruits (*L. hirsutum*), high photosynthetic rate and seedling can survive at 0^{o}C temperature; *L.chilense* can survive on rock as having deep root system and tolerate moisture stress.

Cultural management

Simple, affordable and accessible technologies like, mulching and the use of shelters and raised beds help to conserve soil moisture, prevent soil degradation, and protect vegetables from heavy rains, high temperatures, and flooding.

Grafting of vegetables for stress management

Grafting of susceptible plant (scion) on tolerant plant (rootstock) helps to grow plant successfully under stress condition. Grafting in vegetables originated in East Asia during the 20th century and it has been used primarily to control soil-borne diseases in tomato, eggplant, and cucurbits. However, it can provide tolerance to soil-related environmental stresses such as drought, salinity, low soil temperature and flooding if appropriate tolerant rootstocks are used. Grafting of eggplants was started in the 1950s, followed by grafting of cucumbers and tomatoes in the 1960s and 1970s. Romero *et al.* (1997) reported that melons grafted onto hybrid squash rootstocks were more salt tolerant than the non-grafted melons. However, tolerance to salt by rootstocks varies greatly among species, such that rootstocks from *Cucurbita* spp. are more tolerant to salt than rootstocks from *Lagenaria siceraria* (Matsubara 1989). Grafted plants were also more able to tolerate low soil temperatures. *Solanum lycopersicum* x *S. habrochaites* rootstocks provide tolerance of low soil temperatures (10^{o}C to 13^{o}C) for their grafted tomato scions, while eggplants grafted can be grafted on wild brinjal (*S. integrifolium)* as rootstocks to overcome low temperature (18^{o}C to 21^{o}C).

Development of stress tolerant varieties

Taiwan has made significant contributions to the development of heat-tolerant tomato and Chinese cabbage lines (*Brassica rapa* subsp. *pekinensis* and *chinenesis*) adapted to hot and humid climate. The key to achieving high yields with heat tolerant cultivars is the broadening of their genetic base through crosses between heat tolerant tropical lines and disease resistant temperate or winter varieties (Opena and Lo 1981). The heat tolerant tomato lines were developed using heat tolerant breeding lines and landraces from the Philippines (*e.g.* VC11-3-1-8, VC 11-2-5, Divisoria-2) and the United States (*e.g.* Tamu Chico III, PI289309) (Opena *et al.* 1992). Now, new breeding lines have been developed from CL5915 and other sources that exhibit increased heat tolerance. CL5915 line is considered best combiners for percentage fruit set and total yield in hybrids developed for heat-tolerance (Metwally *et al.* 1996). Similarly for cold tolerance several genotypes have shown very good tolerance like, PI-120256, a primitive tomato from Turkey; LA-1777 (*Solanum habrochaites*) from AVRDC, Taiwan and *Lycopersicon hirsutum*. LA3921 and LA3925 both *Solanum habrochaites* from AVRDC, Taiwan has also shown chilling tolerance. Similarly EC-520061 (*Solanum habrochaites*) can set fruits both under high (40±2 ^{o}C) and low (10±2 ^{o}C) temperature. These lines can be used for development of cold tolerance in various backgrounds. Indian Agricultural Research Institute has developed some varieties of vegetables to mitigate the harmful effect of heat. Tomato varieties Pusa Sadabahar and Pusa Sheetal and one hybrid Pusa Hybrid-1 have been developed. They are tolerant to high and low temperature. Radish variety, Pusa Chetaki has been developed having better root formation under high temperature regime i.e. April-August. Similarly carrot variety, Pusa Vrishti can form root at high temperature and high humidity i.e. March-August. Early cauliflower variety, Pusa Meghna has been developed which can form root at high temperature.

Drought tolerance

Most of the vegetables are sensitive to drought, however brinjal, cowpea, amaranth, tomato can tolerate drought to certain extent. Genetic variability for drought tolerance has been found in wild tomato (*S. lycopersicum)* is limited and inadequate. The best source of resistance is from other species in the genus *Solanum*. Wild accessions of tomato i.e. *S. cheesmanii*, *S. chilense, S. lycopersicum*, *S. lycopersicum* var. *cerasiforme, S. pennellii*, *S. peruvianum* and *S. pimpinellifolium* have stress tolerance. *S. chilense* and *S. pennelli* produce small green fruit and have an indeterminate growth habit.

Salt tolerance

Conventional breeding programs have shown very limited success in improvement of salt tolerance due to the genetic and physiologic complexity of this trait. Few vegetables like, beet palak, tomato can tolerate salt to some extent. In Tunisia, pepper cultivar 'Beldi' significantly out-yielded other test cultivars at high salt treatments. *S. esculentum* accession (PI174263) showed that the ability of tomato seed to germinate rapidly under salt stress.Tomato genotypes, LA1579, LA1606 both *S. pimpinellifolium*) and LA4133 (*S. lycopersicum* var *cerasiforme*) from AVRDC, Taiwan have shown salt tolerance.Wild tomato species *S. cheesmanii*, *S. peruvianum*, *S pennelii*, *S. pimpinellifolium*, and *S. habrochaites are* the potential source of salt tolerance (Flowers 2004).

Use of biotechnology tools in stress management

Several QTLs have been identified to stress tolerance in tomato i.e. for water use efficiency in *S. pennellii and S. pimpinellifolium* as source of salt tolerance.

Climate change bringing new avenues

Due to increase in temperature the area under tropical and sub-tropical vegetables will increase and it can be grown in those areas where it was not grown earlier. Thus will be opportunity to introduce new vegetables in these areas.

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Studies on genetic diversity assessment of chayote in Sikkim

Ashish Yadav*, Avinash, RK Avasthe, ADD Misra, H Kalita, R Gopi, A Kumar, BN Maurya and SV Ngachan

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok, Sikkim

*Correspondence: 2005ash@gmail.com

Introduction

Chayote (*Sechium edule* (Jacq.) Sw.), oftentimes called the poor man's vegetable is very popular vegetable in North Eastern hilly region and grows abundantly without much care and attention from mid to high hills of Sikkim. Edible parts of chayote include the fruit, flowers, seeds, tendrils, young leaves, shoots and the root. The young and tender leaves are eaten and cooked like other leafy vegetables. The seeds are fried, roasted for consumption. The tubers can be removed after two years for vegetable purpose. The fruit, however, is the most popular chayote product in the marketplace. The multipurpose fruit can also be curried, fried, creamed or pickled. All the plant parts are good food for livestock. Chayote is good source of fiber and vitamin C contents, potassium, calcium, iron are also high in fruits.

Methodology

Sikkim has several native cultivars with the varying morphological characteristics of cultivated chayote fruit in different districts are the most obvious signs of its high genetic diversity. Keeping this in view, the study has been under taken with the objectives to collect and document the existing genetic diversity of chayote in the region and by classifying the vegetative growth and fruit parameters *viz.* shape, size, colour, surface texture, growth pattern, yield and other characteristics of chayote at various stages of plant growth. Various vegetative growth parameters *viz.*, branch length (cm), leaf length (cm), leaf width (cm), petiole length (cm), internodal length, number of leaf/m branch and total number of leaves/branch were observed at 20 days interval on 79 chayote accessions for morphological characterization at various stages of plant growth.

Results and Discussion

Chayote can be grown successfully from 300-2000 m amsl and requires high relative humidity (80-85 per cent), well-distributed annual precipitation of at least 1500-2000 mm and 10-12 hours daylight to initiate flowering (Flores 1989; Vargas 1991; Engels and Jeffrey 1993). ICAR Research Complex for NEH Region, Sikkim Centre has collected 86 chayote accessions. The collected chayote germplasm showed varying types of fruit colours *viz.* green, creamish and white types, including spiny and non-spiny, green types. Morphologically different types and colours of fruits were observed *viz*., round, oblong, spiny, very spiny, without spine and creamy white to green, dark green fruits. Among the 79 chow-chow accessions, high morphological variations were observed for branch length (cm), leaf length (cm), leaf width (cm), petiole length (cm) internodal length (cm), total number of leaves/branch and number of leaf/m branch *etc*. High range of fruit phenotypic variations were observed among the 79 chow-chow accessions for several parameters under study such as fresh fruit weight, dry fruit weight, fruit length, fruit width, spine density per unit area and spine length in spiny types, peel thickness, seed weight, seed length, seed width and total soluble solid (TSS) contents. The fresh fruit weight ranged from 93 g to 1250 g, dry weight from 7.09 g to 16.47 g/100 g fresh fruit, fruit length from 37.5 mm to 178 mm, fruit width from 47.2 mm to 102.7 mm, spine density from 3.20 to 62.56 per square inch and spine length 0.5 mm to 7.17 mm in spiny types, peel thickness from 0.14 to 0.51 mm, seed weight from 10 g to 26 g, seed length from 26.31 to 91.46 mm, seed width from 9.52 to 47.31 mm and TSS from 2° Brix to 7.1° Brix were the variations recorded. The yield of chow-chow accessions varied from 0.5 to 62 kg per plant (Fig. 1). The most suitable average temperature was 15-25°C for vegetative and fruit growth of chayote. Temperatures of less than 15°C damaged small or unripe fruits while those above 28°C favoured excessive growth, flower and unripe fruit drop, which reduces overall production.

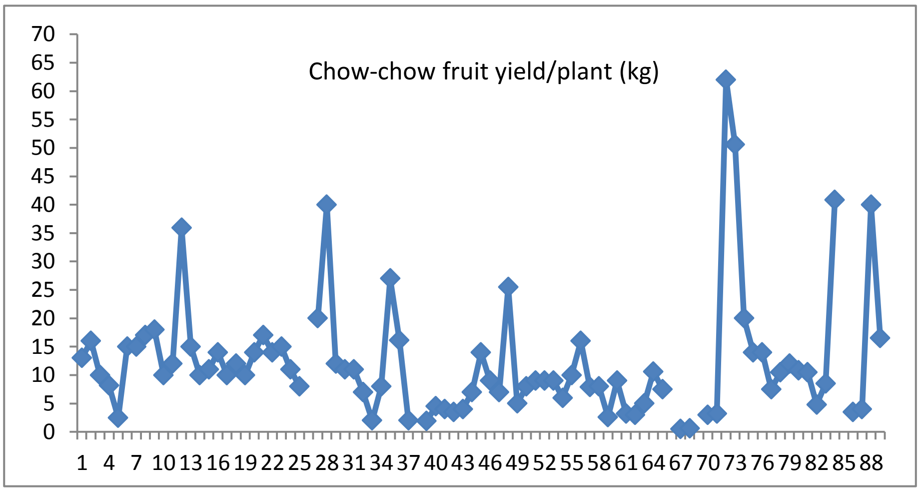

Fig 1. Fruit yield variations of collected chow-chow accessions at ICAR Sikkim Centre

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Year round production cycle of cauliflower and its viability in mid hills of Himachal Pradesh

Bhupinder Singh Thakur*

Regional Horticultural Research and Training Station, Dr YS Parmar University of Horticulture and Forestry, Bajaura, Kullu Himachal Pradesh

*Correspondence: bhupindert@gmail.com

Introduction

Cauliflower (*Brassica oleracea* var *botrytis* L.) is being grown intensively and throughout the year in the mid hills of Himachal Pradesh.

Methodology

To study the economic viability of the year round production system trials were laid out with three varieties ('Pusa Himjyoti', 'PSB K-1' and 'Swati') representing different maturity groups of cauliflower, during 2011-12- and 2012-13.

Results and Discussion

The study revealed that 20th June planting of early season variety 'Pusa Himjyoti' gave and marketable curd yield of 187.7q/ha after 64.2 days of planting giving a B : C ratio of 1.21: 1. The late season variety 'PSB K - 1' planted on October 15th resulted in highest marketable yield of 261.4q/ha. The crop was harvested 119.8 days after planting with and B: C ratio of 0.81: 1. The 2nd March planting of mid late season variety 'Swati' resulted in marketable yields of 234.4q/ha 87 days after planting with a B: C ratio of 1.72: 1. The study therefore revealed that the best year round production pattern with maximum economic gains under the mid hill conditions of Himachal Pradesh is planting early varieties during 15th to 30th June, followed by late varieties planted during 1st to 20th October and mid late varieties planted between 20th February and 10th March.

Genetic variability analysis in bell pepper under mid hills of Western Himalayas

Mayanglambam Bilashini Devi*, NK Pathania, Desraj Choudhary and Nisha Thakur

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: bilashini1712@gmail.com

Introduction

Bell pepper (*Capsicum annuum* L. var. *grossum* Sendt.) popularly known as sweet pepper, green pepper, vegetable paprika or Shimla mirch, a member of family Solanaceae, is an important vegetable crop grown worldwide for its delicate taste, pleasant flavour and colour. In India, bell pepper is commercially grown both for domestic markets and export either under open environment in hilly areas of the country during summer season or under protected structures throughout the year. It is native to Mexico with centre of diversity in South America. Its fruits contain appreciable quantities of ascorbic acid, provitamin A (β-carotene) and other carotenoid pigments such as lycopene and zeaxanthin which are beneficial for prevention of cancer and cardiovascular human diseases.

Preliminary studies have revealed that capsicum can become a money spinner for hill farmers in protected environment. However, information relating to performance of bell pepper germplasm under protected environment is meager in spite of the fact that the demand for varieties suitable for protected cultivation is progressively increasing. The presence of sufficient genetic variability in the available germplasm of any crop is the foremost requirement in the successful execution of any crop improvement programme. The genetic variability studies besides providing information regarding the identification of potential genotypes to be used directly as varieties or as a parents for future breeding programme, also generate valuable information pertaining to the type of gene action involved in the manifestation of different horticultural traits. Hence, the present investigation was planned and executed to assess the nature and magnitude of variation among bell pepper genotypes for marketable yield and horticultural traits. Such information will be useful for future crop improvement programme in bell pepper.

Methodology

The present study was carried out in modified naturally ventilated polyhouse (25×10 m) at the Experimental Farm, Department of Vegetable Science and Floriculture which is situated at 32^0 6' N latitude and 76^0 3' E longitude at an elevation of 1290.80 m above mean sea level with East-West orientation. It is an ideal polyhouse with essential features like double door, side and top ventilation, drip and fogging facility and shading with 50 per cent green agro UV stabilized shade net. The experimental material for the present study comprised of 29 genotypes of bell pepper collected from different sources. These genotypes were planted in Randomized Block Design having 3 replications in a 25 × 10 m modified naturally ventilated polyhouse. The crop was grown on 20 cm raised bed having 90 cm width. Each bed consisted of two rows of 1.5 m length accommodating ten plants per genotype of each entry. The plants were spaced at 45 × 30 cm inter and intra row spacing. Five randomly taken plants of each genotype were used for recording data for the traits *viz.*,days to 50 per cent flowering, days to first harvest, number of marketable fruits per plant, pericarp thickness (mm), lobes per fruit, fruit length (cm), fruit width (cm), average fruit weight (g), marketable fruit yield per plant (kg), plant height (cm), harvest duration (days), ascorbic acid content (mg/100g) and capsaicin content (%).

Results and Discussion

The analysis of variance revealed significant differences among treatments for all the traits studied *viz.*, days to 50 per cent flowering, days to first harvest, number of marketable fruits per plant, pericarp thickness (mm), lobes per fruit, fruit length (cm), fruit width (cm), average fruit weight (g), marketable fruit yield per plant (kg), plant height (cm), harvest duration (days), ascorbic acid content (mg/100g) and capsaicin content (%).

Results obtained from the present investigation on genetic variability studies during summer-autumn, 2012 (Table 1), revealed high estimate of PCV and GCV for number of marketable fruits per plant (34.81 %, 32.50 %), marketable fruit yield per plant (31.15 %, 29.78 %), ascorbic acid content (25.98 %, 25.26 %) and capsaicin content (28.55 %, 25.71%). High PCV and moderate GCV were observed for pericarp thickness (21.57 %, 16.45 %), lobes per fruit (20.71 %, 17.44 %) and plant height (21.08 %, 17.20 %) while, moderate PCV and GCV values were observed for fruit length (18.78 %, 14.55 %), fruit width (17.73 %, 12.94 %) and average fruit weight (17.38 %, 13.66 %). High PCV followed by moderate GCV for pericarp thickness, lobes per fruit and plant height reveals considerable environmental effect in expression of these traits. Moderate PCV (11.69 %) and low GCV (6.13 %) were observed for harvest duration whereas low PCV and GCV values were observed for days to 50 per cent flowering (7.49 %, 6.46 %) and days to first harvest (6.03 %, 2.75 %). Moderate to low PCV coupled with low GCV for the characters *viz.*, harvest duration, days to 50 per cent flowering and days to first harvest indicated that these characters are largely governed by non-genetic factors. Hence, the genetic improvement of these traits through simple selection procedures appears to be quite difficult. Low to moderate estimates of ECV was observed for almost all the traits studied. Sharma et al. (2010) also reported high PCV and GCV for marketable fruit yield per plant and ascorbic acid content thereby, supporting the present findings.

Table 1. Estimates of variability parameters for yield and horticultural traits in bell pepper

Traits	Coefficient of variation (%)			Heritability (%) (h^2_{bs})	Genetic advance (% of mean)
	Phenotypic	Genotypic	Environmental		
Days to 50% flowering	7.49	6.46	3.80	74.20	11.46
Days to first harvest	6.03	2.75	5.36	20.80	2.58
Number of marketable fruits/plant	34.81	32.50	12.46	87.20	62.52
Pericarp thickness (mm)	21.57	16.45	13.96	58.10	25.83
Lobes per fruit	20.71	17.44	11.16	70.90	30.26
Fruit length (cm)	18.78	14.55	11.87	60.00	23.23
Fruit width (cm)	17.73	12.94	12.12	53.30	19.45
Average fruit weight (g)	17.38	13.66	10.75	61.70	22.11
Marketable fruit yield/plant (kg)	31.15	29.78	9.14	91.40	58.64
Plant height (cm)	21.08	17.20	12.18	66.60	28.92
Harvest duration (days)	11.69	6.13	9.95	27.50	7.44
Ascorbic acid content (mg per 100g)	25.98	25.26	4.61	96.90	34.41
Capsaicin content (%)	28.55	25.71	12.40	81.10	0.08

High PCV and GCV estimates for number of marketable fruits per plant, marketable fruit yield per plant, ascorbic acid content and capsaicin content suggest substantial variability for the traits thereby ensuring ample scope for improvement of these traits through selection.

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Selection of suitable time for planting mango ginger (*Curcuma amada* Roxb.)

R Chatterjee[1], V Hnamte[2], T Chongtham[3*], PK Chattopadhyay[4] and SS Roy[5]
[1,2,4]*Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal*
[3,5]*ICAR Research complex for NEH Region, Manipur Centre, Imphal*
*Correspondence: chongthamt@gmail.com

Introduction

Mango ginger (*Curcuma amada* Roxb.) is a perennial herb but cultivated as an annual crop mainly in the states of West Bengal, Assam, Tamil Nadu, Andhra Pradesh, Odhisa, Maharashtra and North Eastern states. The rhizomes are called 'Amada' in Bengali because of its mango flavour and is largely used for preparing preserves, pickles, candies, salads, sauces, chutney *etc*. It has carminative and stomachic properties as reported by Hussain *et al*. (1992). Gupta and Banerjee (1972) reported that its essential oil has antifungal properties. It is also used for preparing preserves, candies, salads, sauces, chutney *etc*. Twenty eight constituents were identified from the rhizome essential oil of *Curcuma amada* of which curcumene (28.1%), beta-curcumene (11.2%), curzernone (7.15%) and 1-8 cineole (6%) were found as the major compounds as reported by Srivastava *et al.* (2001). Considering the commercial value of the crop it was thought necessary to standardize the time of planting of mango ginger in the plains of West Bengal.

Methodology

The experiment was conducted for two years 2008 and 2009 at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to study the effect of different dates of planting on plant growth, yield and quality of mango ginger. The crop was grown on a typical Gangetic alluvial soil (Entisol) with sandy clay loam texture, good water holding capacity and moderate soil fertility status. Different dates of planting were 17th March, 2nd April, 17th April, 2nd May, 17th May, 2nd June, 17th June and 2nd July were selected. The experimental design was RBD with 3 replications. A spacing of 30 cm x 25 cm was adopted with twenty number of plantsplot^{-1}. A fertilizer dose of 30 kg N, 30 kg P_2O_5 and 60 kg K_2O hectare^{-1} was applied along with 25 tonnes of FYM. Observations were recorded on plant height (cm), number of tillers plant^{-1}, number of leaves plant^{-1}, leaf length (cm), clump weight (g), weight of fresh rhizomes plot^{-1} (kg), fresh yield hectare^{-1} (t ha^{-1}), curcumin and oleoresin content in the rhizomes.

Results and Discussion

Plant height (128.62 cm) was recorded maximum by the crop planted in 2nd June and it was minimum (95.89 cm) in 2nd July planting. Average height of the plant was recorded 119.53 cm and 116.57 cm in 17th May and 17th March planting respectively. Significantly higher number of tillers plant^{-1} was recorded by the crop planted in 2nd June planting (4.49). While it was lowest in 2ndJuly planting (3.05).The data revealed that plant raised from 2nd June planting produced maximum leaves plant^{-1}(13.69) and it was statistically superior to rest of the treatments. It is evident from the data that the leaf length was recorded maximum with the planting date of 2nd June (55.54 cm) and minimum leaf length was from the plant which was planted on 2nd July (34.85 cm). Maximum breadth of leaf was found with the planting date of 2nd June (15.05 cm) followed by 17th May (14.39 cm), 17th April (13.89 cm) and 17th June (13.76 cm)and was recorded minimum with 2nd July planting (11.58 cm). Among the different dates of planting, the highest clump weight was recorded by the crop planted in 2nd June (333.54 g) which was statistically different with all the dates of planting while lowest weight of rhizomes clump^{-1} was recorded by 2nd July planting (165.53 g). The yield of fresh rhizomes plot^{-1} was recorded highest in 2nd June (10.55 kg), followed by 17th May (9.25 kg). Weight of fresh rhizomes plot^{-1} was recorded minimum with the planting date of 2nd July (5.57 kg) and it was at par with the planting date of 17th March (6.95 kg). Maximum yield was recorded in the planting of 2nd June (56.26 t ha^{-1}) and variation in this respect was statistically significant with all other planting times under investigation (Table 1).Quality assessment is imperative as mango has tremendous potentiality for use in various food preparation and also for preparation of medicines. Curcumin content was recorded maximum (0.33%) from the rhizomes harvested from 2nd June planting followed by 17th May (0.32%) and 2nd May (0.29%) planting. Rhizomes obtained from 2nd July planting produced minimum (0.18%) curcumin content. It is evident from the data presented in Table 1 that maximum oleoresin content of mango ginger was recorded from the planting date of 2nd June (6.19%) followed by 17th May (6.05%) and the minimum oleoresin content was recorded from the 2nd July planting (4.80%) (Table 1).The results of the experiment with different time of planting, showed significant variation with regard to growth attributes. With shifting of planting date from 2nd June onwards to 2nd July, growth performance of mango ginger decreased. Better rain fall during May possibly encouraged rhizome for better germination in June, due to better moisture availability in the field and also helped for smooth vegetative growth of mango ginger plant as no environmental stress was encountered. Temperature and humidity were also favourable for the growth. According to Panja and De (2000), weight of clump is directly correlated with the plant height, tillers plant^{-1} and leaf number plant^{-1}.Among the planting dates, earlier planting (2nd June) produced higher yield (56.26 t) due to higher growth attributes. Delay the planting from 2nd June – 2nd July correspondingly yield decreased.

Table 1. Yield, and quality assessment of mango ginger as influenced by different dates of planting.

Time of planting	Clump weight (g)	Wt. of fresh rhizome plot^{-1} (kg)	Rhizome yield (t ha^{-1})	Curcumin (%)	Oleoresin (%)
17th March	187.50	6.95	37.06	0.19	4.92
2nd April	249.28	8.75	46.66	0.21	5.42
17th April	250.66	8.88	47.36	0.28	5.81
2nd May	230.33	8.57	45.70	0.29	5.83
17th May	280.04	9.25	49.33	0.32	6.05
2nd June	333.54	10.55	56.26	0.33	6.19
17th June	213.12	8.32	44.37	0.19	5.39
2nd July	165.53	5.57	29.70	0.18	4.80
S.Em ±	4.26	0.149	0.133	0.018	0.037
C.D. at 5%	12.86	0.451	0.403	0.053	0.111

It may be explained that better the height of the plant, more leaves plant^{-1} and the leaf size from early planting might have utilized sunlight more efficiently and resulted better translocation of food material for better rhizome production. The 2nd June planting also showed superiority over other dates of planting with regard to various quality parameters *viz,* curcumin and oleoresin and may be explained that congenial weather was available when the planting was done on 2nd June which had a favorable influence on growth and yield of mango ginger. Because of the higher growth, higher photosynthates that possibly helped in the improvement of quality when compared with other planting dates under investigation.

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Performance of guava genotypes at lower hills of Nagaland

HD Talang, BC Deka, P Sulanthung, Vinika K Aomi, Rajesha G and SV Ngachan

ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland
*Correspondence: hammylliende@gmail.com

Guava (*Psidium guajava* L.) is the most important and commercially cultivated fruit crop belonging to the family Myrtaceae. It was originated in tropical America, stretching from Mexico to Peru and gradually it became a commercially significant crop in several countries (Menzel and Paxton, 1985). Guava is a hardy plant that grows in most of soil types varying from sandy loam to clay loam with a pH of 4.5 to 8.2. Guava fruit is rich in 'vitamin-C', minerals like calcium, iron and phosphorous with pleasant aroma and flavour (Dhaliwal and Dhillon 2003). To those fruit lovers who familiarized with its penetrating aroma, guava is considered as one of the most detectable and fascinating fruits (Menzel, 1985). Besides its exceptionally high nutritive values, guava is also prolific and regular bearer that could produce fruit year round.

North Eastern Hill Region of India is bestowed with a heavy downpour with good distribution for about nine months a year, provide immense scope for the commercial cultivation of guava (Singh 1983). The yield and quality of local cultivars grown by the farmers is quite poor. So that it is requisite to trace the guava genotypes with higher yield and good quality. Hence, attempts were made to evaluate the genotypes suitable for low-hill situation of Nagaland.

Six guava genotypes of three years old viz., RCGH-11, RCGH-1, RCGH-4, RCGH-7, L-49 and Allahabad Safeda were evaluated with respect to plant growth, yield and quality traits of fruit at ICAR Research Complex for NEH Region, Nagaland center, Jharnapani. Four trees per replication of each genotype were selected from bearing orchard and data were taken from selected plants with respect to growth, yield and quality attributes. Ten fruits were randomly harvested from each replication. The growth parameters such as, plant height, plant girth and canopy spread were measured using standard method. The data on fruit yield, fruit size and fruit weight were recorded at the time of harvesting. Total soluble solid (TSS) was determined with the help of digital refractometer. Acidity was determined by titrating the juice against N/10 NaOH and expressed as per cent citric acid. Total sugars were analyzed as per method given by Lane and Eynon (1943). The data was statistically analysed using RBD as described by Panse and Sukhatme (1985). The genotypes showed wide range of variation with respect to plant growth, yield and quality traits of fruit. However, RCGH-1 was found superior in plant height (3.04 m), plant girth (35.17 cm) and canopy spread (3.64 m and 3.85 m in E-W & N-S direction) while RCGH-4 gives better fruit weight (171.28 g), fruit size (6.23/6.97 cm length/diameter) and fruit yield (15.22 kg/tree). The hybrid RCGH-11 was found better in quality attributes like highest TSS (11.53 °Brix), total sugars (8.15%) and lowest acidity (0.40 %). The genotypes viz., RCGH-4 and RCG-11 were outscore other cultivars for growth, yield and quality attributes.

Screening of tomato varieties for higher productivity and profitability of the farmers under Longleng District of Nagaland

K Lily Rangnamei[1*], Manoj Kumar1, [2]Bidyut C Deka[2] and KL Meena[1]
[1]*Krishi Vigyan Kendra, Longleng, Nagaland*
[2] *ICAR Research Complex for NEH Region, Nagaland centre, Jharnapani, Nagaland*
*Correspondence: lrangnamei@gmail.com

Introduction

Tomato (*Solanum Lycoperscum* L) is one of the most important vegetables crops grown both in the plains and hills of NE region. The general popularity and health benefits associated with this vegetables crop make it one of the most commercial crops of all agricultural commodities. The crop required warm weather and abundant sunshine for best growth and development. The plant grows best when provided with uniform moisture and well-drained soil (Gould 1992). Ripe tomatoes have a high content of antioxidant, lycopene and carotene. In Nagaland, Tomato is cultivated in 810 ha with production 4600 MT. Tomato is important crop of Longleng district and its area is around 30 ha with production and productivity is 200 MT and 66.6 q/ha respectively. Tomato production is not able to meet the requirement of the people due to less production, productivity and lack of high yielding variety. Therefore, Krishi Vigyan Kendra, Longleng initiated to conduct on Farm Trail for evaluation of high yielding tomato varieties for higher production and productivity of the Longleng District to fulfill the requirement of the people.

Methodology

Krishi Vigyan Kendra, Longleng is situated at 26° 26' 0" N Latitude, 94° 52' 0" E Longitude with altitude of 1366 m MSL). The soil is generally high in soil organic carbon, medium to high in available N & K and low to medium in available P. On Farm trail was conducted in Longleng district during 2013-14 and 2014-15 to compare the phonological development and production potential of 4 varieties Viz. MT-2, MT-3, Arka Meghali and Pusa Ruby (Local check) under Longleng district of Nagaland with 5 replication, farmers as replication. Seeds of four varieties were sown in a raised nursery beds and after 25- 30 days old seedlings were transplanted at five different locations viz.,Yongam, Pongo, Orongkong, Dungkhao and Hukphang. Seedlings were transplanted with a spacing of 45 cm plant to plant and 45cm row to row. Five plant were selected at random in each plot to record the observation on Plant height, No. of fruit/plant, average fruit weight, fruit length, and fruit breath. The experiment was laid out in Complete Randomized Block Design.

Results and Discussion

The two year pooled data on screening of tomato varieties was presented in the table1. The result revealed that maximum plant height was found in MT-3 (63.5cm) followed by MT-2 (60.26 cm), Arka Meghali (61.65 cm) and minimum in Pusa Ruby (49 cm). Number of fruit/plant was found significantly higher in MT-2(43.44) followed by Arka Meghali (40.8), MT-3(37.4) and lowest in Pusa Ruby (24.8). Maximum fruit breadth was recorded in Arka Meghali (5.25 cm) followed by MT-2 (4.58 cm) whereas maximum fruit length was found in MT-2 (4.67 cm) and minimum in Arka Meghali (4.06 cm) compared to other varieties. Maximum fruit weight was recorded 50.1 g in Arka Meghali followed by MT-2(47.3 g) compared to other varieties, but these two varieties at par with each other. Tomato fruit yield were significantly recorded 176.2, 173.1, 156.0 and 129.10 q/ha of the variety MT-2, Arka Meghali MT- 3 and Pusa Ruby respectively. The yield of and MT-2, Arka Meghali, MT-3 were 36.5, 21.0 and 34.0 percent higher respectively than Pusa Ruby. The trend observed in the results indicates that the higher yield depends on the number of fruits and weight of fruits per plant. It was apparent, that fruit number and weight per plant showed a positive association with fruit yield of tomato.This might be due to MT-2 variety was best suited to climatic condition of Longleng and also this variety was developed and recommended by ICAR RC for NEH region, Umiam, Meghalaya for NEH region. Maximum net profit and B:C ratio were recorded with MT-2 (Rs.251760/- and 3.45:1) compared to Arka Meghali (Rs. 245660/- and 3.43:1), MT- 3 (Rs.212060 and 3.12:1) and Pusa Ruby (Rs. 157660/- and 2.56:1). From the OFT it was concluded that Cv. MT-2 found most suitable variety to grow on under Agro -climatic condition of Longleng District Nagaland for livelihood improvement of the farmers.

Table 1. Growth, yield and economics of tomato crop (Pooled two years)

Varieties	Fruits /plant	Fruit breath (cm)	Fruit length (cm)	Avg. Fruit weight (g)	Fruit yield (q/ha)	Net profit (Rs./ha)	B:C ratio
MT-2	43.77	4.58	4.67	47.3	176.2	251760	3.45
MT-3	37.4	4.51	4.15	39.1	156.0	212060	3.12
Arka Meghali	40.8	5.25	4.06	50.1	173.1	245660	3.43
Pusa Ruby	24.8	4.15	4.1	38.4	129.1	157660	2.56
CD(P=0.05)	6.7	NS	NS	9.2	6.8	-	-

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Yield optimization of cassava through canopy management for increasing food and nutritional security in north eastern hill region of India

MR Sahoo*, M Dasgupta, T Roshni Devi, YI Devi, M Premi Devi, SS Roy, N Prakash and SV Ngachan

ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal, Manipur, India

*Correspondence: *mrsahoo2004@rediffmail.com*

Introduction

Tuber crops play an important role in the food and nutritional security among the tribal population of northeast region of India. Cassava (*Manihot esculenta* Cranz) is one of the important tuber crops grown in the hills and valleys of this region for its starchy tubers used as vegetable. The leaves of cassava are also used widely for animal feed. The productivity in cassava is observed to be low in the hilly regions due to improper cultivation practices. Under these circumstances, optimization of the tuber yield in cassava through canopy management would be greatly beneficial for increasing the rural livelihood. Optimizing rainfed cassava production requires careful attention to planting dates, planting methods and planting positions and canopy and soil management practices that help to conserve water and ultimately increase productivity. Hence, attempt has been taken to study the morpho-physio-biochemical characters of twelve cassava genotypes under three levels of pruning to enhance productivity under foot hill conditions of Manipur.

Methodology

A trial on canopy management of cassava was carried out at Langol hill research farm of ICAR Research Complex for NEH Region, Manipur Centre, India during 2014-15. Twelve genotypes of cassava were evaluated under three treatments [T_1: Control (without pruning); T_2: 25% pruning and T_3: 50% pruning] replicated thrice. Morphological parameters such as plant height, number of branches, leaf area and collar diameter were recorded at 30 and 60 days after pruning (DAP). The tuber yield and yield attributing characters such as number of tubers, length of tubers and girth of tubers was recorded at the time of harvest. Physiological parameters such as relative water content (RWC) and chlorophyll stability index (CSI) were also determined following the procedures of Perez *et al.* 2002 and Mohan *et al.* 2000, respectively. Protein concentration in the leaf tissues was determined following the procedure of Bradford 1976. The total soluble sugar was quantified following the anthrone method as described by Roe 1955 and reducing sugar by the methodology of Nelson 1944. Data on different characters were analyzed using standard statistical methods.

Results and Discussion

Morpho-physio-biochemical and yield attributing characters of cassava genotypes were significantly varied among the treatments. The collar diameter, leaf area, number of tubers, and girth of tuber have been increased however the plant height and length of tubers were decreased significantly at 25% and 50% pruning as compared to control. Total soluble protein and carbohydrate content content in leaf tissues were also varied significantly among the treatments. Plant height was decreased significantly with the increased treatments in the tested genotypes as compared to the control (22.4% at T_1 and 35.6% at T_2). Leaf area was increased significantly by 28.8% at 50% of pruning. Collar diameter of cassava plants was increased at 25% pruning whereas the same was observed to be decreased at 50% pruning while compared with control.

The physiological parameters such as relative water content (RWC) was observed to be higher at 25% pruning (82.16%) followed by 50% pruning (79.06%) and control (61.10%). Similarly, the chlorophyll stability index (CSI) was increased significantly at 25% pruning (25.52%) and 50% pruning (17.5%) as compared to control. The content of total soluble protein (TSP) was observed to be decreased by 12.4% and 9.3% at 25% and 50%, respectively of pruning in comparison to control. Carbohydrate content in turn of total soluble sugar (TSS) and reducing sugar (RS) was observed to be increased under pruning treatment (9-17%) than that of control. The nitrate reductase (NR) and acid phosphatase (ACP) and alkaline phosphatase (ALP) activities were observed to be higher in 25% pruning followed by control and 50% pruning. The average number of tubers was increased significantly at 25% and 50% pruning viz.9.9% and 5.94% over control. The girth of tuber was increased by 13.44% and 5.15% at 25% and 50% pruning, respectively as compared to control. Mean tuber yield was recorded to be higher at 25% pruning (39.5 t/ha) as compared to pruning at 50% (29.8 t/ha) and control without pruning (37.4 t/ha).

The results of the present investigation indicated that, 25% pruning in cassava is not only being helpful in optimizing the yield by manipulating the plant canopy and tuber morphology but also enhances the qualitative parameters in the leaf tissue and tubers to address the challenge of food and nutrition security. The leaf biomass obtained from cassava after pruning would be an alternate nutrient supplement as pig feed in this region. Hence, this study would be helpful in increasing the productivity of cassava along with producing the animal feed in a sustainable way.

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Initial shading: to reduce transplanting shock in tomato crop

Y Ramakrishna [1]*, BK Singh[2], T Boopathi[2], SK Dutta, SB Singh, AR Singh, Lungmuana, Shah S and SV Ngachan [3].

ICAR Research Complex for NEH. region, Mizoram Centre, Kolasib, Mizoram
[1] *Krishi Vigyan Kendra, Ukhrul, Manipur.*
[2] *Indian Institute of Vegetable Research Shahanshahpur, Varanasi, UP*
[3] *ICAR Research Complex for NEH region, Umiam, Meghalaya*
*Correspondence:Ramakrishna_iari@rediffmail.com

Introduction

Mizoram is a mountainous state in North Eastern India with a geographical area of 2.109 million ha. Rabi season tomato crop is remunerative, but shock during transplanting effect seedling crop establishment and growth are limited by high radiation, day temperature, low humidity and low water availability in soil profile (Lyr and Hoffman 1967). To overcome transplanting shock, some farmers of the Mizoram and in Northeast India, provide shade to newly transplanted seedlings trough locally available resource. To understanding the concept, some shade material like wild banana pseudo stem, wild banana leaf sheath, split bamboo shoots, teak leaf, and old magazine papers were studied in transplanted tomato. The objective is to assess the effects of shading materials on the performance of tomato in order to suggest management practices.

Methodology

The present study was conducted at ICAR RC NEH, Mizoram Centre (24°12'47" N, 92°40'35" E) during early rabi season 2011-12 and 2012-13. Tomato (Avinash-2) was selected for the study. The seedling were raised in nursery for 20 day and subsequently transplanted in the terrace on 15 st October 2011and 17th Oct 2012 in a plot size of 3X2 m and replicated four times. Four shading material were tested, and control (without shading). For providing shade, the banana pseudo stem from wild banana (Musa spp.) were peeled and cut to approximately one feet length, a bamboo stick was inserted inside the pseudo stem. In teak leaf, bamboo stick is pierced midrib to petiole side to tip side. The magazine paper and banana leaf were tied to two bamboo sticks. All shading materials were planted towards southern side of the seedling. Shading materials were placed immediately after transplanting and kept for 15 days and Seedling survival was assessed at 15 DAT data were recorded. We considered a seedling as dead when the shoot was clearly dry and gap filling was not taken. Seedling growth was estimated as plant height, stem circumference at 2 cm above the ground, dry matter , dry weight , LAI, relative water content (RWC), total Yield of tomato was recorded as sum all multiple harvest. The experiment was laid on factorial RBD design. For all analysis, statistically significant difference was set at $p < 0.05$. Data was analysis using SPSS-16 software.

Results and Discussion

The study shows that shading by banana pseudo stem had recorded the survivability (97%) significantly higher than rest of the treatment followed by shading by teak leaf, magazine paper and banana leaf. Without shading tomato seedling resulted in lowest survivability (71.5%). Shading improved the survivability of tomato seedling by 26, 16, 18, 16, per cent respectively, by providing shading of tomato by banana pseudo stem and teak leaf, banana leaf, magazine paper over non shading (Table 1). The plant height at 15 DAT was significantly higher with shading banana pseudo stem than rest of the treatment. The RWC at 15 DAT was significantly improved under banana pseudo stem which was at par with banana leaf shading. Strong radiation can limit plant survival and growth in dry environments (Rey Benayas 1998) shading material prevent direct incidence ray. It was observed that in shaded plants, dew drop deposit on the plant canopy and shading material, later collected at the bottom and making moist in rhizosphere.

The newly developing roots were more concentrated on the top 5 cm layer of soil profile, reduction of soil moisture will reduce the survivability and growth of the seedling (Lyr and Hoffman 1967). Shading helped prevent the drying of dew drops on leave surface and soil moisture rhizosphere trough evaporation help to_retain more water in plant and this was in turn reflected as high RWC in the leaves. The stem circumference, LAI and dry matter at 15DAT was higher with banana pseudo stem 3.94 cm, 0.45 and 12.9g respectively, which was significantly superior over non shaded tomato. Low R:FR ratio modified the leaf morphology by increasing the leaf area had no consequences on the net CO_2 assimilation rate and on the biomass allocated to shoots (Heraut-Bron 2000).

Table1. Effect of shading by different material on transplanted tomato

Treatments	Survivability (%)	plant height (cm)	Dry wt (g)	RWC	LAI	Stem circumference (cm)	Yield per plant (g)	Yield (t/ha)
Open transplanting	71.5	25.2	12.6	78.6	0.38	2.72	671	25.7
Banana pseudo stem	97.0	36.4	25.9	90.2	0.53	3.94	784	30.9
Banana leaf sheath	87.3	30.9	17.6	86.8	0.46	3.48	698	26.5
Teak leaf	89.5	30.5	19.3	84.2	0.46	3.72	722	27.4
Paper	87.5	29.7	18.0	85.2	0.43	3.52	714	26.8
SEm±	2.2	0.8	2.3	1.2	0.04	0.2	22.2	0.3
CD at 5%	6.5	2.4	6.3	3.3	0.12	0.6	66.8	0.9

The shading material had shown a significant impact on the on growth and later yield of tomato. Fruit yield per plant was highest in banana pseudo stem (784g/plant) which was significantly superior to non-shaded tomato. Seedling initial shading with banana pseudo stem improved the total yield (30.9 t/ha) of the fresh fruit. Early growth utilizing better utilized crop season and resource able to produce more fruits per plant later over all yield. Shading materials prevent direct sunlight on plant canopy and rhizosphere preventing them from dry at faster rate resulted in lesser moisture stress. This technology or methodology is beneficial for small and medium farmers. It save the seedling replacement cost it can be recommended for water saving method for transplanted rabi vegetable

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Current season shoot: implications for higher flowering and fruiting attributes in *Eleaegnus latifolia* L.

H Rymbai*, AR Roy, NA Deshmukh, AK Jha, VK Verma, LK Mishra and W Shimray
ICAR Research Complex for NEH Region, Umiam, Meghalaya 793 103, India
*Correspondence: rymbaihort@gmail.com

Introduction

Eleaegnus latifolia L. is one of the most important life sustaining underutilized fruit crops prevalent in Meghalaya. Better understanding of this underutilized fruit crop will help in meeting demand for nutritional security and also genetics for conservation. However, flowering and fruiting traits is not well understood which impaired the breeding and production aspects of this crop.

Methodology

The study was conducted in five accessions of *Eaeagnus latifolia* L. collected from different locations of Meghalaya, India to understand the flowering and fruiting traits. Studies were conducted during 2013-2015 in well maintained plants, Division of Horticulture, ICAR Research Complex for NEH Region, Umiam.

Result and Discussion

It was observed that flowers are hermaphrodite. The variations within the genotypes for both flowering and fruiting traits were observed and significant variations were observed among the genotypes for all the flower characteristics such as dimension of ovary, stigmas and pollen length in the polar region. Maximum bud intensity was recorded in REC-3 (16.00) in current season shoot. Number of flower buds was higher in the current season shoot as compared to previous season. Regardless of genotypes, numbers of flower were higher in the middle portion of the shoot. Total number of flower per shoot was maximum in REC-4 (127.00). Flowering duration per inflorescence varies from 6.00 days (in REC-1 and REC-2) to 8.67 days in REC-4. Initial fruit set was recorded maximum in REC-1 (41.23%) and minimum in REC-2 (25.24%). Therefore, for higher productivity and efficient breeding system in this crop, emphasis may be given to the middle portion of the current season shoot.

Subsistence to sustainability through tuber crop based cropping system in Arunachal Pradesh

Thejangulie Angami, Rupankar Bhagawati*, Badapmain Makdoh and LetngamTouthang
ICAR Research Complex for NEH Region, A.P Centre, Basar, Arunachal Pradesh
*Correspondence: rbhagawati@rediffmail.com

Introduction

The tribal of North-Eastern states of India in general and Arunachal Pradesh in particular have the common habit of growing tuber crops like colocasia, cassava, sweet potato, diascorea etc. With diverse agro-climatic condition, varied soil and high rainfall, topography etc. the state is highly suitable for cultivation of tuber crops ensuring significantly in food and nutritional security and have proved to be life sustaining crops in times of natural calamities and famine. They also play an important role in mitigating hidden hunger through diet diversification as they are reservoirs of resistant starch, minerals, vitamins, antioxidants, and dietary fibres (Vision 2050, CTCRI). Besides human consumption, these crops are utilised as animal feed like sweet potato and cassava tubers, colocasia corms and petioles are chopped, boiled and fed to the pigs. Industrial uses like for production of starch, sago, flour, glucose, alcohol from cassava etc. and medicinal purposes where Elephant foot yam is considered good for piles and rejuvenation. Since these crops do not require much attention or care and no serious disease or insect damages are observed, they get preference as risk aversion crops in this difficult region. Considering the importance and mandatory practice of growing tuber crops in the jhum field by the rural populace of the state, the present study was carried out based on the following objectives: i)To evaluate the yield performance of different local and improved cultivars of tuber crops as Crop Model in jhum field. ii) To quantify the economic profitability for developing suitable and sustainable tuber crop based cropping system model for achieving better livelihood in Arunachal Pradesh.

Methodology

Different local and improved varieties of tuber crops *viz.* Colocasia, Sweet potato, Cassava, Elephant Foot Yam, Diascorea etc. were grown at ICAR Research Farm, Gori, Basar, Arunachal Pradesh, during 2014-15. Under this model, scientific approaches like uniform standard and timely cultural practices were followed during the growing season. The present work was carried out at as an attempt to evaluate the performance of different local and improved cultivars of tuber crops as Crop Model in jhum field and quantify the economic profitability to develop suitable tuber crop based cropping system model under rainfed condition.

Results and Discussion

In Colocasia, the net return was Rs. 2,05,400 with benefit cost ratio of 4.54. Sweet potato and Cassava recorded a net return of Rs. 2,33,600 and Rs. 2,38,640 respectively. Among the tuber crop, Diascorea recorded the highest net return of Rs. 3,33,800 and benefit cost ratio of 5.98 followed by Elephant Foot Yam with net return and benefit cost ratio of Rs.2,82,050 and 5.86. The variation in the performance may be due to genetic makeup of particular crop and response to particular agro-climatic condition (Deshmukh *et al.* 2012). The rich biodiversity of tuber crops in Arunachal Pradesh serve as an integral part of food for the tribal. The common practice of growing tuber crops in jhum field which requires less care and attention is considered as a resilient crop towards climate change. The adaptability of tuber crops to the marginal environment, their contribution to household food security as well as flexibility in mixed farming system in jhum even though without adoption of scientific practices makes them important component for improving the welfare of the rural poor and linking smallholder farmers to market. From the above basic attempt, the highly competitive benefit cost ratio from the model confirms its suitability of growing different tuber crops in jhum field for achieving better livelihood which can transform subsistence into sustainability through tuber crop based cropping system with a vision to upscale and replicate in larger areas under jhum for sustainable development.

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Assessment of soil chemical properties under protected cultivation of floricultural crops in the low and mid hill zones of Himachal Pradesh.

Debalina Biswas*

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura

*Correspondence: debalinassac@gmail.com

Introduction

Soil chemical properties are dynamic in nature. The maintenance of soil chemical equilibrium under intensive land use and fast economic development therefore, is a major challenge for sustainable agriculture. In India, adverse effects on soil physical and chemical condition primarily arise from imbalanced proportion different cations and anions in soil due to unwise human interruptions, soil contamination by heavy metals and toxic gases and application of inorganic fertilizers, pesticides & herbicides. Protected cultivation of floricultural crops has emerged in a big way in Himachal Pradesh. Among the various floricultural crops carnation *(Dianthus caryophyllus Linn.)* is being raised widely under protected cultivation. The present research therefore was focused primarily on carnation crop. It is pertinent to add that intensive cultivation of flowers under polyhouse condition has however, lead to injudicious and excess use chemical inputs to produce more & more on a small piece of a land. These chemicals are known to have an adverse effect on soil reaction and ion exchange phenomena. It is, therefore, imperative to assess the above mentioned properties inside the polyhouses and compare the same with the open field conditions. Therefore, the study was undertaken with the objectives to study the impact of intensive cultivation on the exchangeable ion status and reaction nature of soil inside the polyhouses.

Methodology

Present study was undertaken during 2012-2013 to investigate the impact of intensive cultivation practices on fundamental soil chemical properties of the polyhouses located in Bilaspur, Solan and Sirmaur districts covering the low and mid hill zones of Himachal Pradesh. An introductory survey of the selected areas was carried out for assortment of necessary information about cultivation practices, cropping patterns and problems prevailing in the polyhouses. Carnation was distinguished to be the principal flower crop in majority of the polyhouses. In study area, greenhouse plants were fertilized mainly with urea, 12-32-16, 19-19-19, 12-12-12, farm yard manure and vermicompost. Ten polyhouses were selected at random and soil samples were collected from inside the polyhouse as well as from the open field adjacent to the polyhouses. A total number of 60 soil samples (0 to 20 cm depth), with the help of spade and auger were collected from different locations, were air dried, crushed in a wooden pestle and mortar, passed through 2 mm sieve and stored in plastic containers. Thereafter, cation exchange capacity was determined by Sodium and ammonium acetate, Cetrifuge method (Bower *et al.* 1952). 1:2 soil:water suspension method was employed for estimating pH and EC with the help of digital pH meter and EC meter respectively (Jackson, 1973) and the data were subjected to statistical analysis by adopting the two way analysis.

Results and Discussion

The results revealed that the locations and interaction effects of locations and conditions failed to put forth a significant impact on the cation exchange capacity of soil but the cation exchange capacity was recorded significantly higher (15.16 meq/100g) under polyhouse condition than under open field condition (14.25 meq/100g) and fell in the range of 14.70 to 15.00 meq./100 irrespective of open field and polyhouse condition and hence indicating good soil health (Table 1) .The higher CEC values of soil in the polyhouses may be ascribed to the high organic matter additions, as organic matter act as a chelating agent. Tida G. *et al.*, (2011) reported that soil inside the greenhouses recorded greater cation exchange capacity which may be due to higher level of soil management under greenhouse conditions.

The average values of pH were noticed to be statistically significant among different locations and between the two conditions. Further combined effect of location and condition was also found to be statistically significant (Table 1). The soil pH was higher in open field (7.33) as compared to protected condition (7.11). This difference in pH under protected cultivation might have resulted due to long-term combined application of mineral fertilizers with organic manure or crop straw which gradually leads to acidification of the soil. In general soil pH was noted to be neutral (7.08 to 7.34), thus, there is no wide variation in pH of surface soils, irrespective of locations and conditions (Table 1).

Table 1. Status of soil chemical parameters under polyhouse and open field conditions in different districts

C / L	CEC (meq/100g)			pH			EC(dS m^{-1})		
	*Poly	**Open	Mean	*Poly	**Open	Mean	*Poly	**Open	Mean
Bilaspur	15.66	14.33	15.00	7.12	7.57	7.34	0.77	0.53	0.65
Solan	14.92	14.47	14.70	7.15	7.33	7.24	0.44	0.23	0.33
Sirmaur	14.90	14.61	14.75	7.06	7.10	7.08	0.43	0.24	0.34
Mean	15.16	14.25		7.11	7.33		0.55	0.33	
CD (L)	NS			CD (L)	= 0.25		CD (L)	=0.07	
CD (C)	= 0.53			CD (C)	= 0.20		CD (C)	= 0.06	
CD (L×C)	NS			CD (L×C)	= 0.35		CD (L×C)	NS	

*Polyhouse condition **Open field condition, (L = Location), (C=Condition) and (LxC =Location × Condition)

The EC also varied significantly among different locations. Irrespective of locations, EC was recorded significantly different (0.55 dS m^{-1}) under protected cultivation than the open field condition (0.35 dS m^{-1}). Lou *et al*. (2012) also reported that soil electrical conductivity increased significantly in comparison with open field condition mainly due to the reckless application of nitrogenous fertilizer with higher rate in the greenhouses. The electrical conductivity (EC) was found to be in the safe limits (<0.8 dSm^{-1}) as a whole. Thus, the soil chemical condition is not a constraint for the availability of nutrients both from the soil as well from applied fertilizers but marginally influenced by the intensive management practices adopted by the farmers and the degree of manure and fertilizer usage over a period of time. There is a necessity for screening of soil chemical status under polyhouse production system at regular intervals and well-timed adoption of counteractive measures to retain good soil health for sustainable productivity.

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Effect of foliar phosphorus nutrition on yield, fruit quality and leaf nutrient content of Banana cv Martaman

L Dhanabati[1]*, H Lembisana Devi[2] and SK Sarkar[1],
[1] *Faculty of Horticulture, BCKV, West Bengal*
[2] *ICAR Research Complexes for NEH Region, Tripura Centre, Lembucherra, West Tripura*
*Correspondence: lourembamdhanabati@gmail.com

Introduction

Banana being an exhaustive crop, optimum manuring and fertilizer application is desirable for proper growth and higher yield. The requirement of phosphorus is low in banana but it helps in producing a strong root system and healthy rhizome thereby giving good anchorage and prevents from lodging. It is also favourable for fruit development and increases fruit ripening. The absorption of P also depends on the plants root system (root hairs, length, density, branching pattern, root surface volume ratio etc.) and its availability in the soil. Foliar application of nutrients can supply essential elements directly to the foliage and fruits any time when rapid responses may be desired. Greater absorption of P through foliar application helps the plant to increase the rate of translocation of source from expanded leaves as phosphorus deficiency reduces the translocation from source leaves (Radin and Eidenbolk 1986). An increase in yield was observed in mango trees by spraying 0.5 per cent orthophosphoric acid (H_3PO_4) and 2.0 per cent urea (Kumar and Reddy 2008).

Methodology

An experiment was carried out at the Banana Research Centre, Mondouri under Bidhan Chandra Krishi Viswavidyalaya, West Bengal during 2010 to 2013 with four replication and five treatments viz., (i) Orthophosphoric acid (H_3PO_4) @ 1% foliar sprays, (ii) Sodium dihydrogen phosphate ($NaH_2PO_4.2H_2O$)@1% foliar sprays, (iii) Disodium hydrogen phosphate (Na_2 HPO_4) @ 1% foliar sprays, (iv) Trisodium orthophosphate ($Na_3PO_4.12H_2O$) @ 1% foliar sprays and (v) Control (water sprays) in randomized block design. The foliar application of phosphorous was made thrice at $5^{th,}$ 7^{th} and 9^{th} months after planting (MAP) in aqueous solutions with stickers. Leaf samples were collected at $5^{th,}$ 7^{th} and 9^{th} months after planting (MAP) one day before and after 10 days of imposition of treatments. The collected samples were washed, oven dried, ground and stored in butter paper bags. The leaf nutrient content was estimated for each treatment. Observations on yield and yield attributing parameters were recorded and fruit quality parameters were also estimated.

Results and Discussion

Number of hands per bunch, number of fingers per bunch, bunch weight, fruit weight, pulp weight was maximum in 1% disodium hydrogen phosphate which ultimately leads to highest yield in 1% disodium hydrogen phosphate. The foliar application through different sources of phosphorus could not result significant changes in fruit quality characters of treated plants. Though the values for TSS, total sugar, reducing sugar, acidity and ascorbic acid were higher in 1% disodium hydrogen phosphate treatment. The higher leaf N, P and K content in 1% Disodium hydrogen phosphate and 1% Sodium dihydrogen phosphate spray almost throughout the growth period had resulted higher photosynthesis, high carbohydrate assimilation ultimately higher bunch weight and yield.

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Species composition of Tephritid fruit flies infesting cucurbits in Tripura

N Nair[1*], T. Bhattacharya[1], MR Debnath[2]
[1] *College of Agriculture, Tripura*
[2] *Horticulture Research Staion, Nagicherra, Tripura*
*Correspondence: *navendunair@gmail.com*

Introduction

The cucurbits are the major vegetables being widely grown in Tripura. Several biotic factors limit the production and productivity of cucurbits, of which tephritid fruit flies have been recognized as the most important pest in Tripura which is a major constraint in profitable farming of cucurbits (Chaudhary and Patel 2007). The accurate identification of pest species is essential for any pest management programme and regulating the entry of pest species to a pest free zone. Taxonomic keys are of utmost importance in the identification of the species during different research programmes (Prabhakar *et al.* 2012). Therefore, an attempt has been made to identify the fruit fly pests associated with cucurbit crops in Tripura.

Methodology

Different cucurbitaceous crops such as cucumber, bitter gourd, spiny gourd, sponge gourd, ridge gourd, bottle gourd, snake gourd, ash gourd and pumpkin were grown in the Experimental farm and crop museum of the College of Agriculture, Lembucherra, Tripura for attracting fruit flies. Fruit fly infested fruits and flowers were collected from farmers' fields as well as college farms from October, 2014 to October, 2015 and brought to the laboratory and were placed on sand at the bottom of plastic containers with markin cloth covers. Adult flies were fed with artificial food (3:1 sugar:yeast hydrolysate) and water for about 4 days to allow colour patterns used for identification to develop. Traps baited with male lures (cue-lure and methyl eugenol) were installed at ten sites. At each site, two traps, separately baited with two lures, were hung about 2 meters above the ground. Both male and female fruit flies of different species were also collected by using food baits constituted of molasses or over ripe banana (100 g / litre of water). The collected flies were identified to species level based on morphological characters using the keys of Leblanc *et al.* 2014.

Results and Discussion

Seven species of Tephritid fruit flies *viz*., *Bactrocera* (*Bactrocera*) *dorsalis* (Hendel), *B*. (*Hemigymnodacus*) *diversa* (Coquillett), *B*. (*Sinodacus*) *hochii* (Zia), *B*. (*Zeugodacus*) *caudata* (Fabricius), *B*. (*Zeugodacus*) *cucurbitae* (Coquillett), *B*. (*Zeugodacus*) *tau* (Walker) and *D*. (*Callantra*) *longicornis* (Wiedemann) have been recorded to infest cucurbit crops for the first time from Tripura. Out of these, two species *viz*., *B*. (*Zeugodacus*) *cucurbitae* (Coquillett) and *B*. (*Zeugodacus*) *tau* (Walker) were found to be the most serious pests of all the cucurbitaceous crops studied during the present study, whereas *D*. (*Callantra*) *longicornis* was recorded to cause serious damage to snake gourd only and *B*. (*Sinodacus*) *hochii* was reared from some fruits of sponge gourd only. Two species of fruit flies viz., *B*. (*Hemigymnodacus*) *diversa* and *B*. (*Zeugodacus*) *caudata* were observed to infest the flowers of cucurbitaceous plants only and thus are considered as minor pests. *B.* (*Bactrocera*) *dorsalis* is the most serious pest of fruit crops in India but during the present study it has been recorded as a minor pest species particularly in cucurbits.

In the state of Tripura the diversity of cucurbit-infesting fruit fly pest species has not been studied so far. Thus the present finding of the presence of seven species of Tephritid fruit flies infesting cucurbit crops is new record for the state of Tripura. Out of the seven species, *B. cucurbitae* and *B. tau* are the major pests that have been established themselves as the major limiting factor in profitable cultivation of high valued cucurbitaceous vegetables in this state.

Key to the species associated with cucurbitaceous crops recorded in Tripura

1 Large wasp-like red-brown fly (wing at least 8 mm long) with abdomen tergite 1 longer than broad and wing costal band broad and overlapping R4+5 vein; abdominal tergites fused; males attracted to cue-lure ....*Dacus longicornis*

– Smaller fly (wing less than 8 mm long) with abdomen tergite 1 broader than long and wing costal band narrow, confluent with R2+3 or at most overlapping R2+3, abdominal tergites not fused……………….. 2

2(1) Scutum with yellow median postsutural vitta present, though sometimes very reduced 3

– Scutum with yellow median postsutural vitta absent 8

3(2) Wing with infuscations along r-m and dm-cu crossveins, in addition to the costal band and anal streak; Costal band with large apical spot; one pair of scutellar setae present; scutum predominantly reddish brown, with 3 postsutural yellow vittae; males attracted to cue-lure ....*Bactrocera cucurbitae*

– Wing with infuscations restricted to the costal band and anal streak 4

4(3) Prescutellar acrostichal setae absent ; apex of costal band on wing greatly expanded into an enlarged circular spot; yellow median postsutural vitta very short and narrow and yellow lateral vittae absent; face yellow, with a broad black band across the lower portion; males attracted to cue-lure ....*Bactrocera hochii*

– Prescutellar acrostichal setae present; yellow median and lateral postsutural vittae well developed; apex of costal band on wing not so greatly expanded…………….........5

5(4) Face fulvous with a pair of circular to oval black spots; apex of wing costal band expanded into an apical spot; scutum yellowish brown in ground colour , with large black patch; males attracted to cuelure ....*Bactrocera tau*

– Face fulvous, with or without a transverse black band; apex of wing costal band at most slightly expanded...6

6(5) Face entirely fulvous in male or fulvous with transverse dark band across oral margin in female; scutellum with one pair (rarely two pairs in male) of apical bristles; pecten on male abdomen absent...........................*Bactrocera diversa*

– Face entirely fulvous with transverse black band across oral margin in both sexes; scutellum with two pairs of apical bristles; pecten on male abdomen present; femora fulvous with apical fuscous patterns; males attracted to cue-lure ………………………………....*Bactrocera caudata*

8(2) Wing costal band confluent with R2+3 vein, and not expanded apically; lateral postsutural yellow vittae on scutum long, extending to about a level with intra-alar setae; scutum colour pattern highly variable, from almost entirely black to black with variable lanceolate orange-brown patterns to entirely orange-brown; abdomen yellowish brown, abdominal tergite 3 with a transverse black band across anterior margin; a median longitudinal black stripe extending over tergites 3-5, sometimes tergites 4 and 5 each with anterolateral black spots; all femora fulvous; males attracted to methyl eugenol ....*Bactrocera dorsalis*

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Preliminary studies on earthworm resource under Banana plantations in West Tripura

Shilpa Dhar and PS Chaudhuri*
Tripura University, Suryamaninagar, West Tripura, India
*Correspondence: priya_1956@rediffmail.com,

Introduction

Banana (*Musa paradisiaca*) is the second most important fruit crop in India next to mango. In Tripura, banana is probably the most well flourished fruit crop. Earthworm represents a major soil macro fauna of soil invertebrate biomass and are an important component of the decomposer fauna in many terrestrial ecosystem. They have a positive impact of variable magnitude on agricultural production through a variety of biological, chemical and physical mechanisms.

Methodology

The study was conducted during October to December, 2014 in Sekerkot, Mohanpur and Madhupur of West Tripura. Earthworms were sampled during the study by conventional digging and hand shorting method. Soil samples were collected from each experiment site at 0-15 cm depth. Collected soil samples were air dried, ground with mortar and pestle and sieved (1-2mm mesh). Sieved soil samples were analysed to determine soil moisture (Gravimetric wet weight method), pH (1.2:5 dilution method), soil organic matter. Index of general diversity, index of dominance was also measured.

Results and Discussion

The preliminary studies on the ecology of earthworms revealed the presence of 12 species of earthworms belonging to 4 families and 10 genera viz. Megascolecidae [*Metaphire houlleti, M. posthuma, Perionyx excavatus, Lampito mauritii, Amynthas alexandri*] *Kanchuria sp.*, Moniligastridae [*Drawida assamensis, D. papillifer papillifer*], Octochaetidae [(*Eutyphoeus comillahnus* Michaelsen), *Lennogaster sp.*, *Octochaetona beatrix* and Glossoscolecidae [*Pontoscolex corethururus*]. In studied sites mean temperature (^{0}C), moisture (%), pH and organic matter (%) content of soil were (24.5 ± 0.27), (19.36 ±0.94), (6.15±0.2) and (1.27±0.12) respectively. Density and biomass of earthworms were 120. ind. m^{-2} , 65 g m^{-2} respectively. Shannon's diversity index and Simpson's index of dominance were 1.48 and 0.65 respectively. Interestingly, *E. comillahnus* shows restricted distribution only in Tripura. The density and biomass of *P. corethrurus* contributed more than 50%. So, it can be considered as the dominant species of banana plantation. In banana plantation, soil pH (6.15) was higher compared to that of other plantations. Occurrence of large sized earthworms *viz. A. alexandri, M.houlleti, M.posthuma* is possibly responsible for the high biomass value in the studied plantation.

Table1. Earthworm population characteristics under banana plantation in West Tripura (India)

Family and Earthworm Species		Density (ind.m^{-2}) Mean ± S.E	Biomass (gm^{-2}) Mean ± S.E	Relative Abundance (%)	Frequency (%)
Megascolecidae	*Metaphire posthuma*	2.34±0.15	7.96±1.1	2.03	5.69
	Perionyx excavatus	2.18±0.69	4.26±1.2	1.35	1.62
	Lampitto mauritii	8.56±0.91	5.76±0.8	7.17	13
	Amynthas alexandri	1.17±0.2	3.5±0.8	0.9	2.43
	Kanchuria sp.	1.39±0.89	5.4±1.10	0.22	0.81
	Metaphire houlleti	8.33±1.64	15.19±1.2	7.23	26.01
Moniligastridae	*Drawida assamensis*	16.28±1.1	5.8±0.75	12.99	32.52
	D. papillifer papillifer	12.68±0.7	7.47± 0.92	9.94	28.45
Octochaetidae	*Eutyphoeus comillahnus*	0.91±0.5	1.45± 0.88	1.01	0.81
	Octochaetona beatrix	0.95±0.65	1.4±0.6	0.79	1.62
	Lennogaster Sp.	1.1±0.4	1.6±0 .22	1.12	3.25
Glossoscolecidae	*P. corethrurus*	63.60±2.56	26.77±2.1	55.25	78.04

New gerbera hybrids: a promising open-field technology for resource poor farmers

H Rymbai*, AK Jha, AR Roy, RS Assumi, NA Deshmukh, VK Verma, LK Mishra, W Shimray
ICAR Research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: rymbaihort@gmail.com

Introduction

Gerbera (*Gerbera jamesoni* Bolus) is an attractive cut flower crop belonging to the Asteraceae family, the largest family of flowering plants.

Methodology

The study was carried out to study the performance of the newly evolved hybrids of gerbera and their parents under open-field conditions at ICAR Research Complex for NEH Region, Umiam during 2013-15.

Results and Discussion

It was observed that among hybrids, RCGH-117 recorded maximum vegetative traits such as number of leaves (28.02 per plant), leaf length (32.79 cm) and plant spread (82.96 cm). Regarding flowering characters, RCGH-114 showed maximum stalk length (34.65 cm) while highest stalk diameter (4.49 mm), neck diameter (0.41 mm), flower diameter (10.85 cm), number of ray florets (171.62 per head), fresh weight of stalk (7.61 g) and fresh weight of flowers (6.63 g) were recorded in RCGH-117. Furthermore, field durability of flowers was maximum in RCGH-22 (7.65 days) while, RCGH-12 recorded maximum number of flowers (7.09 per plant per month and vase life (6.84 days). Among parents, Benzo recorded maximum number of leaves (24.98) and plant spread (64.67 cm), while maximum leaf length was obtained in J.S. Lal (28.04 cm). Alesmera showed maximum stalk length (41.14 cm), stalk diameter (5.24 mm) and fresh weight of flower (3.61 g). While, Benzo recorded maximum flower diameter (9.52 cm). J.S. Lal had maximum number of ray florets (95.13 per head), while, Alesmera had maximum field durability (7.69 days) and vaselife (7.2 days). Present result suggested that the new hybrids of gerbera would be potential hybrids for profitable cultivation of gerbera under open-field conditions for resource poor farmers catering domestic market demands.

Climate Change- Adaptation and Mitigation Strategies for Hills

- Stress tolerant crops, livestock
- Climate smart farming options
- Simulating agricultural processes

GHG emissions and mitigation: impact on agriculture, water and soil resources in NW Himalayas

UC Sharma*
222-Adarsh Enclave, Trikuta Nagar Sect. 1 Ext., Jammu-180012, J & K, India
*Correspondence: ucsharma2@rediffmail.com

The agricultural sector is an important source of ammonia (NH_3), nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2) to the atmosphere. Gaseous nitrogen compounds (NOx, N_2O, and NH_3) are known to cause severe environmental problems. Ammonia can lead to soil acidification and eutrophication of aquatic systems, NOx promotes ozone formation in the troposphere, and N_2O is a greenhouse gas and contributes to stratospheric ozone depletion. Nitrous oxide has a long atmospheric lifetime of 150 years, contributing to its large global warming potential (GWP), which is 310 times higher than that of CO_2. Methane, with a GWP of 21, is also a potent greenhouse gas that can affect climate directly through its interaction with long-wave infrared energy and indirectly through atmospheric oxidation reactions. Methane is second only to CO_2 in importance as a greenhouse gas and contributes around 18% of the greenhouse effect.

With its strong agricultural base and relatively low levels of heavy industrial activity, the North-western Himalayan states of India have relatively low greenhouse gases emission, compared to other states of the country. Changes of climate conditions influence energy fluxes, cycles of nutrients and materials, primary productivity, biodiversity, ecological functions and carbon equilibria of forest ecosystems; time factors influence physical, biological, ecological, and climatic processes and functions. For example, seasonality, cycles, periodicity, and trends in climate variables; tree growth, forest growth, and forest metabolic activities (i.e., photosynthesis and respiration) are commonly known to be time-related.

The GHG emission can be mitigated by improved feeding practices. Improving the quality of forages, processing feeds to improve digestibility, and adding grain-based concentrates to livestock diets, supplements and additives reduce methane by changing the microbiology of the rumen, usually without yield improvements and optimizing the health and reproductive capacity of herds can reduce the number of animals necessary to sustain a given level of production. Carbon sequestration potential from agroforestry systems adopted in mixed crop-livestock systems in humid and tropical highland areas of the developing world. Agroforestry systems may well have adoption potential across a wider range of agricultural systems. Agroforestry may particularly appropriate for grazing lands or mixed crop-livestock systems as they can provide shade and nutritional benefits for livestock and less likely to displace crops.

Climate change and agriculture in hill ecosystems – some adaptation and mitigation options

DJ Rajkhowa* and SV Ngachan
ICAR Research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: djrajkhowa@gmail.com

Agriculture in North eastern hill region is facing multifarious challenges like degradation of natural resources, deterioration in soil health, fragmentation of land, occurrence of dry spells in undulating hill topography, low crop productivity and securing food for increasing population. The climate variability, low availability of resources and lack of mitigation options with the farmers makes the challenges in further complex. Since 80% of the crop area is under rainfed, future climate change and variability will potentially impact agricultural production pattern in the region (Annon. 2004 GOI).The temperature is projected to rise by another 3–5°C in the North Eastern Region of India during the latter third of this century (Cline, 2007). Results of the recent study conducted by Ravindranath *et al.* (2011) indicate that majority of the districts in North East India are subject to climate induced vulnerability presently and in the near future. Trend of climate change as envisaged through change in rainfall behaviour in NE Region (Saikia 2011) revealed decline in the amount of monsoon rainfall (850-2350mm) and no. of rainy days (57-85 days) during 1991-2007 compared to (900-3000mm) and (65-91days) during 1951 – 1990.

There are large number of options in soil, water and nutrient management technologies which contribute to both adaption and mitigation. Introduction of improved climate resilient crop cultivars, crop diversification, integrated farming systems, introduction of suitable water management practices, rain water harvesting in –situ or ex-situ, improvement/renovation of natural water bodies, biochar and organic manure application, agroforestry intervention, conservation agriculture, integrated nutrient management and other resource conservation technologies are some of the options for sustaining agricultural productivity under climate change scenario. Such technologies can improve the sustainability of agriculture by conserving the resource base with higher input use efficiency and also mitigating GHGs emissions. Soil being one of the potential sinks for global carbon stock (3.5%), soil carbon management holds the key for developing effective adaptation strategy that would sustain the agricultural production, environmental health vis-à-vis food security and livelihood. Huge availability of plant biomass (5-20 t/ha) in the region may be utilized effectively for production use of organic manure (Rajkhowa and Manoj-kumar 2013). Adoption of appropriate package of practices, cropping systems, restoration of degraded lands, agroforestry interventions, conservation agriculture, integrated nutrient management etc. has great potential to sequester carbon and reduce the emission of methane, nitrous oxide and carbon dioxide to the atmosphere. Development of shelter, nutrition and health management practices for livestock are very much important in view of climatic extremes.

An understanding of the impacts and vulnerably of hill agriculture sector and comprehensive understanding of adaptation options is essential. A multi-pronged strategy of using indigenous coping mechanism, wider adaptation of the existing resource conservation technologies and concerted research and development efforts for evolving new technologies are needed for adaption and mitigation. Crop diversification and insurance, information management and capacity building among farmers and other stakeholders are also important in the overall strategies of water resource management.

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Agroforestry *vis-a-vis* climate change

A Arunachalam*
Indian Council of Agricultural Research, Krishi Bhawan, New Delhi
*Correspondence: arun70@gmail.com

Agroforestry, a traditional land use practice designed to suit to the local conditions, food requirements, and cultural integration, has been diversely practiced given the variations in agro-climatic regime and cultural diversity in the country. At regional level, the tree-based farming systems have been integral part of human civilization and hence huge traditional ecological knowledge base exists on the practice *per se*. Given the global climate change scenario, the developing world in the humid tropics particularly in South Asia are experiencing a global challenge of mitigating greenhouse gas emission, where agroforestry practices could help in manuring carbon sequestration process. Likewise, the agroforestry or any tree-based farming system has also intangible benefits such as soil and water conservation, carbon sequestration, *etc*. that has been classified as environmental services. Thus, the systems of agroforestry are having ecological linkages with human ethics and economic benefits.

Prediction of plant disease distribution under climate change Scenario - using CLIMEX software

Raghuveer Singh*, R Bhagawati and Letgam Thouthang
ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar
*Correspondence: singhraghuver@gmail.com

Introduction

Climate change is the biggest threat of the present century. According to a study (Meckinnon 2012), it is already costing the world more than US$ 1.2 trillion, thus wiping 1.6% annually from the global GDP. Climate change is the result of the acceleration in the increase in temperature and CO_2 concentration over the last 100 years. Up to the 1990s, there was little information about climate change impacts on plant disease. Manning and von Tiedemann 1995 recognized that, there was limited knowledge about observed and predicted impacts of climate change on plant epidemics. However, plant pathologists already realized in the 1990s that climate change was clearly set to pose a challenge to many patho-systems. It is now recognized that climate change will affect plant diseases together with other components of global change. Predictions on how changes in climate will affect plant health at various spatio-temporal scales are based on: (i) Already observed effects of climate change on plant diseases, (ii) Extrapolation from expert knowledge and experimental studies and (iii) Computer models.

It is widely acknowledged that climate change is likely to be pervasive across the planet, and will thus be relevant to most of the many existing (and yet to arise) plant health issues. It is important to anticipate invasion risks from both exotic and indigenous pests under climate change scenario. Ecological niche models are defined here as correlative models that predict a species' potential geographical range based on two types of geo-referenced data, biological data describing the species' known distribution (presence and absence) and environmental data which describe the landscape conditions where the species is found (Venette and Cohen 2006). A broad range of algorithms are used in these models. Because of their reliance on environmental data, e.g., climatic or weather data, these models are well suited to studies of the effect of climate change on plant disease, and exotic pest introductions.

The ability of ecological niche models to use limited data such as species presence and generic environmental data makes them complementary to simulation models. In many cases correlative approaches can provide a reasonable indication of high-risk areas for prioritization. Climate envelope models, which involve climate matching, have been used to create predictive maps of critical pests' risk. CLIMEX and NAPPFAST, for instance, have been used by plant pathologists for predicting plant disease occurrences. CLIMEX (Sutherest *et al.,* 2004) has been used by plant pathologists to predict the likelihood of pathogen establishment under current climatic conditions or, more rarely, under climate change scenarios (Paul *et al.* 2005).

Methodology

CLIMEX software, disease incidence data for the India as well as for South Asia. Development of baseline model to characterize suitability of regional climates for facilitating stem rust infection using CLIMEX model (Sutherest *et al.,* 2004). (i) Database climate normals with monthly/weekly for 35 locations along with known locations of Asia; mean, max. and min. air temp, precipitation, RH (morning & afternoon) from 1971-2000. (ii) Develop CLIMEX indices for each locations using eco-climatic index estimation of Eco-climatic index (EI); EI = $[100/52 \sum (TI_w \times MI_w)] \times [(1\text{-}CS/100)(1\text{-}HS/100)(1\text{-}DS/100)(1\text{-}WS/100)]$. Whereas; TI_w= temperature index for week (w); MI_w= moisture index for week (w), CS= annual cold stress, HS = annual heat stress, DS = annual drought stress and WS= annual wet stress. For compare locations and EI values are assigned between 0 and 100 (Salinari *et al.,* 2006): 0 unsuitable; 1-10 marginal; 11-25 favourable; ≥26 highly favourable for establishment. Model parameters selection: Parameters estimates selection based on the available information on the pathogen and its past or current distribution. (i) **Temperature:** DV0 (lower limit of growth); DV1 (lower optimum for growth); DV2 (upper optimum for growth); DV3 (upper limit for growth). Values to be derived through laboratory experiment or its geographic distribution. (ii) **Soil moisture:** SM0 (lower limit of growth); SM1 (lower optimum for growth); SM2 (upper optimum for growth); SM3 (upper limit for growth). Cold, heat, dry and wet stress would be adjusted as 0 or values if available. Model values would be exported to GIS to interpolate values between weather data centres (stations) and measure map attributes. Interpolation through optimized inverse distance weighting method.

Sensitivity analysis of CLIMEX: Baseline model would be tested to evaluate impact of parameter uncertainty on results. Parameters on temperature and high RH hours on pathogen population growth would be adjusted accordingly one by one with constraints DV0<DV1<DV2<DV3 and SM0<SM1<SM2<SM3.

- CLIMEX predicts the effect of climate change on species distribution, using simulation and modeling techniques. CLIMEX attempts to mimic the biological mechanisms that limit species' geographical distribution and determine their seasonal phenology and relative abundance.
- CLIMEX enables you to assess the risk of a pest establishing in a new location and the potential success or failure of a biological control agent with no knowledge of the species, except for knowing the current locations they do occur.
- CLIMEX model predicts a species' potential geographical range based on geo-referenced data, species distribution (presence and absence) and environmental data which describe the landscape conditions where the species is found.
- Future distribution of an epidemic provides support for developing strategies against new threats.

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Carbon sequestration potential and retention efficiency of rice based cropping systems of North Eastern Hilly Region of India

Gulab Singh Yadav*, Mrinmoy Datta, Subhash Babu, Chandan Debnath, H Lembisana Devi and Poulami Saha
ICAR Research Complex for NEH Region, Tripura Centre, West Tripura, Tripura India
*Correspondence: gulab.iari@gmail.com

Introduction

Sequestration of carbon (C) in arable soils has been considered as a potential mechanism to mitigate the elevated levels of atmospheric greenhouse gases. Storing C in soil of the arable ecosystems has the potential to offset a portion of the future atmospheric increases in CO_2. Rice based cropping systems (RBCS) with minimal soil disturbance and residue retention are economically and ecologically more viable option as they save energy and provide favourable soil conditions for sustainable crop production and soil organic carbon (SOC) sequestration for future posterity. However, the rate of added C in the fields under different RBCS in a sub-tropical agro-ecosystem is not yet properly known. The state of Tripura in north eastern region (NER) of India falls under Eastern Himalayas is a highly fragile ecosystem under humid subtropical climate (Ghosh *et al*. 2009) with high rainfall (>2000 mm per annum). Tripura is predominantly under rice (*Oryzasativa*) cultivation. Decline in SOC has been a principal constraint in realizing higher yields. Hence, it is warranted to identify and adopt appropriate cropping systems to improve, and sustain soil quality. Therefore, resource conservation issues have drawn the attention of researchers to identified suitable RBCS for higher productivity and SOC sequestration.

Methodology

The experiments were conducted during 2012-13 and 2013-14 at the experimental farm of ICAR Research Complex for North East Region, Tripura Centre, Lembucherra, Tripura (W), India ($23^0$54'24.02" N and $91^0$18'58.35"E) situated at an altitude of 162 m ASL (above mean sea level). The annual rainfall of the region is 2200 mm; however, cumulative rainfalls were 1990.2 and 2054.8 mm respectively during the periods of investigation. The study was consisted of seven cropping systems namely rice-mustard (R-T), rice-lentil (R-L), rice-field pea (R-F), rice-garden pea (R-V), rice-greengram (R-G), rice-blackgram (R-B) and rice-maize (R-M). All these systems were arranged in a randomized block design (RBD) with three replications for each treatment. The net plot size was 12 m^2. For rice in *kharif*, all plots were ploughed twice and tilled once with a power tiller. Thereafter, water was flooded to about 10 cm height for 24 h for puddling. Winter crops were sown after the harvest of rice with no-till. Glyphosate [N-(phosphonomethyl) glycine] was applied @ 5 ml l^{-1} seven days prior to sowing to control weeds. All crops were sown following their recommended package of practices in the second fortnight of November during both the years. Pendimethalin (3, 4-Dimethyl-2, 6-dinitro-*N*-pentan-3-yl-aniline) was applied @ 1.25 kg *a.i*ha^{-1} after sowing and before emergence of crops. Only one intercultural operation, along with weeding was performed in all the crops. Crops were raised on residual soil moisture and fertility. Nutritional requirements of the crops were met through the application of farmyard manure (FYM) and mineral fertilizers. Harvesting of rice was done in such a way that 50-60% stubble remained in the field for conservation of soil moisture. Winter crops were harvested at different dates. Residues of all *rabi* crops were incorporated in soil during rice field preparation to maintain the system more sustainable. Yields of main and by-products of each crop under various cropping systems were measured by harvesting 12 m^2 areas in each plot based on physiological maturity of respective crops. Economic part of individual crops was separated manually after harvesting. All crops were cut at about 15 cm from the surface, and residue was incorporated in soil after measurement except rice. For estimation of carbon in soil and computation of SOC stock, sequestration and carbon retention efficiency, about 1 kg bulk samples composed of three sub-samples were taken from each treatment at 15 cm depth at the end of the experiment. Half of the bulk sample was air-dried, grinded and sieved through a 2 mm diameter. Total SOC stock of the profile (Mg ha^{-1}) for each of the two depths (0–15 cm and 15–30 cm) by the equation (1) following Srinivasarao *et al*. (2012):

Profile SOC stock = SOC concentration (gkg^{-1}) ×Bulk density (Mgm^{-3}) ×depth (m) ×10   (1)

Sequestration of SOC was computed as per equation (2) given below

C sequestered (Mg Cha^{-1} soil) = SOC current – SOC initial   (2)

Carbon retention efficiency (CRE) was calculated by the following relationship following Bhattacharyya *et al*. (2009): equation (3)

CRE (%) = (SOC final – SOC initial) ×100 ÷ ECI   (3)

SOC final and SOC initial represent SOC ($Mgha^{-1}$) in the final and initial soils, respectively, and ECI is cumulative estimated C input ($Mgha^{-1}$) to soil between the initial and final year of experimentation.

Results and Discussion

The aboveground biomass was significantly (p=0.05) varied among the cropping systems. The amount of biomass added varied from 15 $Mgha^{-1}$ to 23.3 $Mgha^{-1}$. However, highest biomass was added under R-M system, because of production of more biomass. About 6.1-9.5 Mg Cha^{-1} was added to the soil (0–15 cm) through residues incorporation/retention under different RBCS (Table 1). Total residue and C addition under R-M was higher than that under other cropping systems, mainly due to higher aboveground residue production and addition. Among all, the highest plant derived C (9.5 Mg Cha^{-1}) was added under R–M system due to addition of more residues (Table 1).The SOC varied under different cropping system (Table 1).

Table 1. Biomass input, carbon storage, sequestration and retention efficiency of RBCS

Treatment	Total biomass input (Mg ha^{-1})	Total carbon input ($Mgha^{-1}$)	Soil organic carbon content (%)	Carbon stock ($Mgha^{-1}$) in 0-15 cm soil depth	Carbon sequestration rate (Mg ha^{-1} $year^{-1}$)	Carbon retention efficiency (%)
R-T	17.9	7.3	0.733	15.6	0.24	6.78
R-L	17.6	7.2	0.731	15.5	0.22	6.22
R-F	19.1	7.8	0.740	15.8	0.32	8.15
R-V	18.4	7.5	0.736	15.7	0.28	7.35
R-G	15.1	6.2	0.723	15.4	0.14	4.49
R-B	15.0	6.1	0.722	15.4	0.13	4.17
R-M	23.3	9.5	0.750	16.0	0.43	8.98
LSD (*p=0.05*)	0.77	0.32	NS	NS	0.03	0.84

R: Rice; T: Mustard (toria); L: Lentil; F: Field Pea; V: Gardenpea (Vegetable pea); G: Greengram; B: Blackgram; M: Maize.

SOC at 0-15 cm soil depth was higher with R–M and R–F systems than those under other systems. The C stocks C sequestration was also significantly varied under different RBCS. The highest carbon stocks and C sequestration were recorded with R–M and R–F systems than those under other systems. Carbon retention efficiencies in the R–M and R–F systems plots were 8.98%and 8.15%, respectively and were much higher than R–B and R–G systems (Table 1).

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Effect of biochar on the productivity of maize-Frenchbean cropping system

*Ramkrushna GI, Anup Das, Sandip Mandal, Jayanta Layek, BC Verma, Krishnappa R, S Heipormi, DJ Rajkhowa, AS Panwar and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalaya- 793103

*Correspondence: rgidu@yahoo.co.in

Introduction

In the climate change scenario, carbon sequestration through biochar application is one of the important management practices to improve soil properties. Biochar is the carbon-rich solid product produced by the heating of biomass in an oxygen-limited environment. It can store carbon in soil for more than 100 to 1000 of years. The importance of biochar for soil improvement is due to its large surface area and presence of more number of micro pores, which provide a microhabitat for beneficial soil microorganisms and enable moisture retention and adsorption of nutrients. When biochar is applied to soil, it improves physical (soil water retention, hydraulic conductivity etc.) and chemical (pH, CEC etc.) properties of soil which lead to higher crop yield (Lehmann *et al.* 2003; Zwieten *et al.* 2010). Grain yield and yield components of maize are reported to increase when biochar is used as soil amendment, because it improves the field-saturated hydraulic conductivity, as a result net water use efficiency also increase and more moisture and nutrients are available to the crop throughout the growing season (Steiner e*t al.* 2007).

Methodology

A field experiment was conducted in upland agronomy research farm, ICAR Research Complex for NEH region, Umiam, Meghalaya during the years 2013-15. The field is located at latitude $25^0$41'23.21" N and longitude $91^0$55'19.27" E with elevation of 956 meter above mean sea level. The biochar was applied only once before the start of experiment and mixed thoroughly into the soil. During *kharif* season, maize crop (var. DA 61 A) was grown with three levels of biochar treatments (2.5 t ha^{-1}, 5.0 t ha^{-1} and no biochar /control) and four levels of fertilizer treatments (100 % RDF i.e 80:60:40 kg N, P_2O_5 and K_2O ha^{-1}, 75 % RDF, 75 % RDF + 4 t ha^{-1} FYM and 50 % RDF). French bean was grown immediately after harvest of maize under no tillage with same set of nutrient treatments as that of maize. The maize crop was cultivated for grain and French bean for green pod purpose. The experiment was conducted in factorial randomized block design (FRBD) in three replications with twelve treatments combination. The plot size is 12 m^2 with spacing 50 cm x 25 cm. The maize crop was grown under rainfed situation with two hand weeding at 25 and 50 days after sowing, Yield and yield attributes influenced by different treatments were recorded precisely. Soil organic carbon (SOC), exchangeable aluminum, soil microbial biomass carbon (SMBC) and dehydrogenase enzyme content of soil were also studied in the experiment. Soil moisture profile study at 0-150 mm and 150-300 mm depth was carried out in French bean crop.

Result and discussion

The grain yield of maize improved with the increase in rate of application of biochar. The maximum grain yield of maize (4376 kg ha^{-1}) was obtained with the application of biochar at 5.0 t ha^{-1}, followed by 2.5 t ha^{-1} (3296 kg ha^{-1}) which was significantly superior over no biochar application (2368 kg ha^{-1}). In nutrient management treatment, combined application of 75 per cent RDF and 4 t ha^{-1} FYM recorded higher grain yield (3631 kg ha^{-1}) and the treatment which received 50 per cent RDF produced lowest grain yield of maize (2914 kg ha^{-1}). There was no significant effect of different level of biochar and nutrient management practices on number of seed rows cob^{-1} and 100 seed weight. However, higher 100 seed weight (29.7 g) was obtained with the application of 75 per cent RDF and 4 t ha^{-1} FYM. The number of seeds cob^{-1} and seed weight cob^{-1} were obtained significantly higher with the application of 5.0 t ha^{-1} biochar followed by biochar 2.5 t ha^{-1} treatment. Integration of 75 per cent RDF and 4 t ha^{-1} FYM recorded higher number of seeds cob^{-1} (379) and seed weight cob^{-1} (94.9) over other nutrient management treatments.

SOC, exchangeable aluminum, SMBC and dehydrogenase enzyme content of soil at 0-15 cm soil depth were found positively improved with the application of biochar. The highest SOC was observed with biochar application at 5.0 t/ha and was statistically superior over no biochar and biocar application with 2.5 t/ha. Application of 75% RDF with 4 t/ha FYM improved SOC content in soil significantly over other treatments. Soil moisture profile study at 0-15 cm and 15-30 cm depth showed higher soil moisture content under biochar applied with 5.0 t/ha as compared to application of biochar at 2.5 t/ha and no biochar application in both the layers of soil.

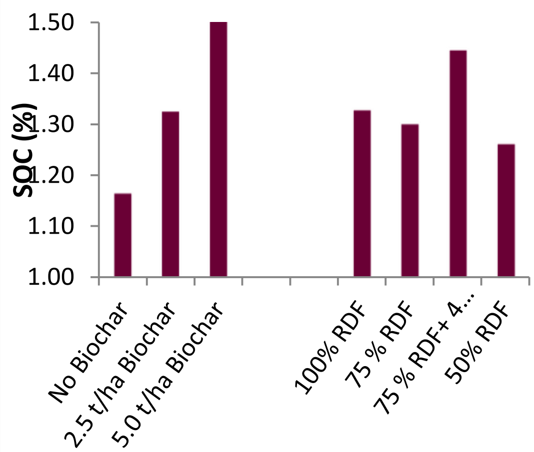

Fig 1. SOC as influenced by different levels of biochar and nutrient management practices

The results from the study showed that the use of biochar in combination with fertilizers improved the grain yield and yield attributes of maize crop. The increased grain yield and yield components with application the biochar may due to the improved of physico-chemical and biological qualities of the soil. Thus, biochar may offer a win-win technology for sustainable maize production system.

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Carbon mineralization from residues and biochar at elevated temperature

BC Verma*, Manoj Kumar, DJ Rajkhowa, S Hazarika, Ramkrushna GI, Ramesh T, P Moirangthem, D Bhuyan, NS Azad Thakur and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, 793103, Meghalaya, India

*Correspondence: bibhash.ssac@gmail.com

Introduction

Rice and maize are the two most important crops in India including the north eastern part of the country. Besides the economic part (grain), it also produces huge quantities of residues (above and below ground biomass). One of the major concerns in production of these crops is the disposal of their residues. Crop residues are mainly burnt after harvest in the main growing regions, which results in hugeloss of carbon and nutrients to the atmosphere resulting in environmental pollution. In recent years, researchers have come up with a better option, to convert these residues into biochar. Biochar is a carbon-enriched product made by thermal decomposition (pyrolysis) of organic materials like wood, manure, crop residues with limited supply of oxygen, and at relatively low temperatures (<700° C) (Lehmann and Joseph 2009). Production of biochar from different crop residues and its incorporation in soil has been proposed by many researchers to improve soil organic carbon stock while improving soil fertility and productivity by influencing soil properties (Liang *et al.* 2006; Asai *et al.* 2009). However there is very limited information available on the mineralization kinetics of biochar prepared from crop residues. With this context, an incubation experiment was conducted to see the carbon mineralization pattern of rice and maize residues and their biochar at elevated temperature.

Methodology

The incubation study was conducted with the rice and maize residues along with the biochar prepared from them. These four sources were applied at two different rates (0.5 and 1%) of the soil weight. Altogether nine treatments combinations [(4 X 2 +1 (control)] were maintained at two moisture levels (field capacity and half of field capacity) and kept at 28^0C in the incubator. These incubated sets were kept for the different durations *viz.* 1,2,4,8 and 12 weeks. To study the carbon mineralization (as release of CO_2), a vial containing NaOH was placed in the conical flask with the help of string and tightly tied with the cork. Mouth of the conical flask was sealed with the cork to ensure that there was no leakage of CO_2 from the conical flask. Carbon di-oxide (CO_2) flux, as measure of C mineralization, was determined by the procedure of Parr and Smith (1969). The vial containing NaOH was taken out and solution was transferred to conical flask with 2-3 washing with distilled water. Excess amount of 1*M* $BaCl_2$was added to saturate the solution, where Na_2CO_3 was converted into $BaCO_3$. Remaining (unreacted) amount of NaOH was determined by titrating with HCl in presence of phenolphthalein indicator. Amount of reacted (consumed) NaOH gave the quantification of C released as CO_2 flux.

Results

Results revealed that, on an average cumulative carbon mineralization (CO_2 flux) was 8% higher in the samples maintained at field capacity (FC) in comparison to the half of field capacity (1/2FC) moisture regimes. It implies that favorable moisture regimes trigger the mineralization. Cumulative CO_2 flux was increasing over the time durations of 1, 2, 4, 8 and 12 weeks. However the increase in carbon flux had not been constant throughout the durations. It was observed that, percentage increase in the CO_2 flux was37, 18, 38 and 10% between the duration of 1-2 weeks, 2-4 weeks, 4-8 weeks and 8-12 weeks, respectively. From this, it can be inferred that the maximum CO_2 flux rate was achieved initially up to the 2 weeks and there was a decline afterwards. Higher CO_2 flux was recorded from the samples containing rice residues as compared to maize residues irrespective of the doses; however, flux was significantly higher at 1% than 0.5% of residue addition. Carbon flux from biochar amended soil was almost similar to control (soil), and it was significantly lower than the residues treated soil. It was also observed that CO_2 flux did not significantly increase in case of biochar, when the rate was increased from 0.5% to 1%.

It is concluded from the study that, optimum moisture condition triggers the CO_2 flux and the rate of increase remains higher initially up to 2 weeks and decreases thereafter. Between the rice and maize residues, rice residues are more susceptible to the mineralization. Conversion of residues into biochar can drastically reduce the CO_2 flux from the soil if amended with the biochar. Thus, biochar amendment is one of the viable options to sequester carbon in soil and reduce the emission of greenhouse gases in changing climate scenario. However, the extent of benefit depends upon the nature and properties of biochar and the substrate from which it is prepared.

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Non-conventional feed resources for sustainable livestock farming in changing climate scenario in Arunachal Pradesh: a review

Doni Jini*, RA Alone, R Bhagawati, MS Baruah, Nirmal and M Kanwat
ICAR Research Complex for NEH Region, Arunachal Pradesh centre, Basar
*Correspondence: donoxini@gmail.com

In Arunachal Pradesh, a distinctive gap exists between the requirements and supplies of nutrients for livestock. It is desirable that adequate feed resources should be built up as one of the mitigation strategy in response to changing climate scenario. A feasible and hence, the most viable proposition could be the inclusion of non-conventional feed resources (NCFR) in livestock rations with suitable and complete feed technology that can utilize the feed sources with maximum efficiency. For the objective of this review, potentially available NCFR in the state include crop residues, plantation wastes and browse foliage. It is known that some of these products are low in energy, proteins and contain high concentrations of lignin, silica and several anti- nutritional substances. Numerous multipurpose browse trees and shrubs have been identified as having significant potential in agro-forestry systems in the region. Browse plants that have been identified and have recently been studied include *Gmelina arborea*, *Moringa oleifera*,*Trema orientalis*, *Terminalia catappa*, *Ficus hirta*, *Bauhinia purpurea* and Bamboos. Protein from plant leaf sources is perhaps the most naturally abundant and cheapest source of protein, such that there has been growing realization in use of plant leaf meals in livestock diets. Several authors have conducted studies on these leaves to determine their nutritive values and usefulness in livestock nutrition. Results obtained from these studies have shown beneficial and economic values from the inclusion of these leaf meals in the diet of livestock.

Critical dry-spell analysis for rain-fed farming in Meghalaya

Lala IP Ray*, SM Feroze, Ram Singh and J Panda

College of Postgraduate Studies, (Central Agricultural University), Umiam, Meghalaya

Correspondence: lalaipray@rediffmail.com

Introduction

The occurrence of critical dry-spell during the rainy season is a matter of concern for the rainfed farmers. To overcome these difficulty suitable suggestive measures may be put in use in addition to contingent planning. The crop yield in rainfed condition depends not only on the amount but also on the distribution of the rainfall pattern. For carrying out agricultural operations, specific information needed for crop planning and sequential phenomena like dry and wet spells (Panigrahi and Panda 2002; Dixit *et al*. 2005). Northeastern states of India fall under high rainfall zone and have a great dependence on rainfall for farming. An effort has been made in this paper to find out the occurrence of dry spell in seven districts of Meghalaya- a northeastern state. The net cropped area of Meghalaya is 2, 82,939 ha with a cropping intensity of 120%. Mono-cropped area is near about 48% of net cropped area. Rice is the main crop of this state with an average productivity of 1.8 t ha^{-1}, with a coverage area of 1, 08,162 ha.

Methodology

For the probability of occurrence of dry and wet week, Markov Chain Probability model was used (Markov 1878). This model analyses sequences of random variables in which the future variable is determined by the present variable but is independent of the way in which the present state has aroused from its predecessors. The Markov model assumes that the future is independent of the past given the present. For the present investigation, two types of scenarios were considered, *viz*., a day is a dry day if rainfall is less than 2.5 mm and rainy day if rainfall is 2.5 mm or more. Markov Chain Probability model package with source code written in FORTAN language was used to analyse the rainfall data. Historic point rainfall data of seven stations (*viz*., East Garo hills district, West Garo hills distict, South Garo hills district, East Khasi hills district, West Khasi hills district, West Jaintia hills district and Ri-bhoi district) of Meghalaya was analyzed with standard protocol.

Results and discussion

The geo co-ordinates of the stations of Garo hills districts, Khasi hills districts, West Jaintia hills district and Ri-bhoi district are presented in Table1. The average annual rainfall along with the rainy days with extreme rainfall events, critical findings and trend of annual rainfall are also presented in Table 1. The annual rainfall of Tura (West Garo hills district) is high (4,851.5 mm), however, the annual rainfall of Jowai (West Jaintia hills district) is 6025.3 mm with 135 numbers of rainy days. The annual rainfall of Jowai was 16,443.3 in 1986. The annual rainfall trend was found to be more or less linear for Shillong and Barapani station, but an increasing trend of rainfall was observed for William Nagar and Tura station. A decrease in rainfall trend was observed for rest stations, *viz*., Baghmara, Nongstoin, Jowai and Nongpoh.

Probability of dry week was analysed for eight different station of Meghalaya. It may be observed that the probability is high for Garo hills district as compared to Ri-bhoi, Khasi hills and West Jaintia district. It has been found that for station Tura and Jowai the chance of critical dry spell is nil, however, Barapani, Nongpoh, Nongstoin and Shillong suitable measures may be taken to overcome the critical dry-spell by creating suitable irrigation facilities.

Suitable contingency crop planning of the existing cropping pattern may be done to overcome the dry spell conditions either by pre-poning or post-poning the sowing date and transplanting of rice. For, Tura and Jowai station the chance of critical dry spell is nil, however, Barapani, Nongpoh, Nongstoin and Shillong suitable measures may be taken to overcome the critical dry-spell by creating suitable irrigation facilities. Crop diversification may be done along with suitable resource conservation techniques for self-sustainable crop production.

Table 1. Description of the station with annual rainfall (rainy days) extreme rainfall events (year), critical findings on dry spell and trend of annual rainfall

Station with Geo Co-ordinates	Average annual rainfall, mm (rainy days)	Extreme rainfall, mm		Critical findings on dry spell	Trend of annual rainfall
		Maximum (year)	Minimum (year)		
William Nagar (89^0 to 91^0 E; 25^0 to 26^0 N; altitude less than 300 m)	3,245.8 (115)	4,231.0 (2000)	2,108.7 (2006)	➢ 28^{th} to 33^{rd}; 38^{th} and 39^{th} SMW	Increasing
Tura (89^0 40`to $90^0$ 30` E;25^0 20` to 26^0 N; altitude 625 m)	4,851.5 (113)	7,584.5 (1984)	3,454.8 (1997)	➢ Nil	Increasing
Baghmara (90^0 38` 30.5`` E; $25^0$ 12` 30.6`` N; altitude 120 m)	2,043.3 (103)	2,334.0 (2004)	1551.4 (2009)	➢ 33^{rd}, 37^{th} to 40^{th} SMW	Decreasing
Shillong (91^0 88` E $25^0$ 57`N; altitude 1,496 m)	2,485.6 (127)	7,425.6 (1980)	1,019.7 (2006)	➢ 22^{nd} to 27^{th}, 29^{th}, 35^{th} and 38^{th} SMW with 50% chances	More or less linear
Nongstoin (90^0 44` to $91^0$ 49` E; 25^0 10` to $25^0$ 51` N; altitude 1,200 m)	3,529.4 (118)	6,189.2 (1988)	1,825.0 (1998)	➢ 37^{th} to 40^{th} SMW with 50% chances	Decreasing
Jowai (91^0 59` to $92^0$ 51` E; 20^0 58` to $26^0$ 03` N; altitude 1,350 m)	6,025.3 (135)	16,443.3 (1986)	2,865.1 (2006)	➢ Nil	Decreasing
Barapani (91^0 55` 25`` E; $25^0$ 41` 21`` N; altitude 1,010 m)	2,410.4 (129)	3,322.6 (1988)	1,808.2 (1998)	➢ 29^{th}, 33^{rd} to 34^{th} SMW with 50% chance	More or less linear
Nongpoh (91^0 40`16`` E; 25^0 40` to $26^0$ 20` N; altitude 620 m)	2,147.0 (117)	2,496.7 (1991)	1,766.8 (1996)	➢ 22^{nd} , 38^{th} to 40^{th} SMW with 50% chance	Decreasing

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Biomass and carbon stock along with elevation in Silvipasture and Grassland of Giri catchment in North Western Indian Himalaya

Matber Singh[1,2,*], B Gupta[2], Shaon Kumar Das[1] and R. K. Avasthe[1]

[1]*ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok, India*

[2]*Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Solan, India*

*Correspondence: matber_singh@yahoo.co.in

Introduction

Variation in biomass and carbon sequestration potential of different agroforestry systems along elevation gradient has attracted worldwide attention following the recognition of agroforestry as a greenhouse gas mitigation strategy. Our information on this topic from the temperate regions of North Western Indian Himalaya is, however, very limited. The objective of this paper was to analyze the biomass and carbon stock along with elevation in Silvipasture and Grassland of Giri catchment, Himachal Pradesh, India.

Methodology

Present investigation was carried out in Giri catchment located between 30^o 33′ 48″ and 31^o 16′ 08″ N latitude and 77^o 02′ 32″ to 77^o 38′ 22″ E longitude in Himachal Pradesh. The climate in this area is sub-humid and sub-tropical in lower parts of the track lying in the Shivaliks and wet-temperate in the upper parts in north-west Himalaya.

Result and Discussion

In Giri catchment, 13 sub-watersheds were selected for study and stratified into three elevations, six vegetation systems viz., agrisilviculture (S_1), agrihorticulture (S_2), agrihortisilviculture (S_3), agrisilvihorticulture (S_4), silvipasture (S_5) and grasslands (S_6) at each elevation were selected to study vegetation composition, phytosociology, biomass and carbon stock. Average fodder and fuel wood consumption was 55.44 and 26.44 kg/household/day, respectively. Prominent tree components in agroforestry systems were *Grewia*, *Toona*, *Morus*, *Celtis*, *Ficus* and *Bauhinia* which were retained on the bunds of agriculture fields, whereas fruit trees of pear, apricot, peach and plum were planted at specified spacing in agriculture fields. In silvipasture systems record 88 genera with 93 species, whereas 86 genera with 94 species in grasslands. The number of species of grasses, sedges, forbs, legumes and shrubs in silvipasture systems were 20, 4, 31, 4 and 27, respectively, whereas in grasslands they were 22, 4, 36, 5 and 27, respectively. At elevation E_1 (900-1300 m), in silvipasture and grasslands, density (tillers/m^2) of herbage vegetation was highest than other elevations E_2 (1301-1700 m) and E_3 (1701-2200 m) and their values ranged from 657.73 to 984.67 and 543.63 to 1250.67, respectively. Mean aboveground biomass of vegetation in different systems decreased significantly in the order: S_5 (70.63 t ha^{-1}) > S_4 (63.13 t ha^{-1}) > S_3 (60.95 t ha^{-1}) > S_1 (48.63 t ha^{-1}) > S_2 (46.85 t ha^{-1}) > S_6 (3.13 t ha^{-1}). The belowground and total biomass followed the trend of aboveground biomass. Total biomass of vegetation in different systems decreased significantly in the order: S_5 (89.24 t ha^{-1}) > S_4 (81.98 t ha^{-1}) > S_3 (78.97 t ha^{-1}) > S_1 (63.13 t ha^{-1}) > S_2 (60.57 t ha^{-1}) > S_6 (4.93 t ha^{-1}). The mean aboveground carbon was significantly higher (35.32 t C ha^{-1}) in silvipasture than all other systems. The total carbon stored by vegetation in systems was highest at elevation E_3 (35.50 t C $ha^{-1}ha^{-1}$) and it decreased significantly with decrease in elevation.

Thus, the potential for soil C sequestration varied greatly among different agroforestry systems due to the differences in micro climate, soil type and also in elevation, illustrating that different agroforestry system is important for future C sequestration.

Interventions in abiotic stress management in fruits through rootstocks and prospects in the North East hilly ecosystem

KS Thingreingam Irenaeus[1], SC Das[2] and SK Mitra[3]
[1,2]*College of Agriculture, Tripura.*
[3]*Section of Tropical and Subtropical Fruits, ISHS (Belgium), West Bengal*
*Correspondence: angamire@yahoo.co.in

Abiotic stresses occur in different forms of which the major ones to crop productivity worldwide include drought, extreme temperatures, salinity and nutrient imbalances, and can be most harmful when they occur together (Mittler 2006). Rootstocks are essential for the ability of plants to adapt to abiotic stresses by mediating a wide range of adaptive responses (Mitra and Irenaeus 2015). Rootstocks in fruit production has been successfully exploited in many parts of the world and it affect the plant in various ways - vigour and tree size, canopy pattern, precocity, fruit production, maturity, quality, anchorage, water and nutrient absorption, storage of photosynthates, hormone synthesis, tolerance to extreme temperature, adverse soil conditions, disease resistance etc. However in northeast India, the knowledge and use of rootstocks in fruit industry is minimal and many orchardists still use seedlings and practice the traditional way of propagation. Latitudinal and altitudinal shifts in ecological and agro-economic zones, land degradation, extreme geophysical events, reduced water availability, rise in sea level and salinization are postulated. The different fruit species with varying levels of adaptabilities to environmental conditions is influenced due to such changes resulting in shift of cultivation and genetic erosion. Various plant processes like vegetative growth, flowering, fruiting and fruit quality are highly vulnerable to stress due to these changes.

Sweet orange trees grafted on Cleopatra mandarin had better plant water status under deficit irrigation stimulating greater vegetative growth than for those on Carrizo citrange. 'Cravo FCAV', 'Cravo Limeira', 'Rangpur' limes showed tolerance to drought. 'Valencia' orange grafted on FA-5 rootstock (Cleopatra mandarin x *Poncirus trifoliata*) also showed higher drought tolerance than its parents. Use of tetraploids (4×) rootstocks has been emphasised in particular with development of somatic hybrids that combine the traits of two parents. tetraploidization induced considerable changes in leaf primary and secondary metabolite accumulation in *C. junos* cv. Ziyang xiangcheng.

It was possible to generate plants resistant to abiotic stressors such as alkalinity, salinity and drought by combining a genome of *Poncirus trifoliata* with a citrus genome such as Cleopatra mandarin (*Citrus reshni* Hort. Ex Tan.) besides other biotic stresses like tristeza and Phytopthora.*Malus prunifolia* and a line of *M. Sieversii*, GMAL3975.k are most drought-resistant rootstocks among apple rootstocks. *M. hupehensis* which thrives in wet habitats though is highly resistant to water-logging, shade, cold, and disease is vulnerable to drought. For grapes rootstocks from *V. berlandieri* x *V. rupestris* and *V. berlandieri* x *V. riparia* are drought tolerant. In areas where water is a limiting factor to grapevine productivity, using drought resistant rootstocks '110R', '140Ru' and '1103P' should be beneficial. *V. cinerea* was considered to be flooding tolerant. Rootstock '3309C' exhibited flooding tolerance, cold hardy with faster acclimation in fall and deacclimation in spring while 'K5BB' and '1103P' showed less frost damage.

Temperature stress greatly affects the reproductive physiology in fruits crops reducing the plant productivity. Genotype variations in response to temperature stress have been reported. In mango, rootstock Carabao was found tolerant to different cold temperature conditions. In peach, rootstock, cultivar and their interaction significantly affected the extent of frost damage to reproductive and vegetative buds. Use of rootstock Myrobalan plum and peach species *Persica* [*Prunus*] *davidiana* showed low levels of damage against frost in cv. Gracia. In Redhaven low levels of reproductive buds were killed on the Myrobalan stock MY-KL-A, and the lowest percentage of vegetative buds killed was on almond MN33 and the MY-KL-A.

In northeast India, soil acidity is prevalent in more than 80% of the land with more Fe toxicity in the plains and Al in the hills. Use of high Al tolerant rootstocks can be one option since plants have different degrees of adaptation to Al variability, e.g., citrus. Rootstocks used in citrus cultivation could be classified for Al resistance as: *Citrus reshni* >

Citrus jhambiri > *Citrus aurantium* > (*Citrus paradisi* x *Poncirus trifoliata*) 'Swingle' > (*Citrus sinensis* x *Poncirus trifoliata*) 'Carrizo'. Root morphology of the rootstocks is the key factor in citrus productivity in regards to the absorbing capacity of the roots and their tolerance to low nutrients. Carrizo citrange and Red tangerine were found as B-efficient, whereas Fragrant citrus and Sour orange were B-inefficient genotypic rootstocks. Carrizo citrange-grafted plants were also more tolerant to low B compared to the plants grafted on Trifoliate orange. In soil pH of 3.5 and 4.9, the accumulation of toxic nutrients in leaves of Anna and Jonagored grafted on MM.106 was highest while essential nutrients (Ca, Mg, P, and N) were least while those grown on MM.111 and MM.106 respectively accumulate maximum concentration of macro nutrients and intermediate on M.9. Rootstocks were also reported to have greatly influenced the scion's tolerance to B deficiency in apple and toxicity in *Prunus*.'Kober 5BB', 'Gravesac', 'Paulsen 1103', and 'IAC 766' grapevine rootstocks genotypes possess resistance to Al and citrate exudation was found related to the Al resistance phenotype. In low soil pH, varieties grafted on rootstock 'C3309' showed promising.

Significant reduction in chlorine accumulation has been shown to occur in chloride-sensitive scions when grown on Dogridge Salt Creek, 1163-3 and 1623 rootstocks. The different salt tolerant *Vitis* species *V. berliendieri, V. riparia* and *V. champini* may be exploited to overcome the salinity problem. 'Ramsey', '1103 Paulsen', '140 Ru', '101-14 Mgt', '143-B Mgt' etc performed fairly in saline soils. Rootstocks vary widely in their ability to restrict accumulation of Cl^-, Na^+ or both from either their own shoot or that of a scion and it has been used as a screening method for classifying salt tolerant genotypes. The lower Cl^- and Na^+ concentration in leaves of 'Sunburst' mandarin grafted on 'Trifoliate orange' and Cleopatra suggest that the salinity tolerance of Cleopatra is associated with ion sequestration in roots with less transport to leaves. In apple, *Malus prunifolia* Borkh cv. Dongbeihuanghaitang, *M. sieboldii* Rehd cv. Daguohongsanyehaitang, *M. prunifolia* Borkh cv. Qiuzi, and *M. xiaojinensis* were reported as salt-tolerant rootstocks, whereas *M. prunifolia* Borkh cv. Yingyehaitang, *M. micromalus* Hemsl, and *M. sieboldii* Rehd cv. Lushihongguo were found as salt-sensitive rootstocks. These differences in sensitivity were associated with variations in the activities of anti-oxidation enzymes and in the amount of organic osmotic.

Mango cultivars, 13/1, Sabre and Olour can be used as rootstocks for mango cultivation in soils upto 35 ESP, whereas Bappakai, Nakkare and Kurukkan can be used as rootstock in soils up to 25 ESP though, all polyembryonic mango genotypes can be used as rootstock in a slightly sodic soil of 15 ESP. In walnut, *Juglans hindsii* and Paradox rootstocks are tolerable.

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Identification of resilient rice genotypes of medium to late duration for water deficit regions in Tripura

Tapas Paul, Debashre Bhattacharjee, Debalina Biswas, Pujaita Ghosh, Bhargobi Chakraborty, Papiya Saha, and SP Das*.
ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura
*Correspondence: drspdas@gmail.com

Introduction

Rice is economically very important staple food for North Eastern India, Asia and the whole world as well. 84% of rice eco-system in north east India are rainfed and the major constraints in the upland hydromorphic valley continuum (upland) is drought or moisture stress. About 80% of this area is cultivated by small-scale subsistence farmers with few resources and using shifting cultivation techniques with fellow periods with are no longer long enough to sustain production. Development of high yielding rice varieties which can produce considerably better yield under moisture stress condition will be a high input addition in rice crop improvement programs . Drought management is a major challenge to rainfed grain and fodder crop production. Drought is known to cause substantial reduction in the economic yield of crop plants. It is a major threat to food security, sustainability of production systems, and the well being of people living in drought-prone areas. It adversely affects the lives of 2.6 billion people (43% of the world population) that are engaged in agriculture. Most rainfed farmers, in general, are resource poor, with small land holdings and a limited capacity to adopt high-input technologies. For farmers trying to minimize the effects of drought on their crops, drought-tolerant varieties are an appropriate farmer-friendly, seed based technology that is easy to disseminate. Losses in yield due to drought in India, for example, range from 30–70%. Since the drought-prone area is large, a modest increase in yield under drought conditions would make a large and significant impact on increase in rice production. Simple indices or traits associated with drought-tolerant germplasm need to be identified for use in trait-based (ideotypic) conventional breeding programs and for marker-aided selection (MAS) methods for improvement of drought tolerance in rice.

Methodology

Total 23 medium to late duration (more than 120days) diverse genotypes including 3 national checks (Samba mashuri, Lalat, Swarna) and 1 local check (Gomati) were evaluated in RCBD design in control and reproductive stress condition . The control trial was planted in well irrigated condition. In case of reproductive stress irrigation was withheld 10 days prior to initiation of flowering and the whole trial was kept without irrigation upto final harvesting .In case of rainfall occurs the water from the field is removed immediately. Both control and stress trial was planted in two replications. Data observations was recorded for different quantitative characters to sort out the best genotypes which performed well in water deficit condition.

Results and Discussion

In control trial all genotypes under study showed significant differences for all the character studied. In terms of average yield range was found to a minimum of SAMBHA MAHSURI (2083kg/ha) to a maximum of IR 83383-B-B-140-3 (7042kg/ha).almost all the genotypes showed significant better yield than other three checks except for local check GOMATI(6573Kg/ha).Only two genotypes exceed the average yield of Gomati are IR 84895-B-127-CRA-5-1-1(6667kg/ha) and IR 83383-B-B-140-3(7042kg/ha). For days to 50% flowering the range was observed between 91 days to 115 days. In stress trial the genotypes expressed significant difference for all the characters studied. The range for grain yield was observed to a minimum of 416 kg/ha (RR 272-28-2) to a maximum of 5417 kg/ha (IR 83873-B-B-47-3). In case of days to 50% flowering and plant height the range was recorded between 98 days to 115 days and 90cm to 115 cm respectively. On average yield basis the most promising 10 genotypes which can tolerate moisture stress are IR 83873-B-B-47-3 (5417kg/ha), IR 84895-B-127-CRA-5-1-1(5000kg/ha), IR 83387-B-B-27-4 (4708kg/ha), IR 83376-B-B-110-2(4375kg/ha), IR 83376-B-B-24-2 (3958kg/ha), IR 80461-B-7-1(3958kg/ha), IR 83383-B-B-140-3

(3750kg/ha), IR 83373-B-B-24-3 (3625kg/ha), IR 83387-B-B-125-1(3333kg/ha), IR 83373-B-B-25-3(3125kg/ha) .the genotypes IR 83873-B-B-47-3 (5417kg/ha) and IR 84895-B-127-CRA-5-1-1(5000kg/ha) followed by IR 83387-B-B-27-4 (4708kg/ha) and IR 83376-B-B-110-2(4375kg/ha)can be best exploited for further study in developing resilient genotypes for moisture deficit regions .

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Soil microbial population affect degradation pattern on metsulfuron-methyl herbicide under changing climate condition

Debasmita Karmakar[1*], Shaon Kumar Das[2] and Ajay Maity[1]

[1]*University of North Bengal, Siliguri, Darjeeling, West Bengal*

[2]*ICAR Research Complex for NEH Region, Sikkim Centre, Gangtok, Sikkim, India*

*Correspondence: debasmita.karmakar@gmail.com

Degradation of metsulfuron-methyl as affected by microbial population count in two West Bengal soils (alluvial and laterite) varying in physicochemical properties was studied under sterile and non-sterile conditions. Recovery of metsulfuron-methyl in soil was in the range of 95.6–96.8%at 0.5 and 1.0 μg g^{-1}, respectively.

The DT_{50} of metsulfuron-methyl at the level of 10 μg g^{-1} in alluvial soil under sterile and non-sterile conditions was found to be 35.7 and 23.4 days, respectively, and in laterite soil under sterile and non-sterile condition was 45.2 and 39.6 days, respectively. Residues of metsulfuron-methyl dissipated faster in alluvial soil (non-sterile followed by sterile) as compared to laterite (non-sterile soil followed by sterile soil). A wide difference in half-life of alluvial and laterite soil under sterile and non-sterile conditions indicated that the variation in physicochemical properties of alluvial and laterite soil as well as the presence of microbes play a great role for degradation of metsulfuron-methyl. The degradation rate in laterite soil was significantly reduced by some of its physicochemical characteristics, despite sterile and non-sterile conditions, which was faster in alluvial soil.

Evaluation and identification of early to medium duration moisture stress tolerant rice genotypes in North-Eastern hill region.

Tapas Paul, Debashre Bhattacharjee, Pujaita Ghosh, Bhargobi Chakraborty, DebalinaBiswas
Papiya Saha, and SP Das*.
ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura
*Correspondence: drspdas@gmail.com

Introduction

Rice (*Oryza sativa* L.) is the staple food of more than three billion people in the world, most of whom live in Asia. Of this total, Asian farmers produced around 600 million tons, which represents more than 90% of global rice Rice is cultivated under diverse ecologies ranging from irrigated to rainfed upland to rainfed lowland to deep water. The frequent occurrence of abiotic stresses such as drought and submergence has been identified as the key to the low productivity of rainfed ecosystems. A recent estimate on climate change predicts the water deficit to deteriorate further in years to come (Wassmann *et al.* 2009) and the intensity and frequency of drought are predicted to become worse (Bates *et al.* 2008). Severe drought in the wet season during the reproductive stage not only had an adverse effect on rice production but also reduced the area sown oilseeds in the subsequent dry season because of the unavailability of sufficient moisture in the soil, thereby reducing the production of these crops. Despite the importance of drought as a constraint, little effort has been devoted to developing drought-tolerant rice cultivars. Most of the high-yielding varieties—IR36, IR64, Swarna, and Sambha Mahsuri—grown in rainfed areas are varieties bred for irrigated ecosystems and they were never selected for drought tolerance. Farmers of drought-prone areas require varieties that provide them with high yield in years of good rainfall and sustainable good yield in years with drought and in water deficit conditions. Drought or moisture deficit during reproductive period is known to cause substantial reduction in the economic yield of crop plants. It is a major threat to food security, sustainability of production systems, and the well-being of people living in drought-prone areas. The present study focuses on identification of some promising rice varieties and delivery of resulting improved varieties to farm communities in drought-prone or poorly irrigated production environments Losses in yield due to drought in India, for example, range from 30–70%. Since the drought-prone area is large, a modest increase in yield under drought conditions would make a large and significant impact on increase in rice production. The present study was undergone to identify some tolerant genotypes which can give a better yield under moisture stress condition.

Methodology

The present study comprising of evaluation of 36 diverse early to medium (less than 120 days) duration rice genotypes including 4 check varieties (National checks) under control and moisture stress/reproductive stress condition. The experimental materials for both control and stress were planted in RCBD design in 2 replications. The control was planted in well irrigated conditions. In case of stress irrigation was withheld 10 days before initiation of flowering and entire trial was continued without watering during reproductive stage. In case rainfall occurs, water was removed from the field immediately. Stress trial was conducted under field managed reproductive stage for moisture. Data observations were recorded for quantitative characters to assess the yield and overall performance in both control and stress trial.

Results and Discussion

In control the majority of the characters showed significant better performance for most of the characters studied. Based on the grain yield parameter the genotypes ranged from 5320kg/ha to 6550kg/ha. Among 36 genotypes 4 genotypes showed yield more than 6 tons/ha. Maximum yield recorded in IR 87759-2-2-1-1(6550kg/ha) followed by IR 83376-B-B-110-3 (6350 kg/ha), IR 83887-B-B-11-4(6170 kg/ha) and IR 87751-17-5-1-2 (6170 kg/ha) and also exceeds the average yield from the four checks.

In reproductive stress trial majority of the genotypes exhibited significant difference for yield and yield attributing characters. Surprisingly most of the genotypes performed better than the check varieties in stress condition. The genotype IR 87751-17-5-1-2 found to be most superior on overall mean basis with a grain yield of 6060 kg/ha under stress condition. Under stress only two genotypes exceed yield more than 5 tons. The mean Grain yield of the entries ranged from a minimum of 1515 kg/ha to a maximum of 6060 kg/ha, the maturity date ranged from 111 days to 119 days and plant height ranged from 78 to 107 cm , while no of panicles /plant ranged from 6 to 17. Out of 36 only 10 genotypes recorded yield more than 4 tons/ha (4166kg/ha to 4924 kg/ha). A minimum of 1520 kg/ha yield recorded in IR 78875-131-B-1-4-1. Most of the genotypes showed significant yield superiority over the check varieties in moisture deficit condition. From their performance in terms of yield improvement under stress condition the genotypes which can be further evaluated are IR 87751-17-5-1-2(6060 kg/ha), IR 83381-B-B-137-3(5303 kg/ha) ,CR 2642-52(4924 kg/ha), IR 87753-13-1-1-3 (4545kg/ha), IR 83377-B-B-42-3(4545 kg/ha), IR 87761-39-2-3-2(4216 kg/ha) , IR 87759-2-2-1-1(4166kg/ha) respectively. These genotypes can be taken into consideration for further evaluation and development of stress tolerant genotypes for water deficit regions.

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Integrated Soil, Water and Nutrient Management

- Integrated nutrient management
- Integrated watershed approach
- Input use efficiency and soil quality

Role of micro-nutrients in sustainable agriculture

Yashbir Singh Shivay*
Indian Agricultural Research Institute, New Delhi
*Correspondence: ysshivay@hotmail.com

Sustainable agriculture is the management and utilization of the agricultural ecosystem in a way that maintains its biological diversity, productivity, regeneration capacity, vitality and ability to function, so that it can fulfil - today and in the future - significant ecological, economic and social functions at the local, national and global levels, and that does not harm other ecosystems. The sustainability of agriculture has faced some of the most significant challenges in recent years. Major challenges include: (i) first of all, the rapid growth of the human population and the increased demand for agricultural land and resources, (ii) mining of the nutrients especially micro-nutrients (iii) overdependence on fossil energy and the increased monetary and environmental costs of non-renewable resources, (iv) global climate change, and (v) globalization. These dominant issues are challenging agriculturists to develop more sustainable management systems like no other time in history. To meet the food and nutritional needs of a growing population, agriculture will need to move beyond the past emphasis on productivity to encompass improved public health, social well-being and a sound environment.

The crucial role played by micronutrients in enhancing food/crop production in India is now a well-recognized fact. Widespread micronutrient deficiencies in crops, now being recorded all over the country, have resulted in severe losses in yield and nutritional quality. It is estimated that nearly half of the soils on which food crops are grown, are deficient in zinc (Zn). Next to Zn, boron (B) (33%) and iron (Fe) (15%) deficiencies are also limiting the crop production to a large extent. Extensive manganese (Mn) (6%) deficiency is now being manifested in the most widely spread 'rice-wheat' cropping system in northern India, particularly in Punjab (18%) and Haryana (12%). Intensive agriculture in north India and soils rich in organic matter in southern part of the country also exhibited copper (Cu) (8%) deficiency. Extensive micronutrient deficiencies lead to decline in factor productivity even with balanced NPK fertilization. Although the crop response to micronutrients application varies with soil type, crops and genotype, agro-climatic conditions and severity of deficiency, an enormous response to micronutrient fertilization has been reported in a wide variety of crops including horticultural crops across the country. It has been estimated that proper Zn management contributes about 18.4 million tonnes (with economic value of Rs. 2,11,619 million) for major food grain crops, and it may further enhance the contribution up to 24.85 million tonnes (with an economic value of Rs. 2,32,119 million) if sugarcane, cotton and potato are included. The contribution of B is estimated about 4.02 million tonnes assuming 10% of cultivated area is receiving B fertilization (Shukla *et al.* 2012). Number of crops also exhibited a sizeable response to Mn, Cu and Fe application under deficient situations. Oilseeds and pulses productivity could be enhanced substantially by Mo application as evidenced from scattered studies in Andhra Pradesh, Madhya Pradesh and Maharashtra. Micronutrient nutrition in relation to crops, optimization of doses, sources and methods of application; nutrient interactions, behaviour in cropping system, delineation of deficient areas, identification and cataloguing of micronutrient disorders, development of micronutrients fertilizers have been researched extensively under aegis of All India Coordinated Research Project (AICRP) on micronutrients. Micronutrient deficiencies/malnutrition in animal and human being are becoming increasingly important globally including India (Prasad 2012). The crops grown in micronutrient deficient soils contain low level of micronutrients to meet the demand of animal and human being. Thus, research on enriching the food grains and fodder with micronutrients through agronomic and genetic biofortification and their bioavailability in animal and human should be taken up in soil-plant animal/human continuum. Micronutrient research provides invaluable information highly useful in sustaining food security and well-being of animals and human being without harming the environment.

Since importance of micro nutrients is increasing beyond soil and plant system and nutritional security of the people of country is becoming a crucial concern, some systematic studies on micronutrient in soil-plant-animal-human continuum need to be conducted to find out effect of micronutrients deficiencies in soils on animal and human health. In order to enhance micronutrient use efficiencies, the use of nano technology options along with testing of new micronutrient products may be taken up. The smart delivery of micronutrients by using nano-based formulations in rhizosphere studies may be useful in enhancing the use efficiency and reducing the cost. In addition, nano particles could be useful in remediation of contaminated soils as it has very large surface area. Micronutrients research on fruits and vegetable crops is scattered and scanty; however, there is ample scope for micronutrients use in these crops for enhancing quality and yield. Intensive micronutrients research in fruits and vegetable need to be carried out.

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Managing soils with changing climate in hills and mountain ecosystems

M Datta*, GS Yadav, A Haldar and Anup Das
ICAR Research Complex for NEH Region, Lembucherra, Tripura
*Correspondence: mdatta2@rediffmail.com

Introduction

Mountain soils have long performed a host of vital ecosystem services that help to ensure food security and nutrition to 900 million mountain people around the world and benefit billions more living downstream. Soils are the basis for healthy food production. They help people to mitigate and adapt to climate change by playing a key role in the carbon cycle and in water management, improving resilience to floods and droughts. Soil is a fragile resource that needs time to regenerate. Every year, an estimated 12 million ha are lost through soil degradation. Mountain soils are particularly susceptible to climate change, deforestation, unsustainable farming practices and resource extraction methods that affect their fertility and trigger land degradation, desertification and disasters such as floods and landslides (FAO, 2015).

The Earth's climate system is changing due to changing levels of greenhouse gases in the atmosphere; the most important of these gases are carbon (C) and nitrogen (N) based. Because soils are part of the C and N cycles and C and N are both important components of soil organic matter, the organic matter content of soils will be influenced by climate change. Changes in average temperatures and in precipitation patterns will also influence soil organic matter and in turn will affect important soil properties such as aggregate formation and stability, water holding capacity, cation exchange capacity, and soil nutrient content. Therefore, there is need to identify the soil properties, which are most affected by climate change and sustainable measure for their improvements.

Soils as a part of the global carbon and nitrogen cycles

Soils are integral parts of several global nutrient cycles. The two that are the most important from the perspective of soils and climate change interactions are the carbon and nitrogen cycles because C and N are important components of soil organic matter and carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the most important long-lived greenhouse gases. The largest active terrestrial C pool is in soil, which contains an estimated 2,500 Pg of C compared to 620 Pg of C in terrestrial biota and detritus and 780 Pg of C in the atmosphere. Carbon is readily exchanged between these pools; therefore, they are called active pools. In addition to the active pools, there are approximately 90,000,000 Pg of C in the geological formations of Earth's crust, 38,000 Pg of C in the ocean as dissolved carbonates, 10,000 Pg of C sequestered as gas hydrates, and 4,000 Pg of C in fossil fuels. The global C and N cycles were in balance with inputs approximately equaling outputs prior to the industrial revolution when low populations and levels of technology minimized the anthropogenic generation of greenhouse gases, but the burning of fossil fuels, tilling of soil, and other human activities have altered the natural balance such that we are now releasing more C and N into the atmosphere each year than is taken up by global sinks. Human management of soils can have a profound impact on the balance of C and N gas emissions from those soils, and therefore influences global climate change.

Influence of climate change on soil properties and processes

Soil organic matter is important for many soil properties, including structure formation and maintenance, water holding capacity, cation exchange capacity, and for the supply of nutrients to the soil ecosystem. Soils with an adequate amount of organic matter tend to be more productive than soils that are depleted in organic matter, therefore, one of the biggest questions concerning climate change and its effects on soil processes and properties involve how potential changes in the C and N cycles will influence soils. In addition to sensitivity of mountain soil to climate change, soil degradation in mountain environments is a worldwide problem. Mountain soils are intrinsically vulnerable and therefore very sensitive to degradation processes such as water erosion, loss of chemical and physical quality, and desertification. Degradation processes result from a combination of factors: low soil formation rates and slow pedogenesis; steep slopes favouring profile erosion and even topsoil truncation; limited organic matter inputs; extreme climate affecting the soil biological communities and the organic matter turnover. The deterioration of soil quality/health is the combined result of soil fertility, biological degradation (decline of organic matter, biomass carbon, decrease in activity and diversity of soil fauna), increase in erodibility, acidity, and salinity, and exposure of compact subsoil of poor physicochemical properties. Northeast India is characterized by high soil acidity/Al+3 toxicity, heavy soil, and carbon loss, severe water scarcity during most parts of year though it is known as high rainfall area. The extent of soil and nutrient transfer, causing environmental degradation in North eastern India, has been estimated to be about 601 million tons of soil, and 685.8, 99.8, 511.1, 22.6, 14.0, 57.1, and 43.0 thousand tons of N, P, K, Mn, Zn, Ca, and Mg, respectively (Saha *et al*. 2012). Excessive deforestation coupled with shifting cultivation practices have resulted in tremendous soil loss (200 t/ha/yr), poor soil physical health in this region.

Technological options for management of mountain soils

Nearly 37.1% of the total geographical area in Northeast Himalayan region of India is under the threat of land degradation, where erosion is a major land degradative process (Saha et al. 2012). With the great concern of poor soil health and severe land degradation, there is a need of viable option for eco restoration and maintenance of soil resources which could sustain long-term soil productivity and improve food security of the north-eastern Himalayan region.

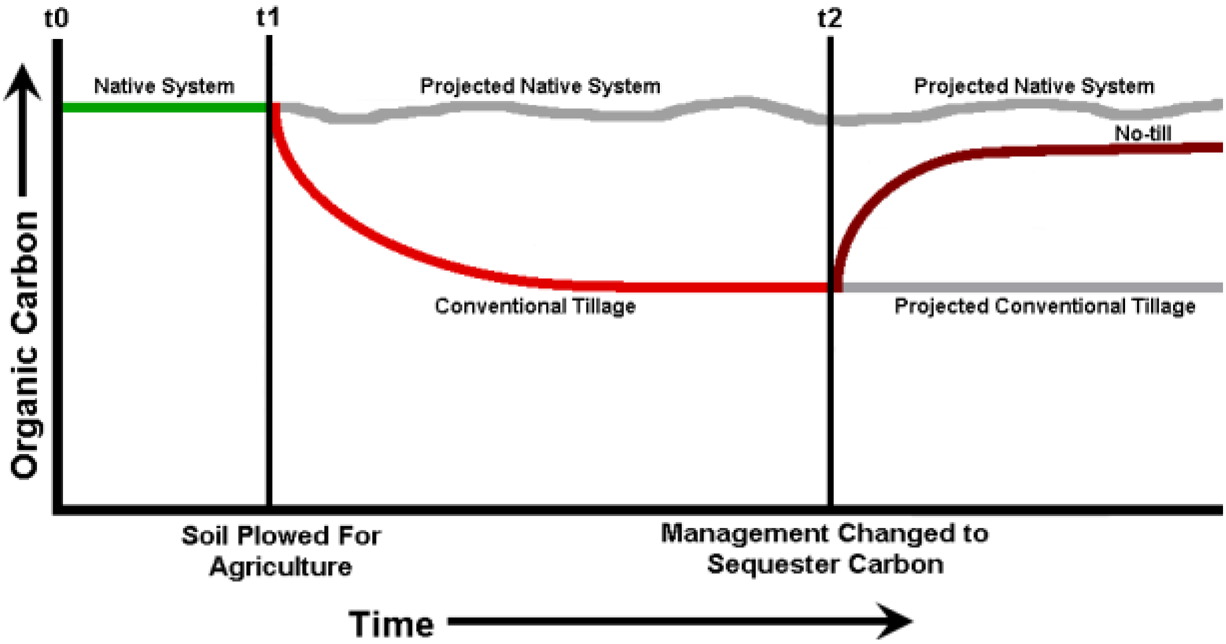

Fig 1. Tilling a native soil leads to reduced soil organic C levels, while management changes such as a conversion to no-till techniques may lead to increased soil organic C as compared to conventional tillage techniques (Brevik, 2012).

The research approaches are needed for control of soil erosion particularly in Hill ecosystems, soil acidity management, eradication in micronutrient maladies, soil carbon management, soil microbial management, soil water management etc. A wide range of best management practices are recommended managing the hills and mountain soils viz. mechanical measures (contour bunding, terracing, bench terracing), integrated farming system, conservation agriculture, crop rotation with an approach to inter/mixed cropping followed by its popularity among the farming community, maintenance of soil fertility with strengthening in its monitoring approach , micronutrient assay and its proper methods of eradication in micronutrient maladies, agroforestry system, soil carbon sequestration and management. The strategy is to increase soil organic carbon (SOC) density in the soil, improve depth distribution of SOC and stabilize SOC by encapsulating it within stable micro-aggregates so that C is protected from microbial processes or as recalcitrant C with long turnover time. Soil management techniques such as no-till systems may result in lower CO_2 emissions from and greater C sequestration in the soil as compared to management systems based on intensive tillage (Figure 1), although some recent studies have indicated that no-till systems may simply result in higher C accumulations in the upper 15–20 cm of the soil with no increase in C when the entire soil profile is considered.

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Furrow liming a potential management practice in hill agriculture – an experience

M Raychaudhuri* and S Raychaudhuri

ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha

*Correspondence: mausumiraychaudhuri@gmail.com

Introduction

More than 90 per cent soils of the northeastern region of India are acidic in nature. The only option for increasing production seems to be the proper management of these acid soils. The management could be viewed in terms of growing suitable crops and following judiciously, integrated nutrient management envisaging use of inorganic and organic fertilizers. The article provides an understanding of acid soils and a brief about the liming technology introduced to the region with a success story. The soils of north – eastern hill region comprising of seven states are entirely (90.3 %) acidic in nature. In Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura acid soil below pH 5.5 consist of about 77.8, 83.5, 52.9, 60.1, 96.7, 84.9 and 76.8 percent respectively and are considered strongly and moderately acidic.

Intense leaching of bases due to heavy rainfall and accumulation of undecomposed organic matter under marshy conditions have contributed towards acid soil development. In addition, soil acidification due to prolonged use of acid forming fertilizers and heavy leaching are also contributory factors. Land use pattern also affected various forms of soil acidities in such soils. The soils under shifting cultivation exhibited maximum acidities of either kind followed by forest cover and terrace cultivation. Major contributing factors for different forms of acidities in these soils were exchangeable Al^{+3}, extractable Al^{+3}, exchangeable H^+ and organic matter.

Studies at Manipur reveal that the extractable [4.06 cmol (p^+) kg^{-1}] and exchangeable [1.32 cmol (p^+) kg^{-1}] forms of Al dominates in soils under jhum compared to that of terraced land [1.48 and 0.47 cmol (p^+) kg^{-1} respectively] and under forest cover [3.11 and 1.01 cmol (p^+) kg^{-1}, respectively] (Mausumi Raychaudhuri 2005).

Liming

Liming is the best option to ameliorate acid soils. Liming increases nutrient availability to plant and improve the environment for beneficial soil microorganisms. It promotes a more rapid breakdown of organic materials in the soil, releasing nutrients for growing plants. Liming also promotes nodulation by nitrogen-fixing bacteria in legume crops like oilseeds and pulses. The use of surface applied nitrogen fertilizers for several years' results in an acid layer at the soil surface. There are two effective ways in which lime can be applied to the soil for a measurable pH change i) Broadcasting and ii) Furrow application. Lime is broadcasted on the basis of lime requirement of the soil. Liming @ 0.25 LR is recommended for acid soil for broadcasting beyond which liming limits potassium availability in soil (Raychaudhuri and Sanyal 1999). Furrow lime application @ 500 kg ha^{-1} and 250 kg ha^{-1} is recommended for leguminous crops like soybean, groundnut, black gram etc. in an economic way for proper root development and harbouring of nodule bacteria for better yield in moderately and slightly acidic soils. However, it takes a minimum of 4 weeks for a significant amount of the lime to dissolve and make the desired changes in soil pH. For upland paddy furrow liming @ 1000 kg ha^{-1} is recommended for moderately acidic soils with pH 4.5 to 5.5.

Lime can be broadcasted one month before transplanting or sowing of the crop while furrow liming is done at the time of sowing with adequate soil incorporation and moisture. The most common source of lime for agricultural use is ground limestone. Limestone's quality is determined by its purity and fineness of grind. Farmers of north eastern hill region are fortunate to have large deposits of limestone of high purity available in these areas. How fine the lime is ground is just as important as stone purity. As per the specifications "agricultural lime" must be ground fine enough that 90% will pass a 10 mesh screen and at least 35% will pass a 50 mesh screen.

Industrial wastes like lime sludge from paper mills, pressmud cake produced through carbonation process of sugar mills, cement kiln wastes can be used depending on the calcium content and availability. Datta and Gupta (1983) reported increase in yield of maize-wheat crop sequence with application of 2 t/ha press mud along with fertilizers in an acid soil of Nagaland.

Method of lime application

Lime must be spread uniformly for neutralizing soil acidity. Distribution can be improved by spreading half in one direction and the other half at a 90 degree angle. For maximum effectiveness, lime should be mixed with the soil. This is especially true when the soil pH is very low and a large application of lime (2 tons/ha or more) is needed. A good method in this case is to apply half the lime before tillage and the other half after. Furrow application of lime was found to be more effective than broadcasting in bringing up the desirable change in pH in the rhizosphere. At the time of sowing 15 - 20 cm deep furrow is drawn with desired spacing and lime was placed uniformly in the furrow. Then mixed thoroughly and uniformly so that no lime is visible on the surface. Then the seeds are placed and furrows are closed. Little water is sprinkled to keep the field moist.

Crop response to liming

The general recommendation for liming in north-east region varied from 2 – 5 t ha^{-1}. Liming is not recommended for lowland paddy grown under water logged or flooded condition. Liming @ 1000 kg ha^{-1} is recommended for upland soils with pH < 5.0. The grain and straw yield and their respective N and P uptake increased significantly with lime in furrows, biofertilizer (Azospirillum and Azotobacter) and phosphorus levels over control. The lime phosphorus interaction was found significant for grain and straw yields. Maximum grain yield of 23.91 q/ha was obtained with 1000 kg/ha lime + biofertilizer + 13 kg P/ha. The residual lime and phosphorus interaction was also found significant. Maximum yield of potato 73.33 q/ha was obtained with residual 500 kg/ha lime + biofertilizer + 26 kg P/ha closely followed by residual 1000 kg/ha lime + biofertilizer + 26 kg P/ha (70.00 q/ha) over control (22.67 q/ha). The result suggest that 1000 kg lime + biofertilizer could be an organic recommendation for an optimum yield of upland paddy (RC- Maniphou 6) but for potato (Kufri CH 1) application of 26 kg P/ha in addition gave the optimum yield (Raychaudhuri and Raychaudhuri 2006).

Liming showed an antagonistic effect on the availability of soil K and K uptake by the plants beyond 0.25 LR of lime application (Raychaudhuri and Raychaudhuri 2009) in organic matter rich acid hill Ultisol. This is because with the presence of high aluminium content in different forms and organic matter the soils are not expected to follow the normal Gapon exchange behavior i.e. exchanges involving K^+ vs Ca^{2+} + Mg^{2+} ions.

Raychaudhuri and Kumar (2002) recommended increase in amount of K fertilization with increased level of lime beyond 0.25 LR to maintain the availability of soil potassium to maize and soybean under terraced cultivation.

Liming alone and in combination with Rhizobium inoculation increased the rhizobial population remarkably (Raychaudhuri and Raychaudhuri 2008). Moreover, if Rhizobium treated seeds are lime pelleted, that makes the micro environment for Rhizobium more conducive to multiply, reducing the initial shock for environmental difference for rhizobia.To minimize the amount of lime, furrow liming @ 250, 500 and 1000 kg/ha $CaCO_3$ has been recommended for crops (Patiram 1994). Liming @ 0.25 LR (Lime Requirement) for cereals through broadcasting or 500 kg/ha lime in furrows for legumes are recommended under permanent terraced cultivation in the acid hill soils of north eastern region (Raychaudhuri 2002). It has been observed that with application of 500 kg lime / ha in furrows there is 51.2, 76.9 and 85.3 per cent increase in groundnut, soyabean and black gram respectively. When coupled with FYM @ 10 t /ha then their yield increased by 114.3, 157.4 and 147.1 per cent respectively (Mausumi Raychaudhuri 2005). Furrow liming technology has been demonstrated in farmers' fields across the Northeastern region of India.

The management of acid soil should aim to improve the production potential either by counteracting soil acidity through the addition of amendments, meeting the deficiencies through balanced fertilization with an integrated approach or by manipulating the agricultural practices through a farming system approach. Emphasis has been given to soil acidity by including exchangeable Al^{3+} content and lime requirement of the soil in the Soil Health Cards designed and issued to the farmers by the ICAR Research Complex for NEH Region, Manipur Centre along with other soil physical, chemical and biological parameters during 2007. Amelioration of acid soils by liming material is the most suitable option for increasing the production potential of hill soils. However, to use lime in a more economic and effective way furrow liming is the best option for acid hill soils under terrace cultivation.

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Status of land degradation and strategies for land reclamation in north eastern hill region

Debashis Mandal*

ICAR National Fellow, IISWC, Kaulagarh Road, Dehradun
*Correspondence: dmandalcswcrti@gmail.com

The North Eastern Hilly (NEH) Region of India comprising of the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura has a total geographical area of 262179 sq km being inhabited by 45.5 million people as per 2011 census, representing about 8% of total area and 3.07% of total population of India, respectively. The Eastern Himalayan Region is very vulnerable to soil erosion because of its undulating topography, steep slopes and high rainfall. Moreover, the land encroachment and agricultural activities on forest areas have further aggravated the problems of land degradation in the region especially on steeply sloping land with no conservation measures. Indiscriminate deforestation and practice of *Jhum* cultivation (slash and burn agriculture or shifting shifting agriculture) lead to accelerated erosion for which proper conservation measure need to be established especially on very steep slopes. The Himalayas also suffer from overgrazing problem with 2.4 to 4.5 times higher than the carrying capacity of forest. According to the Government of India harmonized database, about 120.7 M ha of land area is degraded in India (NAAS, 2010), 70% of which is contributed by water erosion. The extent of water erosion is more severe in NEH (22.27% TGA) than NWHs (12.61% TGA). Among the North Eastern States, Assam has highest area under water erosion problem (46.73% TGA) followed by Meghalaya (38.93% TGA), Tripura (12.91% TGA), Manipur (11.36% TGA), Arunachal Pradesh (10.84% TGA), Sikkim (4.76 TGA) and Nagaland (4.0% TGA). Land degradation due to acid soils is more severe in Indian Himalayas (13.95% of TGA) than rest of the country (3.72% of TGA). Extent of acid soils affected area is much more in NEH than that in NWH. Land degradation in forest areas is an acute problem in Indian Himalayas. The area under open forest with <40% canopy is more in Himalayan region (3.06% of TGA) than overall national figure (2.52% of TGA). The data analysis further indicated that land degradation due to open forest is about 6 times more in NEH (5.54% of TGA) than NWH (0.95% of TGA). In NEH, high percentage of area falls under shifting cultivation and indiscriminate forest felling. Comparatively more area in Indian Himalayas (0.49% of TGA) is occupied by waterlogged and marshy land than that of India (0.27% of TGA). About 0.94% of TGA in NEH region is occupied by wetlands compared to 0.11% in NWH.

By integration of causes and responses of land degradation, areas should be identified where degradation is being arrested and even reduced as "bright spots" and areas where degradation risks are high as "hot spots". Suitable indicators or indices in relation to risks of soil erosion and crop productivity loss, nutrients depletion and soil contamination through heavy metals and pesticides need to be developed and implemented. The Himalayan region has large area under acid soils with maximum area under Arunachal Pradesh followed by Assam. About 17.6 million ha of lands with pH value less than 5.5 are critically degraded with very poor physical, chemical and biological characteristics. The soils suffer due to deficiencies of phosphorus, calcium, magnesium, molybdenum and boron and toxicities of aluminum and iron. The fertilizer use is still low in the region. The productivity of the soils is, therefore, low due to poor soil health. The addition of lime to these soils neutralizes soil acidity and creates favourable environment for microbial activity, nutrient release and their availability to plants. The conjunctive use of lime and adequate fertilizers, therefore, holds key for higher productivity of these soils. Rapid restoration and maintenance of soil productivity in shifting cultivated areas can be achieved by improved fallow with woody and herbaceous legumes with primary purpose of fixing N as a part of short fallow (2-3 years) to increase the accumulation of large quantities of N and to provide a residual effect to two or three subsequent crops. The main legumes of the genus *Sesbania, Tephrosia, Leucaena, Mucuna, Centrosema, Pueraria, Crotolaria, Cajanus, Indigofera* and *Mimosa* can be successfully used for the short fallow to rejuvenate the soil fertility lost during cropping. Accelerated soil erosion induced by indiscriminate deforestation and practice of Jhum in the region needs to be reduced through site-specific conservation measures especially on very steep slopes.

Impact of Fe-oxide nanoparticles on soil quality and crop growth: a mechanistic approach

P Das, S Pratihar and SS Bhattacharya*

Tezpur University, Assam

*Correspondence: satya72@tezu.ernet.in

Introduction

Fe is an essential micronutrient element for several agricultural crops. It plays a vital role in chlorophyll synthesis, chloroplast structure and many enzymatic activities (viz. cytochrome in electron transport chain) (Tavakoli *et al*. 2014) etc. Fe deficiency is a global concern for calcareous or alkaline soil due to high pH and low Fe availability. Intensive Fe deficiency shows chlorotic symptom in plant leaves. Fe toxicity problems are prevalent in mainly waterlogged soils. Ferrous sulphate is one of the most commonly used iron salt may be used as a foliar spray or soil application. However, long term use of $FeSO_4$ may induce soil acidity greatly.

Under such context, application of Fe nanoparticles can be a useful proposition because these may not acidify the soil in the same way. Nevertheless, using nano forms of Fe may greatly influence the soil physical and chemical characteristics. Nano sized materials have able to attract copious attentions from researcher community because of their numerous useful properties in various sectors (medical science, industry, IT, energy, food science). Nanoparticles made up of any such elements (Fe, Mn, Zn etc.) probably enhance the use efficiency of crop plants due to their size and agglomerating property providing structural stability to the soils. However, report of in-depth research in the arena of environmental impacts of nanoparticles is rather scanty in the literature.

Under these perspectives, in the present investigation oxalate capped iron oxide nanoparticles (FeONP) have been applied in soil in various concentration and the effects on physico chemical properties of the soil was studied through a lab-based pilot scale study. Moreover, we studied the solubility pattern of major ions in soil samples treated with FeONP and predicted dissolution/adsorption dynamics through Visual MINTEQ geochemical models. We also conducted few lab scale mimic experiments to define the underlying mechanism of nanoparticle induced changes in soil properties. Finally, we are undergoing a field experiment with tomato, to see the effects of the oxalate capped iron oxide nanoparticles on crop growth. Some preliminary results of this study are also encouraging.

Methodology

Oxalate capped iron oxide nanoparticles (FeONP) were prepared by chemical synthesis adopting green chemistry method using Mohr salt, oxalic acid and sodium borohydrate (Merck, India) (Pegu *et al*. 2014). Stock solutions of the prepared nanoparticles were serially diluted to get the required concentrations (10, 20 and 50 mg kg^{-1}). The treatment combinations used for this study were: $FeONP_{10}$ - 10 mg kg^{-1} concentration of FeONP, $FeONP_{20}$ - 20 mg kg^{-1} concentration of FeONP, $FeONP_{50}$ - 50 mg kg^{-1} concentration of FeONP, $FeSO_4$ - 3% concentration of $FeSO_4$, Control- Soil without FeONP. Soil samples (pH= 5.5±0.1; EC= 0.012±0.002; Available K= 109.1±2.8; Available N= 308±28; Available P= 56.4±1.3; TKN= 1.3±0.14; MBC= 57.4±2.9; Fe= 186.6±1.2) were collected from typical alluvial soil of Assam and processed subsequently. Earthen pots of 2 litre volume were filled with the prepared test soil and incubated with the above mentioned treatments. Soil samples were periodically collected at 0, 30, 60 and 90 days respectively and analysed for pH, easily mineralizable N, available P, K, Microbial biomass carbon (MBC), and phosphatase following established methods (Page *et al*., 1982; Vance *et al*., 1987; Tabatabai *et al*., 1969). Moreover, the soil samples were subjected to XRD and SEM-EDX analysis to locate the nanoparticles and also to enumerate the influence of nanoparticles on physical composition of the soil. Release pattern of Fe from FeONP under different chemical conditions was studied by introducing known levels of the nanoparticle in aqueous solution of different pH (4, 5, 6, 7, 8, and 8.5) in *Lab-scale mimic experiments.* Moreover, the influence of FeONP on dissolution/precipitation dynamics of phosphate was studied through dissolving known levels of FeONP and $FeSO_4$ solutions.

Solubility study was conducted to determine the water soluble concentrations of various cations and anions in nanomaterial treated soil. Soil samples from the pot study collected and mixed with distilled deionised water (1: 10, w/v) were reacted at 120 rpm for 7, 14 and 21 days. Suspensions were filtered and the filtrates were used for analysis of cations (Ca, Mg, Mn, Zn, Fe) and anions (PO_4^{3-}, NO_3^-, SO_4^{2-}, Cl^-, CO_3^{2-}). Then, solubility data were put in the visual MINTEQ geochemical model to find out the probable precipitation dynamics of the studied attributes.

Results and Discussions

The inherent pH of the soil was acidic and interestingly the pH shifted towards neutrality over time in FeONP treated soils. Prominent effect on N mineralization was depicted from FeONP treatments (20>50>10 mg/kg). Fascinatingly, FeONP application significantly augmented the P mineralization in soil as compared to $FeSO_4$ treated soils. We substantiated this finding with two lab-scale mimic experiments. In the first experiment we observed that the amount of Fe release from FeONP increased in moderate to neutral solution. However, the second experiment showed that FeONP efficiently promoted release P from PO_4 salts and did not allow the formation of insoluble Fe-P compounds. This is interesting because in this study the release of Fe in ionic state probably slowed down due to the oxalate capping which in turn reduced the potential of phosphorus fixation in soil (Sree Ramulu et al., 1967). Moreover, enhancement in phosphatase activity might be another reason of increment of P availability in soil. We also observed high K mineralization in most of the nanoparticles treated samples which could be due to improvement in particle size distribution and granular stability provided by the added minerals. Solubility of elemental ions chiefly governs the leaching process depending on precipitation, dissolution and adsorption equilibrium. The pH of all FeONP treated samples varied between 5.4 to 5.7. In solubility pH was found to increase from 7 to 21 days in case of 10 and 50 mg kg^{-1} FeONP. However, in 20 mg kg^{-1}, pH first decreased from 7 to 14 days, afterwards increased after 21 days. FeSO4 3% had highly acidic range of pH throughout the study. However, acidic range of pH in FeONP signifies that the oxalate capped Fe slowed down the natural process of Fe hydrolysis in aqueous medium. Moreover, soluble Mg may be one of the principal contributors of change in pH. Alkalinity also depicted overall increment after 21 days in FeONP treated soil. This may be due to high occurrence of Ca and Mg in soluble form. Moreover, P and S solubility considerably increased in FeONP treated soil as compared to $FeSO_4$ (slow release of Fe ion). The formation of complex insoluble compounds of sulphate and phosphate probably reduced their solubility under FeSO4 treatments. Interestingly, bioavailability of Fe significantly increased under all the FeONP levels in the later period of the study (21 days), which may be due to slow release of Fe from the oxalate capping. These results indicate that the FeONP application can be fruitful in soils suffering from Fe deficiency, without compromising the inherent P availability in such soils.

Table 1. Represent the changes in soil properties due to application of FeONP and $FeSO_4$

Treatments (mg/kg)	pH	N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})	MBC (µg g^{-1})	Total N (%)	Fe (mg kg^{-1})	Phosphatase
$[FeONP]_{10}$	5.57	378±32	105.5±1.03	504.7±4.6	216.94±1.9	9.38±1.3	146.85±1	26.7±0.4
$[FeONP]_{20}$	5.7	504±28	101.8±0.52	514.3±10.3	514.3±1.9	9.24±0.7	179.1±1	28.6±0.2
$[FeONP]_{50}$	5.7	410.7±37	88.3±0.3	269.8±5.8	517.7±2.63	9.43±1.1	185.1±1	22.85±0.1
$FeSO_4$	4.8	280±28	52.1±1.05	270.8±11.7	264.1±2.5	7.28±0.14	174.9±1	9.5±0.02
Control	5.62	336±28	67.7±0.4	322.9±8.3	252.66±0.3	4.8±0.5	150.4±1	8.9±0.1

Fig. 1. The SEM images of FeONP (10, 20 and 50 mg kg^{-1}) and control samples. This figure clearly indicates enhancement of porosity in FeONP treated samples compared to control.

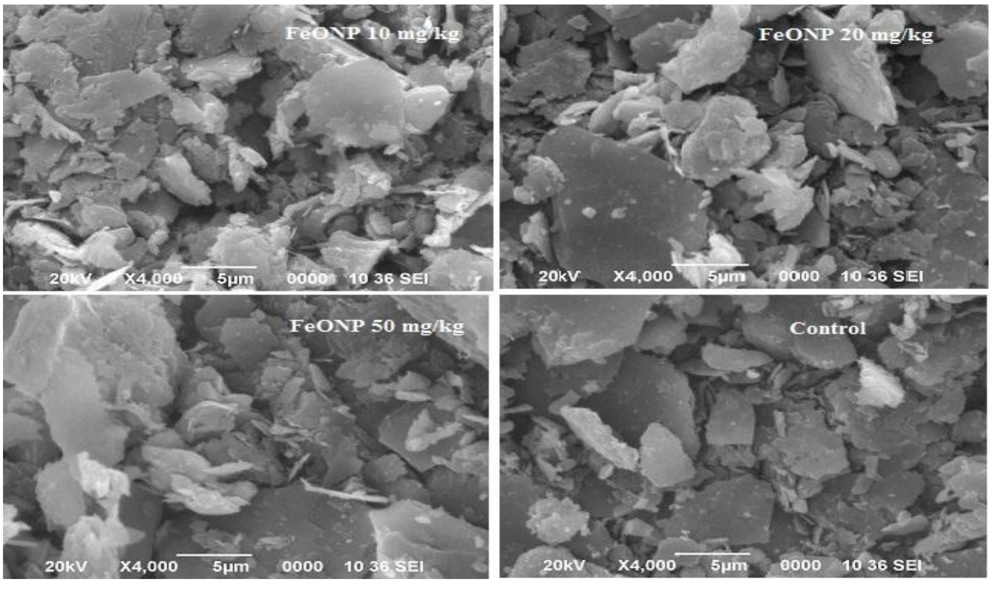

Fig 1. SEM images of FeONP (10, 20 and 50 (mg kg^{-1}) and control

Although the study is still undergoing, the preliminary results are encouraging. However, the long term effects of FeONP application can be understood after completion of the on-going study for at least two seasons.

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Long-term effect on physico-chemical properties of soil in various land use systems under Longleng and Mokokchung districts of Nagaland

A Namei[1*], PK Singh[1], G Rajesha[2], P Chowdhury[3] and Manoj Kumar[3]

[1]*Nagaland University, SASRD, Campus : Medziphema, Nagaland*

[2] *ICAR Nagaland Centre, Jharnapani, Nagaland*

[3] *Krishi Vigyan Kendra, Longleng, Nagaland*

*Correspondence: anamei611@gmail.com

Introduction

Land use has a great influence on many soil quality attributes. Inappropriate use and management have caused severe degradation of soil quality in the tropics. Inceptisols dominate the soils of the State with 66% followed by Ultisols 23.8%, Entisols 7.3% and Alfisols 2.9 %, of the total area 16.6 million hectare of the State Geographical Area. Nearly 37.1% of the total geographical area in Northeast India is under the threat of degradation, where soil erosion is a major land degradation process due to hilly terrain. With the great concern of poor soil health and severe land degradation, there is a need of viable option for ecorestoration which could sustain long-term soil productivity and improve food security of the poor farmers of North Eastern India.

Methodology

The present investigation was carried out in the Laboratory, Department of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University. Six land use systems *i.e.* agriculture, agri-horti-silvi-pastoral, forestry, livestock-based land use system, natural fallow and shifting cultivation were considered as treatments. Seasonal soil samples was collected from six different land use patterns from two depths, *viz.*, 0–15 and 15–30 cm.

Results and Discussion

Maximum soil organic carbon (SOC) was recorded 2.0 (%) in Longleng district under livestock based land use followed by forest (1.9 %) at a depth of 0-15 cm and minimum SOC 1.5 (%) in natural fallow. Whereas, In Mokokchung district higher SOC content was found under forest 1.82 (%) followed by shifting cultivation. In a depth of 15-30 cm, maximum SOC was recorded 1.90 (%) in both the forest and livestock which was followed by agri-horti-silvi-pastoral 1.78 (%) and minimum 1.48 (%) in natural fallow in Longleng District and under Mokokchung District maximum SOC was found in Agriculture 2.12 (%) land use followed by forest 1.80 (%).The maximum available nitrogen was found 250 kg ha^{-1} under agri-horti-silvi-pastoral in both the soil depth followed by Agriculture, forest and shifting cultivation in Longleng district. In Mokokchung district, maximum available N was found 188.2 kg ha^{-1} under agri-horti-silvi-pastoral in both the depth and the lowest was125.4 kg ha^{-1} in all the land use systems at both the depth except livestock based land use 188.2 kg ha^{-1} at a depth of 15-30 cm. On the basis of the average values for various land use systems the available nitrogen may be arranged as Agri-horti-silvi-pastoral > shifting cultivation > livestock based land use = forestry = agriculture > natural fallow. In a soils depth of 0-15 cm, available phosphorus in two district ranges from 4.5 to 5.4 kg ha^{-1} and 4.6 to 7.2 kg ha^{-1} with under Longleng and Mokokchung district respectively. Maximum available P was recorded 8.1 kg ha^{-1} under livestock based land use at a depth of 15-30 cm under Longleng. Whereas in Mokokchung, highest available P was found in forest (8.4 kg ha^{-1}) followed by agri-horti-silvi-pastoral. At a soil depth of 0-15 cm, available potassium in two district was ranges from 67.2 to 131 kg ha^{-1} and 56.6 to 184.8 kg ha^{-1} under Longleng and Mokokchung district respectively. In all the land use systems, agri-horti-silvi-pastoral showed the highest available potassium value (173.6 kg ha^{-1}). The lowest available K was recorded in forestry soils 74.4 kg ha^{-1}. From the findings of present investigation, it can be concluded that the shifting cultivation adversely affects the soil physico-chemical properties. On the basis of the parameters analysed, agri-horti-silvi-pastoral system appeared to be the most suitable land use among the various land use systems as adoption of this integrated system.

Role of AM fungi in moisture stress management in fruits

Amar Bahadur*,[1] Sukhen Chandra Das[2] and KS Thingreingam Irenaeus[2]

College of Agriculture, Lembucherra, Agartala, Tripura
*Correspondence: amarpatel44@ rediffmail.com

Mycorrhiza is a symbiotic mutualistic relationship between special soil fungi and fine plant roots, the association is mutualistic, both organisms benefit from the association. Important fruit plants that associate with mycorrhizal fungi are strawberries, citrus, apples, peaches, grapes, Litchi, tea, cocoa, forest species and wild plants. Mycorrhizae can be described as a symbiotic relationship between a fungus and a plant. Numerous fungi live in intimate contact with plant root only few inter into symbiotic association. The mycorrhizae affects the plant with growth, yield, improved fitness, increase the root absorption area of nutrients, while the fungus receives carbon from the associated plant.

Both biotic and abiotic stresses are major constrains to agricultural production. Under stress conditions, plant growth is affected by a number of factors such as hormonal and nutritional imbalance, ion toxicity, physiological disorders, susceptibility to diseases, etc. Mycorrhiza can promote plant growth by regulating nutritional and hormonal balance, producing plant growth regulators, solubilizing nutrients and inducing resistance against plant pathogens. In addition to their interactions with plants. These interactions may be vital for sustainable agriculture because they mainly depend on biological processes rather than on agrochemicals to maintain plant growth and development as well as proper soil health under stress conditions. Mycorrhizal benefits that have been mostly reported include tolerance to various biotic or aboitic stresses. From all of these beneficial effects on plant performance and soil health, it is evident that arbuscular mycorrhizal (AM) fungi are crucial for the functioning of terrestrial ecosystems.

In a changing climate, horticulturalists and landscape professionals are looking for ways to ensure the establishment and healthy growth of plants, whilst minimizing the use of both water and chemical fertilizers. The demands on potable water have never been greater than they are today and with rising populations demands are likely to increase further. Many soils have become nutrient deficient due to years of intensive farming, overuse of chemical fertilizers and from the effects of industrialization. Mycorrhizae are now being seriously considered as a means of improving nutrient deficient soils. It is considered that mycorrhizae can play an essential role in plant growth by enhancing plant vigour in poorly performing soils, and through their ability to store large amounts of carbon, they may ameliorate some of the effects of global warming. These naturally occurring symbiotic associations are characterized by the exchange of nutrients during the growing season. There are two main kinds of mycorrhiza: (A) Arbuscular mycorrhizae (AM) penetrate the plant root tissues. (B) Ecto-mycorrhizae (EM) surrounds the roots without penetrating them.

Ecto-mycorrhiza (ectotrophi mycorrhiza): Ectomycorrhizas are characteristic of many trees in the cooler parts of the world - for example pines, spruces, firs, oaks, birches in the eucalypts etc. However, some trees can have both ectomycorrhizas and arbuscular mycorrhizas, and most tropical trees have only arbuscular mycorrhizas. The fungi involved are mainly Ascomycota and Basidiomycota, including many that produce the characteristic toadstools of the forest floor. They gain most of their sugars from the living plant roots in natural conditions. In ecto-mycorrhizas the terminal branches of the root system are highly modified, the roots are short and stumpy, covered with a mantle (sheath) of fungal tissue.

Endo-mycorrhiza (endotrophi mycorrhiza): Arbuscular mycorrhizas (AM) are found on majority of wild and crop plants, with an important role in mineral nutrient uptake and sometimes in protecting against drought or pathogenic attack. It is thought that these fungi colonised the earliest land plants and that mycorrhizal associations could have been essential for development of the land flora. The fungi involved are members of the zygomycota. The Genera as *Acaulospora*, *Entrophospora*, *Gigaspora*, *Glomus*, *Sclerocystis* and *Scutellospora* and they seem to be obligate symbionts, none of them can be grown in axenic culture, i.e. in the absence of their hosts. These are separate into two groups on the basis of nature of fungi. (a) *Endo-mycorrhiza with septate fungi:* Orchids which are obligately dependent and further development. Seed of orchids are typically minute or no reserve food materials. Seed can germinate depend on external source of carbohydrate which is supplied by the AM fungi. The fungus that form endotrophic mycorrhiza with orchids are all the member of basidiomycota e,g. *Armilaria mellia*, *Fomes* sp., *Corticium* and *Marasmius* and *Rhizoctonia* ap (imperfect fungi) associated with mycorrhiza. Ectotrophic mycorrhiza fungi are capable of utilizing complex carbohydrates like cellulose and lignin in soil. (b) *Endo-mycorrhiza with aseptate fungi (Vesicular arbuscular mycorrhizas):* The vesicular arbuscular (VA) mycorrhiza is the most common among all mycorrhizas. These are occurring in all groups of plants e.g. Bryophytes, pteridophytes, Gymnosperms and angiosperms. Large number of Agriculture crops form VA type mycorrhiza and fruit crops such as apple, strawberry, avocado citrus, coffee, cocoa, coconut and other plants rubber and tea etc.

Effect of tillage and nutrient management practices on productivity and soil quality under rice-pea cropping system in North Eastern Hill Region of India

Anup Das*, Ramkrushna GI, Jayanta Layek, Savita, AS Panwar and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: anup_icar@yahoo.com

Introduction

Rice (*Oryza sativa* L.) is the staple food of the North Eastern Region of India. The productivity of rice is low due to cultivation of low yielding local varieties, poor agronomic practices, inadequate nutrient supply; deteriorated soil quality due to removal or burning of residues and excessive/improper tillage practices etc. Recycling of crop residues and plant biomass in the soil is a promising option for replenishing soil fertility, improving physico- chemical properties and enhancing/sustaining crop yield (Das *et al.* 2008). Rice is mostly mono-cropped in the region and cropping intensity is only around 133%. Pulses like vegetable pea can be cultivated in rice fallow with adequate package of practices which would enhance system productivity and soil quality. Therefore, this study emphasize on in-situ management of weed biomass and crop residues along with reduction in tillage intensity to reverse soil degradation trends for enhanced crop productivity of rice -pea (*Pisum sativum*) system and thereby augmenting economic returns of small and marginal farmers in hill agriculture.

Methodology

The present investigation was carried out at ICAR Research Complex for NEH Region, Umiam, Meghalaya. The experiment was laid out in a factorial randomized block design (FRBD) with three replications. Treatments comprised of three tillage practice i.e., no-till (NT), minimum tillage (MT) and conventional tillage (CT)as main plots and five nutrient management(NM) practices as sub-plot i.e., 100% NPK (80:60:40 N:P_2O_5:K_2O kg ha^{-1}), 50% NPK (40:30:20 N:P_2O_5:K_2O kgha^{-1}), 50% NPK + *in-situ* residue retention (ISRR) of rice straw @ 5 t ha^{-1}, 50% NPK + weed biomass (WB) of *Ambrosia artemisiifolia* @ 10t ha^{-1} on fresh weight basis and 50% NPK + green leaf manure (GLM) of *Tephrosia purpurea* @10 t ha^{-1} on fresh weight basis. After harvest of rice (cv. Shahsarang 1), pea variety Prakash (field pea) was sown under NT with 20 cm standing rice stubble and grown with recommended package of practices (20:40:30 NPK kg ha^{-1}). Residual effects of treatments applied to rice were evaluated on pea. The composite soil samples were collected at 0-15cm depth after harvesting of pea and analyzed for physical, chemical and biological properties following standard produces. Initial soil parameters of the experimental site (2012) was bulk density (ρb) is 1.12 Mgm^{-3}, soil organic carbon (SOC), available N, P_2O_5 andK_2O was 2.40 % , 250, 20.2 and 230 kg ha^{-1}respectively.

Results and Discussion

The average grain yield (Table 1) of rice was significantly higher under NT (4.79 t ha^{-1}) than that of MT (4.49 t ha^{-1}) and CT (4.44 t ha^{-1}). Among the NM practices, application of 50% NPK+WB recorded significantly higher rice grain yield as compared to 50 % NPK or 100% NPK but is statistically at par with 50%NPK+ISRR and 50% NPK+GLM. The average rice grain yield under 50 % NPK+WB were 16.7 % and 9.10% higher than that of under 50 % NPK and 100% NPK, respectively. The residual effect of tillage and NM practices applied for rice had significant effect on green pod yield of pea in rice fallows. The pooled green pod yield of pea was highest under MT (8.13 t ha^{-1}) followed by CT (7.45 t ha^{-1}) and lowest was under NT (6.40 tha^{-1}). Among different NM practices followed in rice on the productivity of pea was recorded significantly higher under, 50%NPK+WB than that of 50%NPK alone.

In comparison with the initial baseline, there was a marked improvement in physico-chemical and biological properties of soil after three years (after harvest of pea crop) which are presented in Table 1. The ρb under CT (1.04 Mg m^{-3}) was at par with MT (0.99 Mg m^{-3}) but was significantly higher than those recorded under NT (0.96Mgm^{-3}). Among the residual effect of NM practices in rice, 50%NPK recorded significantly higher ρb and lower was under 50% NPK+GLM. Soil under NT had significantly higher available nutrients (N, P_2O_5, K_2O), SOC and soil microbial biomass carbon (SMBC) concentration than those under CT. The available N, SOC and SMBC of soils were recorded significantly higher under 50%NPK+GLM as compared to 50% NPK alone at 0-15 cm soil depth. The accumulation of crop residues on the soil surface, results in enrichment of soil OM in the surface layer and the microbial activity in soil under NT and MT (Mathew *et al.* 2012).

Table 1. Effect of tillage and NM practices on grain yield of rice, seed yield of pea and soil fertility status in after harvest pea

Treatments	*Grain yield of rice (t ha^{-1})	*Green pod yield of pea (t ha^{-1})	Bulk density (Mg m^{-3})	Available nutrients (kg ha^{-1})			SOC (g kg^{-1})	SMBC (μgg^{-1} dry soil)
				N	P_2O_5	K_2O		
A. Tillage								
NT	4.79	6.40	0.96	290	26.6	260	28.0	163.3
MT	4.49	8.13	0.99	284	24.8	252	26.2	156.4
CT	4.44	7.45	1.04	276	23.5	235	24.4	151.2
CD(*p*=0.05)	0.24	0.29	0.03	6.24	0.76	16.1	1.20	6.80
B. Nutrient management practices								
100 % NPK	4.42	7.28	1.02	268	24.0	239	25.8	143.1
50 % NPK	4.13	6.41	1.05	251	22.9	230	23.1	131.0
50 % NPK + ISRR	4.73	7.50	0.99	292	27.3	269	26.6	167.9
50 % NPK + WB	4.82	7.78	0.98	300	26.0	256	26.4	171.3
50 % NPK + GLM	4.77	7.65	0.95	305	24.4	251	29.0	178.3
CD(*p*=0.05)	0.29	0.37	0.04	8.06	0.98	20.8	1.50	8.78

*Mean yield of three years, NT-No-till, MT- Minimum tillage, and CT- Conventional tillage, ISRR- *in-situ* residue retention; WB- weed biomass; GLM- green leaf manure, SOC -Soil organic carbon, SMBC- Soil microbial biomass carbon.

The grain yields of rice were recorded higher under ZT and MT than that of CT. After three consecutive rice-pea cropping cycle, crop productivity and soil fertility status was improved under NT followed by MT as compared to CT. Green pea yield of 6-8 t ha^{-1} was obtained under different tillage and NM practices. It was evident that proper NM practices with crop residues and weed biomass can assure a fairly good crop productivity and overall improvement in soil fertility of rice-pea cropping system under NEH region.

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Assessment of hydrological behavior of prominent land use systems in mid-hills of Meghalaya for conservation planning

BK Sethy*, RK Singh, KP Mohapatra, Arvind Kumar, Hijam Jiten Singh and SV Ngachan
ICAR Research Complex for NEH Region, Umiam, Meghalaya
**Correspondence:* bsethy088@gmail.com

Introduction

Land and water are the most important natural resources which need to be managed judiciously for sustainable agricultural production. Soil erosion by water is a major factor causing land degradation and environmental deterioration in eastern Himalaya region of India. The degradation process is often triggered and accelerated by inappropriate land use and / or poor management. The region is typical with diversified climatic conditions, ranging from subtropical to alpine, favorable for growing a wide variety of crops. However, in spite of its total geographical area of 18.4 million hectares (5.6% of total geographical area of country) contributes only 1.5% to the national food basket. Practice of slash-and-burn agriculture on steep slopes and expansion of agriculture to erosion-prone land results in generation of huge runoff with annual loss of 76.6 tonha^{-1} soil (Satpathy 1996). The multi-vegetated agricultural land use converts about 14% of total rainfall into runoff with 22 tonha^{-1}yr^{-1} sediment yields, 33 kg ha^{-1} nitrogen, 0.30 kg ha^{-1} of phosphorous, 27 kg ha^{-1} potassium and 700 kg ha^{-1} of organic carbon (Singh 2010). Watershed based farming systems coupled with vegetative and structural measures at appropriate location has potential to retain maximum rainfall within the slope and help dispose off excess runoff to foothills with non-erosive velocity. Eight micro-watersheds were developed and different land uses and conservation measures were imposed in these watersheds. Estimation of hydrological behaviors of prominent land uses have been attempted in this paper to assess the conservation efficiency of different land uses.

Methodology

Five micro-watersheds for predominant land use systems in 9.53 ha area (W_1-Agriculture: 0.64 ha, W_2-Agri-horti-silvi-pasture: 1.03ha, W_3-agro forestry: 2.94ha, W_4-forestry: 3.89 ha and W_5-natural fallow: 1.03 ha) were considered for study. The area is characterized by sandy clay loam soil, land capability class of VIIe with relief of 89-110 m above MSL and average slope of 32.02 to 45.87%. Maximum length and width varies from 250-320 m and 65-230m respectively. The area receives 2415.8 mm normal rainfall in 110 rainy days. Two years (1982-83) rainfall, runoff and sediment yield data were used for calibration of micro-watersheds having different terrain features for comparing the impact of conservation measures. Land and water conservation measures (W_1-contour trenches and grassed waterways, W_2-Contour bund + bench terraces+ grassed waterways + half-moon terraces, W_3-no measures, W_4-no measures and W_5-same as W_2) were undertaken along with fodder, food + fodder and fruit crops, fodder + trees, trees and natural flora respectively. Runoff and sediment yield data for 23 years were collected at the outlet of the micro watersheds and compared with calibrated values. Water Conservation Efficiency (WCE), Soil conservation Efficiency (SCE) and Soil and Water Conservation Efficiency (SWCE) of treatments were worked out by the relationship as suggested by Madhu *et al.* (2001).

Results and Discussion

The area received an average annual rainfall of 2391 mm in 108 events over the period of 23 years. Runoff and sediment yield data presented in table 1 indicated land use practices reduced significantly. The runoff and soil loss was inversely proportional to the increase in the runoff trapping potential of the land use system density. Land and water conservation measures drastically reduced the runoff and soil loss with increase of land use system densities as compared to control (Fallow). The runoff was observed to be 4.64,3.43,6.18,17.45 and 24.16% of average annual rainfall in W_1, W_2, W_3, W_4 and W_5 respectively. Twenty three years average data revealed that runoff was reduced by 5.2,7.04,3.91 and 1.39 times in W_1, W_2, W_3 andW_4 respectively as compared to control(W_5). Similarly, soil loss was reduced by 25.06, 9.33,80.2 and 30.85 times in W_1 , W_2, W_3 and W_4 respectively over control (W_5). This may be because of the fact that land and water conservation measures act as barrier to decrease runoff velocity by impounding the runoff water in the system and increase the time of opportunity of runoff for infiltration as compared to control. Runoff and soil loss was reduced in all the land use systems due to development of canopy year after year. Soil, Water and Soil Water Conservation Efficiency was calculated. The highest SCE was recorded in W_3 as compared to control (W_5) during all the years where as highest WCE were observed in W_2 during all the years. The average Soil Conservation Efficiency of land uses for W_1, W_2, W_3 and W_4 were 95.93, 89.34,98.75 and 96.76 percent respectively. Similarly, the averages Water Conservation Efficiency of land uses were 80.8,85.8,74.43 and 62.3 per cent respectively. Overall, the highest Soil Water Conservation Efficiency was observed in W_1(88.37%), followed by W_2 (87.57%), W3(86.6%) and it was lowest in W_4 (79.53%). Thus, for development of hilly micro-watersheds, appropriate land and water management measures in agriculture, agri-horti-silvi-pasture, agro-forestry, forestry land use systems w.r.t altitude are needed for enhancing water use efficiency of various crops and sustainability of the system. Conservation measures for farming system approaches should be planned on watershed basis for for developing degraded hilly watersheds.

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Foliar application of micronutrients in French bean

Joydip Mandal[1] and Arkajyoti Bhattacharyya[2]

[1]*Institute of Agriculture, Visva-Bharati (A Central University), Sriniketan, West Bengal,*
[2]*Institute of Agricultural Sciences, Calcutta University, Kolkata - 700019, West Bengal, India*

E-mail: joydip_hort@rediffmail.com

Introduction

French bean (*Phaseolus vulgaris* L.) is a leguminous vegetable, mostly grown for its tender green pods used as vegetable or processed. Immature seeds of French bean are also consumed either as *dal* or used in making curries. Micronutrient deficiencies in vegetable crops have led to appearance of many disorders though they are required in very small quantity. Boron plays an essential role in the development and growth of new cells in the meristematic tissue. It enhances cellular activity such as cell division, differentiation and maturation. Boron imparts stability to the pollen tubes. Boron deficiency has been reported to be associated with internal tissue breakdown *i.e.* "internal brown spot" (IBS) in some bean varieties (Warncke 2005). Zinc affects enzyme systems that regulate various metabolic activities like protein synthesis, in the formation of some growth hormones, formation of chlorophyll, transformation of carbohydrates, regulates sugar in plants and in the reproductive process of certain plants. Moreover they play role in seed formation, maturation date, height of plant, if present in sufficient quantities in the leaf. Molybdenum is a component of the enzyme nitrogenase, which is essential for the processes of symbiotic and non-symbiotic nitrogen fixation. Molybdenum stimulated N-fixing activity of *Phaseolus vulgaris* (Vakhaniya *et al.* 1990). Traditional agricultural practices mostly rely on organics for meeting the crop demand for micronutrients. However, modern input demanding cultivation techniques with high yielding / hybrid cultivars demand more from the soil and surroundings; thus needed supplemental application of micronutrients, which is mostly meeting up *via* foliar application. French bean is successfully grown in Coastal Saline Zone of West Bengal during cooler months. Growers show their interest to this crop for its ready demand and better market return. Thus, a location specific trial was felt necessary to standardize micronutrient dose towards productivity enhancement. Keeping these points in view, an investigation was conducted with the objective to find out the effect of boron, zinc, molybdenum and their combinations on growth, yield attributes and yield of French bean.

Methodology

The present investigation was conducted at the field of a local farmer Sri Badal Chandra Singha, Purba Pitpur, P.O. Keshapat, Panskura, Dist. Purba Medinipur (West Bengal) during the period from November 2014 to February 2015. The soil of the experimental site was sandy loam in texture with p^H 6.2. The experiment comprised of 7 treatments, which was laid out in randomized block design with three replications. Micronutrients *i.e.* boric acid (H_3BO_3) @ 0.5%, zinc sulphate heptahydrate ($ZnSO_4.7H_2O$) @ 0.5% and ammonium molybdate ($H_{24}MO_7N_6O_{24}.4H_2O$) @ 0.1% was used as treatment in various combinations or alone. Split application of micronutrients was done as foliar spray at 25 and 35 days after sowing. The Spray volume was kept 400 litre /ha. The treatments were as follows: Control *i.e.* water spray (T1), boron (B) (T2), zinc (Zn) (T3), molybdenum (Mo) (T4), B+Zn (T5), B+ Mo (T6), B+Zn+Mo (T7). French bean cultivar Laboni (Mali-Agri-tech Pvt. Ltd., Ranaghat, Nadia, W.B.) was taken for this study. Sowing was done on 6^{th} November, 2014 at 30cm x 20 cm spacing. The plot size was kept 3 m x 2m. Farm Yard Manure @ 10/ha and standard doses of nitrogen @ 60 kg N /ha, phosphorus @ 50 kg P_2O_5 /ha and potassium @ 50 kg K_2O /ha were applied to the entire field as basal. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and Muriate of potash. Observations were recorded on different traits *viz.*, plant height and number of branches/plant at 90 days after sowing (DAS), days to fifty percent flowering, pod length, pod girth, average pod weight, percentage of pod dry weight, number of pods /plant, pod yield /plant and pod yield /ha.

Results and Discussion

The mean sum of squares due to treatments were found significant for plant height, number of pods, average pod weight, pod length, pod yield /plant and pod yield/ha. It was noted non-significant for number of branches/plant, days to fifty percent flowering, pod girth and percentage of pod dry weight. Plant height at 90DAS was noted statistically significant. T7 (B+Zn+Mo) produced maximum plant height (54.83 cm), followed by T5 (B+Zn), T6 (B+Mo) and T2 (B). It seems that boron played a major role either alone or in combination with zinc and/or molybdenum to increase plant height. Application of micronutrients increased pod length, except when boron and zinc applied alone. Again, pod length was significantly increased with the combined application of boron and zinc &/or molybdenum. Foliar application of boron and zinc, and boron, zinc and molybdenum impart greater effect on pod weight. Spraying of zinc and molybdenum alone was not much effective. The average pod weight was recorded 5.29 g. Total four harvests were done in the entire crop period. Pods /plant were significantly influenced by foliar spray of micronutrients in all the four harvests and also in total. Maximum value of total number of pods per plant was noted in T7 *i.e.* combination of boron, zinc and molybdenum, followed by spraying boron alone (T2). Average pod yield per plant was registered 159.4 g. In first three harvests maximum pod yield /plant was noted in T7 *i.e.* combined application of boron, zinc and molybdenum. However, spraying of zinc registered maximum pod yield/plant at fourth harvest. Maximum cumulative pod yield per plant was noted in T7 *i.e.* combined application of boron, zinc and molybdenum. Experimental data also revealed that application of micronutrient either alone or in combination with others result significant increase in pod yield per plant than control. Average pod yield per hectare was noted 88.08 q/ha. Various doses of micronutrients showed considerable effect on pod yield/ha. Maximum yield was noted in T7 *i.e.* combined application of boron, zinc and molybdenum in first three harvests. Application of zinc registered maximum yield at fourth harvest. Total yield was obtained by adding all the four harvests. Application of boron, zinc and molybdenum (T7) registered maximum pod yield per hectare (11.1 t/ha). This finding is *at par* with Moniruzzaman *et al.* (2008). Present investigation revealed that the combined application of boron, zinc and molybdenum was beneficial towards yield enhancement. It registered about 44% yield increase over water spray (control). Application of boron, zinc and molybdenum also registered maximum plant height (54.83 cm), pod length (14.12 cm), average pod weight (5.63 g), number of pods /plant (50) and pod yield /plant (181.1 g/ha). Thus, foliar spray of boric acid (0.5%), zinc sulphate (0.5%) and ammonium molybdate (0.1%) in two splits at 25 and 35 days after sowing with spray volume of 400 litre /ha to the French bean cv. Laboni may be advice to the farmers of Coastal Saline Zone of West Bengal for productivity enhancement.

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Morpho-physiological responses of pea cultivars to tillage and nutrient management practices in acid soils of Meghalaya

Anup Das[1], Krishnappa R[*2], Savita[1], Ramkrushna GI[1], Jayanta Layek[1], Juri Buragohain[1], AS Panwar[1] and SV Ngachan[3]

ICAR Research complex for NEH Region, Umiam-793103, Meghalaya, India

*Correspondence: krishphysiology@gmail.com

Introduction

In the wake of global climate change, integrated nutrient management and resource conservation technology (RCTs) are important eco-friendly agronomic technologies in sustainable agriculture to enhance water, soil and energy efficiency. The conservation tillage practices improves the soil organic carbon (SOC) content, reduces soil erosion, increase water storage capacity and subsequently enhances soil quality and resilience (Madejon *et al*. 2007). Likewise, conservation tillage and efficient residue management practices can improve soil quality, conserve residual soil moisture and thereby improving the plant physiological response that leads to alleviation of the effect of multiple abiotic stresses on crop growth (Das *et al*. 2014). Pea (*Pisum sativum L.*), being a versatile annual cool season legume and cover crop, predominantly self-pollinated with determinate flowering habit widely cultivated for both human food and livestock feed. It is a rich source of protein (21-25%), amino acids, sugars (12%), carbohydrate, vitamins A and C, calcium and phosphorus. However, the studies on impact of such RCTs along with residue management practices on physiological advantage of pea are scanty. Therefore, the present study was undertaken to assess the residual effect of tillage and NM practices of *kharif* rice on physiology, soil quality, and productivity of *rabi* season pea under lowland rainfed conditions of Meghalaya in Eastern Himalayas.

Methodology

A field experiment was conducted during 2014 -15 in agronomy farm of ICAR Research Complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya. The experiments were laid out in factorial randomised block design (FRBD). Treatments of *kharif* rice were comprised of three tillage practices i.e., ZT, MT and CT as main treatments and five NM practices as sub-treatments i.e., 100% NPK (80:60:40 NPK kg/ha), 50% NPK (40:30:20 NPK kg/ha), 50% NPK + ISRR @ 5 t/ha of rice straw, 50% NPK + WB of *Ambrosia artemisiifolia* @ 10t/ha on fresh weight basis, 50% NPK + GLM of *Tephrosia purpurea* @10 t/ha on fresh weight basis with three replications. The NPK content (%) of *A. artemisiifolia* and *T. Purpurea* is 3.12, 0.11, 0.78 and 2.25, 0.3, 0.77 respectively. Under ZT, application of systemic herbicide (Glyphosate @ 5 ml/litre water) at 10 days before transplanting with dibbling without any ploughing or puddling. For MT, One ploughing practiced at 20 days before transplanting followed by levelling. For CT, 3 ploughings at 20 days before transplanting followed by levelling was performed. After harvest of rice leaving at 20cm height stubble, two varieties of pea viz., Prakash (field pea) and Arkel (garden pea) were sown after one week with zero tillage and recommended package of practices. The observations on growth performance, physiological parameters, root growth and its architecture at active growth stage (60DAS) and yield components at harvest were recorded. Chlorophyll and carotenoid pigment levels in fresh leaves were estimated. Details of root size and distribution of pea plants grown under different tillage and management practices were studied by careful uprooting and smooth loosening of the soil surrounding the root system and by washing of adhering rhizospheric soil with gentle flush of water. The fresh and air dried plant roots were scanned using root scanner (Winrhizo^R software) to record the root images to study parameters of root architecture.

Results and Discussion

The total chlorophyll pigment (Chl a and b) content of two pea varieties recorded at active growth stage showed, significantly reduced quantities of chlorophyll under CT compare to ZT and MT and it did not vary significantly among different NM practices (Table1). Anthocyanin being another important nutrient stress responsive pigment also showed significant variation in both pea varieties across tillage and NM practices. Both the pea varieties synthesised more anthocyanin comparatively in ZT and 50% NPK+WB. Increased carotenoids under ZT and 50% NPK+WB, in addition to function as accessory pigments, they form a key part of the plant antioxidant defence system to protect photochemical processes under stress conditions (Havaux 1998).

Table 1 Physiological parameters of pea varieties as influenced by tillage and NM practices.

Treatment	Tot Chl		Antho		CMS		RSA		TRL	
	Arkel	Prakash	Arkel	Prakash	Arkel	Prakash	Arkel	Prakash	Arkel	Prakash
A.Tillage										
ZT	1.19	1.27	32.1	29.4	9.62	10.7	33.7	36.0	85.4	86.7
MT	1.18	1.26	27.1	27.2	8.18	9.24	33.7	34.7	79.6	82.9
CT	1.06	1.14	25.4	25.7	6.59	7.68	29.6	32.6	74.4	76.7
C.D. (*p*=0.05)	0.13	0.11	3.94	2.89	0.89	1.09	3.06	NS	5.66	5.02
B. Nutrient management practices										
100 % NPK	1.12	1.20	27.0	24.9	7.26	8.33	30.75	33.56	71.85	74.15
50% NPK	1.10	1.18	22.0	23.2	6.10	7.17	26.45	28.99	65.80	68.14
50% NPK+ ISRR	1.14	1.22	29.5	27.2	8.66	9.73	28.65	32.31	77.20	79.52
50% NPK+ WB	1.17	1.25	32.4	31.9	9.89	10.9	39.37	39.42	88.24	90.54
50% NPK+ GLM	1.20	1.28	30.2	29.9	8.74	9.81	36.40	37.80	95.89	98.23
C.D. (*p*=0.05)	NS	NS	5.09	3.72	1.15	1.41	3.96	4.51	7.31	6.49

Tot. Chl: Total chlorophyll content (mg/g FW), Anth:Anthocyanin content (µg/g FW), TRL:Total root length (cm/plant), RSA : Root surface area (cm^2/plant), CMS:Cell membrane stability (%)

The CMS of the fresh leaves of both pea cultivars varied significantly among tillage and NM practices. Both the pea varieties recorded significantly higher CMS in under ZT compare to CT and MT and 50% NPK+WB compare to other NM practices. Root growth parameters like root surface area and total root length of the both the varieties were also comparatively higher under Zero or minimum soil disturbances (ZT and MT) and crop residue application (WB and GLM). This improved root architecture changes acts as drought protective mechanisms, enabling the plant to explore increased quantities of water and essential nutrients from deeper layer of the soil.

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Effect of micronutrients and soil amendments on enhancing productivity and quality of rice in acid soils of North-Eastern Hill Region of India

LK Baishya*, MA Ansari, Rishikanta Singh, A Menthoibi and N Prakash

ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Manipur

Correspondence: lkbaishya@rediffmail.com

Introduction

Micronutrient malnutrition, the so-called hidden hunger, affects more than half of the world's population, especially women and preschool children in developing countries. The role of micronutrients such as iodine, iron and zinc in human nutrition has increasingly been recognized over the last decade. The diets of over two-thirds of the world's population lack one or more essential mineral elements and the people of north eastern India are no exception. Agronomic approaches currently taken to biofortify food crops with the mineral elements like iron (Fe), zinc (Zn), copper (Cu), calcium (Ca), magnesium (Mg), iodine (I) and selenium (Se) are most commonly lacking in human diets. Micronutrients supplementation is a simple and effective agronomic practice to increase concentration of micronutrients in grain. The concentration of several micronutrients in grain can effectively be enhanced by the application of appropriate mineral nutrients. Organic amendments, especially FYM, can increase the concentration of many nutrients and can be seen to enhance the nutritional value and nutrient balance of plant food. Foliar fertilization has many advantages over soil application due to lower requirement and immediate crop response. Therefore, an attempt has been made in this investigation to study how does the use of micronutrients and soil amendments improve the grain quality and increase the productivity of rice in acid soils of North-Eastern Himalayan Region of India.

Methodology

The field experiment was conducted at the Research farm of ICAR Research complex for North Eastern Hill Region (NEHR), Manipur Centre, Lamphelpat during *kharif* season of 2013 and 2014. The soil of the experimental plot was sandy loam in texture, acidic in reaction (pH 5.0), medium in available nitrogen (290 kg N/ha) and available phosphorus (10.0 kg P/ha) but high in available potassium (230 kg K/ ha). The experiment was laid out in split plot design with four main plot treatments consisted of different soil amendments [A_0= Control, A_1= Farm yard manure (FYM) 5t ha^{-1}, A_2= Lime 200 kg ha^{-1} and A_3= Lime 400 kg ha^{-1}] and four sub-plot treatments of micronutrients fortification [M_0= Control (No micronutrient), M_1= spraying of 0.5% $ZnSO_4$, M_2= spraying of 2% $FeSO_4$ and M_3= spraying of 0.1% Na selenate] in three replications. All the plots received recommended dose of fertilizers (60 kg N + 13.1 Kg P + 25.0 kg K /ha). Lime as per treatments was applied at 15 days before planting. The micronutrient spraying as per treatment was done once at booting (50 DAT) and the other at grain filling (70 DAT). Observations on yield and yield attributes, NPK uptake, soil fertility status etc were taking as per standard procedures.

Results and Discussion

The soil amendment with FYM and lime exerted significant effect on both grain and straw yields of rice. Application of lime 400 kg ha^{-1} produced the highest grain yield (6.67 t ha^{-1} in 2013 and 7.65 t ha^{-1} in 2014), which was significantly greater than that of lime 200 kg ha^{-1} (5.75 t ha^{-1} in 2013 and 6.39 t ha^{-1} in 2014), FYM 5.0 t ha^{-1} (6.00 t ha^{-1} in 2013 and 6.76 t ha^{-1} in 2014) and control plots (4.31 t ha^{-1} in 2013 and 5.03 t ha^{-1} in 2014). Application of lime 400 kg ha^{-1} showed its superiority over other soil amendments during both the years as well as in pooled analysis. It increased grain yield by 16.0, 11.2 and 54.8% over that with the application of lime 200 kg ha^{-1}, FYM 5.0 t ha^{-1} and control plots, respectively. Soil amendment with FYM 5.0 t ha^{-1} and lime 200 kg ha^{-1} also increased grain yield by 39.2 and 33.4% respectively over that of the control plots that recorded the lowest grain yield during both the years. Soil amendments, especially, lime and FYM, increase the availability of many plant nutrients that helped in better nutrition, greater growth of the crop and thus greater productivity (Ram et al., 2013).

Micronutrients fortification showed significant effect on grain yield of rice. Foliar spray of 0.5% $ZnSO_4$, 2% $FeSO_4$ and 0.1% NaSe markedly increased both grain yield of rice. The highest grain yield of rice (6.25 and 7.08 t ha^{-1} in 2013 and 2014, respectively) was recorded due to spraying of 0.5% $ZnSO_4$. Spraying of 0.1% NaSe also out yielded the control plots that produced the lowest grain yield of rice. The crop receiving 0.5% $ZnSO_4$, 2% $FeSO_4$ and 0.1% NaSe spray produced 25.6, 21.5 and 10.5% higher grain yield over those of the control plots, respectively. Micronutrients fortification increased the availability and uptake of the nutrients resulting in improving the crop metabolic activities, thus, enhanced accumulation of assimilates and increased crop productivity.

As nutrient content in rice grain did not vary much between the two years, the average values over two years data have been presented here. The soil amendment treatments recorded significant effect on nutrient contents in rice grain (Fig. 1). The N, P, K, Zn, Fe and Se contents in rice grain increased significantly over those of the control plots due to the use of different soil amendments; but none of them varied significantly among the different soil amendment treatments. The foliar application of different micronutrients exerted significant effect on their respective contents in rice grain under the study. The crop receiving 0.5% $ZnSO_4$ increased Zn content in rice grain over that of the other treatments. Similarly, spraying of 2.0% $FeSO_4$ and 0.1% NaSe significantly increased the Fe and Se contents in rice grain, respectively over those of the other treatments. Organic carbon content in soil increased significantly over that of the control plots due to the application of FYM 5 t ha^{-1}, but use of lime at both levels (200 and 400 kg ha^{-1}) did not cause significant variation in soil organic carbon content when compared with the control plots.

All the soil amendment treatments (5 t ha^{-1} FYM, 200 and 400 kg ha^{-1} lime) significantly increased the available N, P, K, Fe, Zn, Mn and Cu content in soil over those of the control plots. However, the above macro- and micro-nutrients did not differ significantly among the different soil amendment treatments under the study. The results suggest using soil amendment (FYM 5.0 t ha^{-1} or lime 400 kg ha^{-1}) along with foliar feeding of Zn (0.5% $ZnSO_4$) and/or Fe (2% $FeSO_4$) at booting and grain filling stages of rice for sustainable quality rice production.

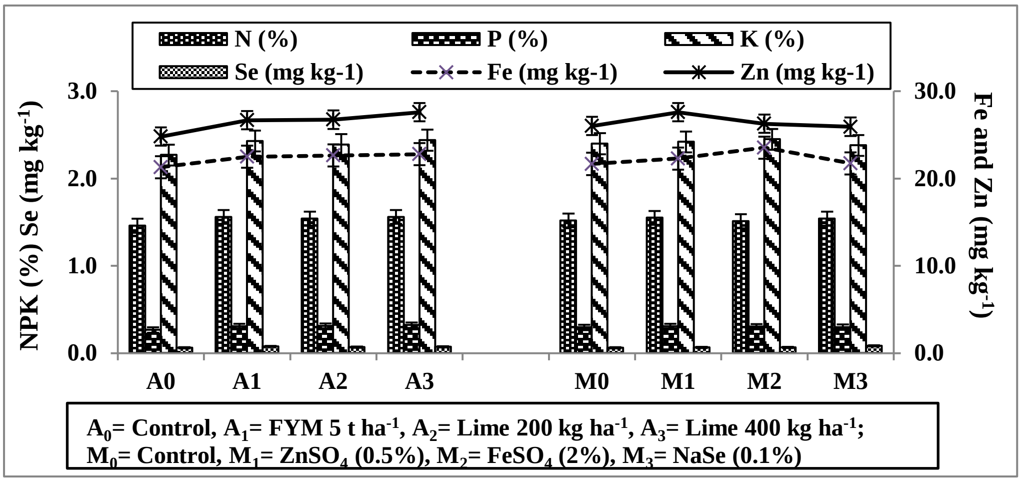

Fig 2. Effect of amendments and micronutrients on nutrient contents in rice grain

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Effect of continuous fourteen years of integrated nutrient management practices on the performance of upland rice on terraced land

Manoj Dutta*, Lenjing Gao and Sewak Ram

School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, Medziphema, Nagaland, India

*Correspondence: manojdutta1997@yahoo.com

Introduction

The development of soil fertility of the exposed subsoil of terraced fields for sustained production is a time taking process. To increase the productivity of terraced land, integrated nutrient management practices should be adopted to ensure a steady buildup of soil fertility together with other soil properties suitable for plant growth. Crop residues and farm yard manure are excellent material for improving the soil physical condition when incorporated. The integrated application of inorganic fertilizers along with organic sources like poultry litter, FYM etc., not only enhances the soil fertility but also improves the soil physical properties like porosity, field capacity, available water content, particle density, MWD and decreases the bulk density which will result in increase in production of the crop. The data pertaining to the long term effect of integrated nutrient management practices on the performance of upland rice in respect of plant height, number of tillers, grain and straw yield, and soil fertility status on terraced land in acid soils of Nagaland are scanty. The present investigation was carried out to evaluate the effect of integrated nutrient management practices on the performance of upland rice on terraced land under continuous cultivation for fourteen years under rainfed conditions of Nagaland.

Methodology

The effect of integrated nutrient management practices on the performance of upland rice (*Oryza sativa* L.) on terraced land under continuous cultivation were studied in a field experiment conducted on the experimental farm of the School of Agricultural Sciences and Rural Development under rainfed conditions. Twelve treatments involving N, P and K (NPK) fertilizers, FYM, poultry litter, forest litter incorporated and burned, *Azospirillum* and Zn either alone or in combinations were applied for 14 years and rice crop cultivated continuously. The plant heights at 90 days after sowing (DAS) were measured from the ground base to the tip of the ear of the selected plants and average height was computed. The plant population at 30 DAS, numbers of tillers at 60 DAS and number of panicles at harvest were computed from one square meter area. For determination of straw and grain yield, one square meter area from each plot was kept undisturbed. The plants of this area were harvested from the ground base. The harvested plants were thrashed and grains separated from straw and air-dried. The grain and straw yield (g m^{-2}) was obtained thereafter. The data was used to compute straw and grain yield (q ha^{-1}). Soil samples from individual plots were collected after the harvest of rice crop and air dried at room temperature. The soil samples were analyzed for available N, P and K following standard procedure.

Results and Discussion

The plant heights of rice at 90 DAS ranged from 80.6 to 101.9 cm with an average of 89.5 cm. After fourteen years of continuous application of fertilizer, FYM, poultry litter and *Azospirillum* in different combinations result in a significant increase in plant height in all the treatments except in ½N+ PK treatment over control. The plant height in NPK+ FYM, NPK+ Forest litter and NPK+ FYM+ Zn was significantly higher than NPK. Also, substituting ½N with FYM results in a significant increase in plant height as compared to NPK. The plant height was 13.4, 9.5 and 6.2% higher in NPK+ FYM, NPK+ FYM+ Zn and NPK+ Forest litter over NPK, respectively. The number of tillers m^{-2} varied from 87.3 to 253.9 with an average of 196.3. The significant increase in number of tillers ranged from 82 to 190.8% with an average of 136.1% over control. The number of panicle m^{-2} ranged from 68.6 to 240.9 with an average of 166.9. The maximum of number of panicle was recorded in NPK+ FYM+ Zn and lowest in control. The number of panicles in the treatments NPK+ FYM+ Zn, NPK+ Poultry litter, NPK+ FYM and NPK+ Forest litter were significantly higher over NPK. The significant increase of panicles in NPK+ FYM+ Zn, NPK+ Poultry litter, NPK+ FYM and NPK+ Forest litter over NPK was 43.8, 28.3, 21.3 and 15.9%, respectively. The grain yield of rice varied from 15.3 to 38.7 q $ha^{-1}$with an average of 30.7 q ha^{-1}. The maximum grain yield was recorded in NPK+ Poultry litter and lowest in control. The grain yield in NPK+ FYM, NPK+ Poultry litter and NPK+ FYM+ Zn was 24.2, 28.5 and 19.9% higher over NPK, respectively. The increase in straw yield in different treatment over control varied from 29.9 to 167.8% with an average of 103.1%. Chauhan *et al*. (2010) reported an increase of 8.2% straw yield with the addition of NPK+ FYM as compared NPK treatment alone.

Table 1. Effect of integrated nutrient management practices on grain yield, straw yield and available macronutrients in soil

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1-Control	15.3	31.1	433.5	14.8	208.1
T_2-½N+ PK	24.0	43.7	581.1	19.7	233.3
T_3-NPK	30.1	55.2	623.0	21.6	251.6
T_4-NPK+ FYM	37.4	82.2	656.7	25.4	298.6
T_5-½N+ PK+ ½N FYM	33.0	67.0	632.5	24.7	255.4
T_6-NPK+ poultry litter	38.7	83.3	660.3	25.1	271.6
T_7-½N+ PK+ ½N poultry litter	34.4	65.1	637.8	25.3	281.1
T_8-NPK+ forest litter	31.8	58.2	627.9	20.4	257.3
T_9-½N+ PK+ ½N forest litter	32.8	63.7	637.5	20.4	301.1
T_{10}-½N+ PK+ *Azospirillum*	28.4	60.8	639.9	20.7	271.8
T_{11}-NPK+ FYM+ Zn	36.1	75.2	649.1	24.0	289.0
T_{12}-Forest litter burned+ ½ FYM	26.8	40.4	505.0	17.3	235.9
SEm $\pm$	1.54	2.27	3.47	1.13	2.07
CD (p=0.05)	4.52	6.57	10.19	3.33	6.08

The increase in available N in soil in different nutrient management practices ranged from 71.5 to 226.8 kg N ha^{-1} with an average of 189.3 kg N ha^{-1}. The rate of buildup of available N in various nutrient management practices after fourteen years of continuous cultivation was estimated to be 5.1 to 16.2 kg N ha^{-1} yr^{-1} with an average of 13.52 kg N $ha^{-1}yr^{-1}$. The increased in available P in various nutrient management practices ranged from 4.9 to 10.6 kg P ha^{-1} with an average of 7.4 kg P ha^{-1}. After fourteen years of continuous cultivation and nutrient management the rate of buildup of available P in different integrated nutrient management practices was estimated to be 0.44 to 0.96 kg P $ha^{-1}yr^{-1}$ with an average of 0.52 kg P $ha^{-1}yr^{-1}$. The increase in available K content in soil in different nutrient management practices ranged from 25.2 to 90.5 kg K ha^{-1} with an average of 59.7 kg K ha^{-1}. The rate of buildup of available K in various nutrient management practices after fourteen years of continuous cultivation was estimated to be 1.82 to 6.46 kg K $ha^{-1}yr^{-1}$ with an average of 4.26 kg K $ha^{-1}yr^{-1}$. Among various treatments NPK+ Poultry litter is the best nutrient management practice that can be adopted for terrace cultivation followed by NPK+ FYM+ Zn and NPK+ FYM. The treatments ½N+ PK+ ½N Poultry litter, ½N+ PK+ ½N FYM and ½N+ PK+ ½N Forest litter could be used as an alternative nutrient management practices on terraced land.

Determination of critical limit of boron for cowpea in acid soils of Arunachal Pradesh

P Debnath*, SK. Pattanaika, D Sah and AK Pandey

College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh

Corresponding author: kanupran@yahoo.co.in

Introduction

Boron is one of the most important microelements essential for plant growth (Berger and Truog 1940) and involved in several plant metabolic functions. In recent years, boron has become crucial element because of its role in fertilization and flowering processes of crops. Application of boron either through soil or foliar spray has been found beneficial for increasing the yield of several crops such as black gram (Singh *et al*. 2002), soybean and rice (Debnath and Ghosh 2011). The yield and yield attributes of cowpea which is a good source of vegetable protein in Indian diet, is significantly benefited by the application of boron during *rabi* season.

Methodology

Twenty two soil samples in bulk from plough layer (0-20 cm) were collected from different locations of cultivated land of East Siang district of Arunachal Pradesh. The physico-chemical properties were analyzed by the standard procedure (Jackson 1973). A pot culture experiment was conducted in a greenhouse in polythene lined pots (7 kg capacity) at the Instructional farm Pasighat, Arunachal Pradesh with cowpea (*Vigna ungiculata* L.Walp, variety – Kashi Kanchan) as test crop. Boron was applied at the rate of 0, 0.5, 1 and 1.5 mg kg^{-1} soil as reagent grade borax. Each treatment was replicated thrice in a completely randomized design.

Results and Discussion

The organic carbon, clay content, CEC and pH are widely considered to influence the availability of boron in soils. The soil texture varied from sandy loam to silty loam. The soils had pH values ranging from 4.3 to 6.3 with a mean value of 5.15, indicating that soils are strongly acidic in reaction. The organic carbon status of soil samples ranged from 9.8 to 34.5 g kg^{-1} with a mean value of 23.8 g kg^{-1}. The plot of Bray's per cent yield against soil available B and plant tissue B were 0.46 and 23.50 mg kg^{-1}, respectively as the critical concentration of B in soils and plant by the graphical procedures (Figure 1 and 2).The available B content in most of the soils of the study area was low to medium which ranged from 0.22 to 1.21 mg kg^{-1} with mean value 0.54 mg kg^{-1} . The average response of dry matter yield at optimum level of applied B in deficient soils ranged from 9.5 to 74.2 per cent with a mean value of 39.5 per cent. Whereas, in soils with adequate available boron content (above the critical limit), the percentage response decreased which varied from (-) 10.66 to 29.02 per cent with a mean value of (-) 1.80 per cent. The available B exhibits significant positive correlation with organic carbon (r = 0.74), clay(r = 0.87) and CEC(r = 0.69) of the soils, suggesting that organic matter, clay and CEC are the major soil properties that influence available B content in soil.

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An approach of rainwater harvesting and utilization for enhancing crop production in hill agriculture

Sanjay Kumar Ray, P Chowdhury, Tasbina R Borah, Santosh Baishya, KK Barman, Bidyut C Deka

ICAR Research Complex for NEH Region, Jharnapani, Nagaland

Correspondence: dr.sanjaykumarray@yahoo.in

Introduction

The total geographical area of the Wokha district is around 1, 62,800 ha, which falls under three different agro-ecological situation viz., sub-tropical hill zone, sub-tropical plain zone and mild tropical hill zone lying between $26^0$00'02" N to $26^0$26'98" N latitude and $93^0$55'12" E to $94^0$23'15" E longitude with altitude ranging from 98 to 1503 m. The rain-fed agricultural practices are dominated in the hilly terrains of the Wokha district. The district receives a reasonably high amount of annual rainfall (199.6 cm) and 72.1% of the average annual rainfall is concentrated for the period of June–September (kharif season) (Ray et al. 2015). But, this bounty rainfall is lost through runoff or deep percolation which becomes unavailable for the crops as the major soils are coarse with poor water holding capacity. Such type of Geo-hydrological condition leads to acute water scarcity problems during post-rainy season, particularly in the month of December to March of the year, resulting in lower surface water and groundwater potential which is a main constraint in the agricultural development in the District.

One of the difficulties with regard to the water resources in the district is a lack of awareness and management in rainwater harvesting for agricultural and allied activities. Traditional farm ponds are generally practiced by the farmers are being exposed to potential losses likes infiltration, percolation, seepage flow and evaporation to a great extent (Saha *et al*. 2007). The constructions of the farm pond through conventional methods; by using bricks, stone-slabs, *etc.* is very expensive and becomes complicated for the poor farmers. In this scenario, popularization of low-cost rainwater harvesting structure by using *silpaulin* sheet may assist to the rural poor farmers, to harvest rainwater during the rainy season. At the same time, judicious utilization of the harvested water for the diversified farming may generate some direct and indirect employment opportunities for farmers and rural youth through subsidiary occupation.

There is a very scanty of work on the efficacy of rainwater harvesting by using *"jalkund"* and its diverse utilization of water in hilly areas of the district. Keeping all the above facts under consideration, a frontline demonstration was conducted with two different sized of rainwater harvesting structure *"jalkund"* were taken up to study (a) the most farmers preferable sized of water harvesting *"jalkund"* to meet the ever increasing water demand during post rainy season (b) the diverse possible activities/options for harvested water utilizations in agriculture and allied farming system, and (b) the utmost possibilities of income earning capabilities through agriculture & allied farming after intervention of *"jalkund"*

Methodology

Altogether, 14 numbers (5x4x1.5 m^3 and 7x6x1.5 m^3) of low-cost rainwater harvesting structure *"jalkund"* were demonstrated with two different sized at different villages (Table 1 &2) of Wokha district. The water harvesting sites were selected in view of the water storing and its utilization feasibilities. In all the cases *jalkund* were installed at higher elevation than the targeted water utilization areas. The embankment type ponds were constructed (dug out) for water harvesting capacity of 30,000 and 63,000 liters respectively. The side and bottom walls were plastered with a mixture of clay and cow-dung in the ratio of 5:1.Cushioning (3-5 cm thick) was given with locally available crop residues and banana, pineapple and pine leaves. The 300 GSM *silpaulin* sheet was laid down on kund. In every demonstration unit a 25X25 cm trench dug out, all round, of kund to divert the surface runoff. In all the cases water collected into the *jalkund* either from nearby season spring or through roof catchment system.

Results and Discussion

Hill farmers generally suffer to grow *rabi* season crops and crops usually fail due to less *insitu* soil moisture content, in addition to non-availability of the irrigation water facility during the growing periods. The economically viable *"jalkund"* were having minimum seepage losses, provided an ample opportunity to the poor farmers, to meet the individual water requirement. The flexibility of these "*jalkund"* in terms of size had also provided an option to the farmers to adopt the dimensions based on their own water requirements. With respect to the size of *jalkund*, it was identified that the demonstration of two different types of *jalkund* had considerable impact on installation cost and water utilization systems. The demonstration of 63,000 liter capacity (big size) of *jalkund* at farmers field was associated with the higher initial installation investment (excluding *silpaulin* sheet) as compared to the 30,000 liter (small sized) capacity *jalkund*, but the cost in terms of per liter of harvested water was much lower for the big sized *jalkund* (Rs/- 0.072-0.082) compared to small sized *jalkund* (Rs/- 0.10-0.14). The key cost differences within the size of *jalkund,* were due to the presence of stone and gravel in soil and working flexibility under different land topography. It was also observed that more than 70% of the farmers were being utilized water for three farming components, when they adopt the bigger size of *jalkund*, whereas only 57% of the farmers were able to undertake more than one component after adopting the small sized *jalkund*.

Adopting bigger size of *jalkund* gave more water utilization, flexibility to the farmers and were also able to flourish diversified farming *viz.* strawberry and *naga* king chilli cultivation under shade net as high value crops, year round vegetable production in poly house, lifesaving irrigation for fruits and winter vegetables, nutritional gardening, fish, pig and poultry rearing, vermicomposting besides the domestic water requirements. But most of the cases the farmers were able undertake only one income generating farming activity likes nursery of mandarin orange, tree bean, flowers and rubber plantation, rearing of pigs, vermicomposting, winter vegetable cultivation in rice field and year round mushroom production; when they adopt smaller sized of *jalkund* in their farm. The sufficient availability of the irrigation water for agriculture and allied farming activities increased the gross return from Rs/- 7,000 to 61,200 for the bigger sized and Rs/- 6,800 to 60,000 for the smaller sized of *jalkund*. Using of the harvested water for different farming activities also increased the net return from Rs/- 5,000 to 34,400 for bigger sized and Rs/- 4,700 to 31,000 for smaller sized of *jalkund*. In terms of net return from the different farming activities, it was observed that the use of harvested water for livestock and the nursery based farming system was found the most profitable entrepreneurships at the district. The demonstration of the water harvesting techniques was found to be effective and well accepted to the farmers moreover also capable to meet the required water demand at lean period. The smaller harvesting structure was found in favour of one farming activity, although used for more than one farming activities bigger structure fitted more appropriately. The water harvesting approach was also offeredd some prospect to produce year round farm production besides subsidiary income generating interventions likes mushrooms, fish, piggery, poultry, *etc.*as it was very simple, economical and create scopes for earning directly or indirectly.

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Microbial transformation of arsenic as influenced by phosphorus and organic matter

Suvo Kumar Das*[1] and Shaon Kumar Das[2]

[1]*Bidhan Chandra KrishiViswavidyalaya, Mohanpur, Nadi, West Bengal*

[2]*ICAR RC for NEH Region, Sikkim Centre, Gangtok, Sikkim, West Bengal*

Correspondence: dassuvobckv@gmail.com*

Introduction

Arsenic is one of the most toxic elements with diverse chemical behaviour. Magnitude of arsenic contamination in ground water in a sizeable area of West Bengal is alarming. Not only in the drinking water, accumulation of arsenic through underground irrigation water and there after intake of it through food chain are a serious concern. The problem requires great attention to resolve. Among different approaches, microbial bioremediation can be a tool for the purpose. To get better efficiency of the arsenic transforming micro-organisms, the role of organic matter and phosphorus as interacting ions to be judged. Keeping this in view, the present study of "Microbial transformation of arsenic as influenced by phosphorus and organic matter" was undertaken in a controlled condition in the laboratory through incubation studies.

Methodology

Enumeration of total bacteria, fungi, actinomycetes and cyanobacteria (CFU) in the soil were studied by serial dilution pour plate technique. Stock solutions of 1000 mg L^{-1} arsenic were prepared by dissolving sodium arsenate (Na_2HAsO_4, 7 H_2O) in a one litre volumetric flask. A requisite volume of the arsenic solution containing 10 and 15 mg L^{-1} arsenic was applied to treatment. The arsenic extracting solution used in this treatment was 0.5 M $NaHCO_3$ solution (sodium bicarbonate). The solution was prepared by dissolving 42 gm of $NaHCO_3$ in distilled water and volume was made up to 1 litre after adjusting the pH of the solution at 8.5.

Results and discussion

Two experiments viz. (i) "Effect of phosphorus on bacterial transformation of arsenic in broth" with different concentration of phosphorus (0, 10, 15 mg L^{-1}) and arsenic (10, 15 mg L^{-1}) and (ii) "Effect of phosphorus and organic matter on transformation of soil arsenic by bacterial strains" with different doses of phosphorus (0,10,15 mg kg^{-1}) and organic matter (0,5,10 t ha^{-1}) at different days of incubation (30, 60 and 90 days) with the inoculation of *Citrobacter koseri* and *Pseudomonas putida* were conducted. The soil was neutral in reaction and non-saline in nature. The nutrient content of the soil was low to medium range. Total and extractable arsenic content were 16.5 mg kg^{-1} and 4.29 mg $kg^{-1}$of soil and it was in higher range. The bacterial inoculants *Citrobacterkoseri* and *Pseudomonas putida* efficiently remove arsenic from As^{v} enriched broth after 14 days of incubation. Percentage of removal of arsenic ranges from 47 to 58%, bioaccumulation 29 to 39% and loss 17 to 21% was made by *Pseudomonas putida* and it was 47 to 59% (removal), 29 to 38% (bioaccumulation) and 17 to 23% (loss) by *Citrobacter koseri*. No significant contribution of phosphorus was observed on bacterial removal or bioaccumulation or loss of arsenic from the broth.In soil incubation study, bacterial inoculants, *Citrobacter koseri* and *Pseudomonas putida* significantly contributed towards reduction of total and extractable soil arsenic and increase in extractable phosphorus in presence of organic matter. The performance was better when organic matter (FYM) @ 10 t ha^{-1} was added. The effect of organic matter and bacterial inoculation was reflected on increase in total bacterial population and biomass carbon of the soil but not on soil organic carbon. A significant reduction of total and available arsenic was observed upto 90 days of incubation. The results of these experiments clearly depicted that the bacterial inoculants with the addition of organic matter have the capacity to decontaminate a portion of arsenic by transformation, intracellular accumulation and loss probably through volatilization.

Therefore, these two promising bacterial strains *Citrobacter koseri* and *Pseudomonas putida* along with the FYM @ 10 t ha^{-1} can be used in future to ameliorate soil arsenic.

Baseline concentrations of trace elements in black soils of Sehore and Vidisha districts

T Basanta Singh[*,1], S Rajendiran[2], Ch Bungbungcha[1] and MA Ansari[1]
[1]*ICAR Research Centre for NEH Region, Manipur Centre*
[2]*Indian Institute of Soil Science, Bhopal*
*Correspondence: basantasingh.t@gmail.com

Introduction

Huge quantity of heavy metals are being mined out from deeper layers of earth crust and pose threat to the environment by affecting crop productivity and soil microbial biodiversity and also to human and animal health. Due to variation in natural factors like parent materials, climate, physiography etc. wide variation in heavy metals contents among soils from different uncontaminated regions of different countries have been reported. Among heavy metals, Ag, As, Hg, V, Cd, Co, Cr, Cu, Ni, Se, and Ti have high to moderately high toxicity to plants and Ag, As, Cd, Cr(VI), Hg, Sb, Se, Ti, and V exhibit high toxicity to mammals. The mean heavy metal concentrations in natural soil varies widely from 0.06–1.1 µg/g for Cd, 1.6–21.5 µg/g Co, 7–221 µg/g for Cr, 6–80 µg/g for Cu, 0.02–0.41 µg/g for Hg, 4–55 µg/g for Ni, 10– 84 µg/g for Pb, 17–125 µg/g for Zn in non-contaminated soil of the world. Due to such divergent approaches, wide differences in regulatory limiting values have been observed among different countries. However, such information is scanty in our country which has diversified types of soils and agro-climatic conditions.

Methodology

Hundred soil samples from various locations fifty soil samples each from these two districts were drawn out from twenty villages of Sehore district and from twenty-two villages of Vidisha district. Soil pH, Electrical conductivity (EC), Organic carbon and $CaCO_3$were estimated by standard analytical methods. For total heavy metal analysis, 1.0 gram dry soil (0.5mm) was first pre-digested with 10 mL of concentrated HNO_3 for one night. The pre-digested samples were digested in hot plate by adding 10 mL of di-acid (4 parts of $HClO_4$ and 9 parts of HNO_3) till the acid gets evaporated to near dryness. Process is repeated till the soil residue becomes whitish by adding di-acid mixture. One mL of $HClO_4$was added and the sample was evaporated until the appearance of white fumes. The residue was dissolved by adding 4.0 mL of 12 N HC1 (kept for 1 minute) +50 mL of double distilled water and kept on sand bath for 4 hours. Finally the volume of the digest is made to 100mL and filtered by using Watman No. 42 filter paper. The filtrate is directly fed to ICP-OES for trace metals (Cu, Zn, Cd, Cr, Pb, Ni). Correlation between the soil properties and heavy metals were carried out. Baseline concentrations can be determined both numerical and statistical ways, viz, range and mean ± standard deviation. In that case, the geometric mean (GM) and geometric standard deviations (GSDs) are used to represent the central tendency and variation of the data. Baseline concentrations of the seven trace metals are defined as the range between GM/GSD^2 and $GM \times GSD^2$ and taking the concentrations between the fifth and the 95^{th}percentiles. This range included 95% of the samples (Zhang *et al.* 2008). This method was used to determine the baseline limit in this experiment.

$$Lower\ baseline = \frac{Geometric\ Mean}{Geometric\ Standard\ Deviation^2}$$

$$Upper\ baseline = Geometric\ Mean\ \mathrm{X}\ Geometric\ Standard\ Deviation$$

Results and Discussion

The concentrations (total) of six heavy metals, i.e., Copper, Cadmium, Lead, Chromium, Nickel and Zinc in Sehore and Vidisha districts were estimated from the soil digest with the help of ICP –OES and they are presented in the table 1-a. The heavy metal concentration range of Sehore districts were 44.0-309.1µg/g for Cu, 0.1-0.85 µg/g for Cd,6.06-26.65 µg/g for Pb, 22.2-102.5 µg/g for Cr, 31-92.5 µg/g for Ni and 31.4-97.6 µg/g for Zn, with their corresponding geometric mean value of 91.89 µg/g, 0.27 µg/g,16.26 µg/g, 65.05 µg/g, 57.34µg/g and 61.97 µg/g, respectively. For Vidisha district, their concentrations were 39.55-141.9 µg/g for Cu, 0.20-0.65 µg/g for Cd, 11.33-23.18 µg/g for Pb, 57.95-62.30 µg/g for Cr, 42.85-69.73 µg/g for Ni and 44.85-73.70 µg/g for Zn, with their corresponding geometric mean value of 59.67 µg/g, 0.35 µg/g,15.17 µg/g, 77.27 µg/g, 53.15 µg/g and 55.55 µg/g, respectively. The range of heavy metal concentrations i.e., Copper, Cadmium, Lead, Chromium, Nickel and Zinc in both the districts were 34.3-309.1 µg/g for Cu, 0.1-0.35 µg/g for Cd,6.06-26.65 µg/g for Pb, 22.2-128.7 µg/g for Cr, 28.1-92.5 µg/g for Ni and 30.9-109.6 µg/g for Zn. The geometric mean value for concentrations of Copper, Cadmium, Lead, Chromium, Nickel and Zincwere 72.56 µg/g, 0.30 µg/g, 15.65 µg/g, 70.68 µg/g, 55.40 µg/g and 58.71 µg/g, respectively.

The baseline concentrations of six heavy metals i.e Copper, Cadmium, Lead, Chromium, Nickel and Zinc in Sehore and Vidisha districts were estimated and presented. The lower and upper baseline limits (range) of six heavy metals for Sehore district are 36.8 µg/g and 229.6 µg/g for Cu, 0.1 µg/g and 0.8 µg/g for Cd, 9.5 µg/g and 28.0 µg/g for Pb, 35.4 µg/g and 119.4 µg/g for Cr, 35.0 µg/g and 94.1 µg/g for Ni and 38.7 µg/g and 99.2 µg/g for Zn. The lower and upper baseline limits (range) of six heavy metals for vidisha district are 32.3 µg/g and 101.5 µg/g for Cu, 0.2 µg/g and 0.5 µg/g for Cd, 11.2 µg/g and 20.3 µg/g for Pb, 57.6 µg/g and 102.3 µg/g for Cr, 42.8 µg/g and 66.9 µg/g for Ni and 38.7 µg/g and 99.2 µg/g for Zn. The upper and lower baseline concentrations of heavy metals for both the districts are 29.6µg/g and 178.1 µg/g for Cu, 0.1µg/g and 0.7 µg/g for Cd, 10.0µg/g and 24.4 µg/g for Pb, 42.7 µg/g and 116.9 µg/g for Cr, 37.5 µg/g and 81.8 µg/g for Ni and 40.4 µg/g and 85.2 µg/g for Zn.

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Nitrogen management through LCC in rainfed lowland rice ecosystem of lower Brahmaputra valley region of Assam

Teekam Singh* BS Satapathy, KB Pun and Kanchan Saikia

Regional Rainfed Lowland Rice Research Station, Gerua, Assam
(ICAR-National Rice Research Institute)
*Correspondence: tiku_agron@yahoo.co.in

Introduction

Better matching of nutrient supply with crop demand is often considered a basis for improving and stabilising yield, in irrigated as well as rainfed systems. Split applications of nitrogen or use of controlled-release formulations may improve synchrony of supply and demand, but whether any yield advantage is realised in rainfed lowlands depends on choice of an appropriate release time for the controlled-release fertiliser and conditions suitable for the response to be expressed. Leaf colour intensity of rice is directly related to leaf chlorophyll content and leaf nitrogen status. Japanese scientists developed an N management tool called leaf colour chart (LCC) (Furuya 1987) which was subsequently modified by different nations as well as research Institutes as per their local needs. The colour panels of the LCC are designed to indicate whether rice plants are hungry or over-fed by nitrogen fertilizer. By matching the colour of the rice leaf to the colour on the LCC, farmers can decide proper time and amount of N fertilizer for application. LCC validation experiments in Vietnam and other countries have shown that farmers can save a substantial amount of nitrogen without any reduction in grain yield, which subsequently led to its wider adoption. In the real-time option, farmers monitor the colour of rice leaves at regular intervals of 7–10 days from early tillering (20 DAS) and N is applied whenever the colour is below a critical threshold value (Nayak *et al*. 2013). For high-yielding inbreds and hybrids who bears dark green colour leaves, N application should be based on a critical LCC value of 4, whereas, for inbreds and hybrids who bears light green colour leaves, N should be applied at a critical value of 3 (Nayak *et al*. 2013). It is not clear to what extent rice yields are limited by nutrients, water, and the interactions between them, over the diverse soil types, cultural practices, and seasonal conditions of the rainfed lowlands. Thus, the objective of this study was to quantify the nitrogen requirement of rainfed lowland rice in lower Brahmaputra valley of Assam.

Methodology

An experimental trial was conducted during2013-14 at Research Farm of RRLRRS, Gerua, Assam to quantify the nitrogen requirement of rainfed lowland rice. It is located at 28º 14' 59" N latitude, 91º 33' 44' E longitudes and at an altitude of 49 m above mean sea level and characterized in the long-term by a subtropical monsoon climate. The annual average rainfall is 1500 mm of which about 75% falls during June to September. Four treatments consisting of control, N recommended (60 kg ha^{-1}), N based on LCC (60 kg ha^{-1} fixed) and N based on LCC (variable) were tested in randomized block design with five replications. High yielding rice variety Naveen was used for experiment which having light green colour leaves. Seedlings of 30 days were carefully uprooted from the nursery beds and transplanted in the last week of July each year according to the treatments in the well-puddled experimental plots with spacing of 20 cm × 15 cm. A recommended fertilizer dose of 60-30-30 kg ha^{-1} of N-P_2O_5-K_2O was applied through urea, di-ammonium phosphate (DAP) and muriate of potash (MOP) in the field. One-third N and full doses of P_2O_5 and K_2O were applied as basal dose at the time of final land preparation and incorporated well into the soil. Remaining nitrogen was applied in two equal doses in recommended treatment at maximum tillering and panicle initiation. Leaf colour was monitored continuously from 21 days after transplanting at 10 days interval until panicle initiation. The remaining N in LCC (fixed) was applied in two splits with equal fixed quantity at maximum tillering and panicle initiation while N in LCC (variable) was applied 10 kg N ha^{-1} as basal dose and remaining N as per need at rate of 20 kg N ha^{-1}whenever the colour is below a critical threshold value (3) of LCC. All other agronomic practices were kept normal and uniform for all the treatments of the experiment. The yield and yield attributes recorded on the basis of net plot 6 x 5 m harvested and threshed. The collected data were statistically analyzed at 5% probability to compare means of treatments.

Results and Discussion

The performance of treatments indicated that number of panicles per square meter and number of filled grains per panicle was significantly influenced by N management techniques while plant height and panicle length remained statistically at par (Table 1). The maximum number of panicles (352.5 m^{-2}) and filled grains per panicle

(131.2) was recorded with N based on LCC (variables) which was also significant over control and recommended doses of N. It might be due to sufficient availability of N and satisfying the crop needs for N during maximum tillering and photosynthetic assimilation from source to sink. The leaf N status of rice, which is closely related to photosynthetic rate and biomass production, serves as a sensitive indicator of the crop demand for N during the growing season (Singh *et al.* 2012). These higher values of yield attribute resulted significantly higher grain yield (5.8 t ha^{-1}) with N management through LCC (variable) over the control but remained at par with other treatments. The N used in LCC (variable) treatment was 50 kg ha^{-1} thus 10 kg Nha^{-1} saved. The maximum net return (` 42056 ha^{-1}), B:C (2.11) and nitrogen use efficiency (34 kg grain kg^{-1} N) were obtained with LCC (variable). LCC was successfully used to increase N-use efficiency while maintaining high yields in rice production (Singh *et al*. 2002).

Table 1. Effect of Nitrogen Management through LCC on the performance of rice

Treatment	Plant height (cm)	Panicles (m^{-2})	Filled grains Panicle^{-1}	Panicle length (cm)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Net return (` ha^{-1})	B:C	Nitrogen use efficiency (kg grain kg^{-1} N)
Control	105.4	271.0	107.8	22.4	4.3	4.1	21346	1.61	-
Recommended doses of N (60 kg ha^{-1})	106.2	326.2	115.5	22.6	5.4	5.2	33134	1.86	18.3
N based on LCC (60 kg ha^{-1})	106.8	338.5	124.5	23.3	5.9	5.4	34839	1.88	21.7
N based on LCC (variable)	107.9	352.5	131.3	23.9	6.1	5.8	42056	2.11	34.0
CD (P=0.05)	NS	20.42	14.99	NS	0.91	0.92			

On the basis of higher grain yield along with corresponding higher net return, B:C and nitrogen use efficiency and other parameters, LCC at threshold value <3 for light green leaf colour varieties was judged to be the critical values for proper N management.

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Micronutrient management in agriculture for food security

YK Sharma and SK Sharma
SASRD, Nagaland University, Medziphema, Nagaland
Correspondence: yk2310sharma@rediffmail.com

Crops grown in of the most soils in India suffer from one or more micronutrient deficiencies, even though the soils are apparently adequate in total amounts of the respective elements. The nature and extent of micronutrient deficiencies differs with soil type, crop genotype, crop management and agro-ecological situations. Deficiencies of micronutrients are now common in the crops of intensive cropping systems. Multi micronutrient deficiencies are now becoming an increasing problem in the country. Micronutrients requirement of various crops through chemicals varied from 1kg (Mo) to 50 kg (Fe) per ha. Very less part of these nutrients is taken up by the crops and the rest are lost. Nutrient use efficiency of micronutrients is extremely low. Huge amount of micro nutrients either fixed in the soil or losses by other means. Effect of micronutrient deficiency can be very severe in terms of stunted growth, low yield, dieback and even plant death. Very small application of micronutrients may produce dramatic results. The chief sources of micronutrients are organic materials available in agriculture farms which are good alternative of micronutrient fertilizers. These include FYM, poultry manure, green manure, compost, animal dungs, and crop residues. Efficiency of micronutrient applied through fertilizers in soil is only 2-10% whereas availability of micronutrients reported more than 10% when applied through organic sources and supply is continuous. Macro plant nutrients require supplementation from inorganic fertilizers, whereas the micronutrients supplied through organics do not need supplementation of micronutrient fertilizers. Crop removal of micronutrients can be met through supplementing organics, which are eco-friendly, slowly available to the crops as per requirement and larger part is retained by soil for the next crop.

Influence of residue management of rice cultivars on soil health and productivity of succeeding lentil

Emdor Shylla[1,2], Anup Das[2*], Ramkrushna G. I[2], and Jayanta Layek[2]

[1]*College of Post Graduate Studies, CAU, Umiam, Meghalaya*
[2]*ICAR Research Complex for NEH Region, Umiam, Meghalaya*
[*]Correspondence: anup_icar@yahoo.com

Introduction

Rice is the major staple food crop of the region occupying 3.5 m ha, which accounts for about 7.8% of the country rice area and 6.5% of the crop production. In mid-altitude (>900 m above mean sea level) of the NER of India, a second crop of rice following the harvest of main *kharif* (July to mid-November) rice is not possible mainly due to early onset of winter (<15°C) from November onwards, which causes spikelet sterility in rice. Pulses are the ideal crop that can occupy the area vacated by rainy season rice leading to increase in cropping intensity, productivity per unit area and farmers income. Lentil is a drought tolerant pulse crop and can be grown in high rainfall areas and lowlands during dry season with adequate water management. Draining excess water in physiological maturity of rice (about 10 days before harvest) is an adaptation option excess moisture in lowlands for cultivation of pulses in high rainfall mid-hills ecosystems of eastern Himalayan region (Das *et al.* 2014). Because of its adaptation to intercropping and relay cropping, lentil occupies a unique place in cropping systems in northern, eastern, and central India. Retention of residues of previous crops can conserve soil moisture for succeeding crop grown during dry/winter season leading to improved water use efficiency. Thus, cultivation of lentil or any pulse crop after rice would enhance the cropping intensity, pulse production, availability of high protein food and in the long run improve the soil health due to N-fixation and soil quality enhancement. With this background, the present study was conducted.

Methodology

The experiment was conducted during *kharif* and *Rabi* of 2012 at the Experimental Farm of the ICAR Research Complex for North Eastern Region, Umiam, Meghalaya. Geographically, Umiam is located in North-East Hill Region of India at 25°41'N latitude, 91°54'E longitude and at an elevation of 950 m above the mean sea level. The experiment was laid out in a double split design with two main plots (Shahsarang 1- medium duration, HYV and Mendri- long duration, local cultivar), two sub plots (DPL 81-Early duration with high biomass and IPL 406-Medium duration with high biomass)and three sub sub-plots (20 cm standing stubble, mulching and residue removal) and replicated thrice. The size of individual plot was 4 x 3.8 m^2 and altogether there were 36 plots. Soil moisture content was recorded every 15 days from 30-120 DAS whereas growth attributes and other physiological parameters were recorded once every month from 30-90 DAS. Soil physico-chemical and biological parameters as well as yield, lentil equivalent yield, water use efficiency and net return was analyzed and calculated after the harvest of lentil.

Results and Discussion

Rice cultivars did not showed much significance in respect to soil organic carbon stock (SOC stock), yield, net return and water use efficiency (WUE). However, Shahsarang 1 recorded higher to yield (1.7 t/ha), lentil equivalent yield (LEY) (3.67 t/ha) net return (Rs. 75, 807/ha) and water use efficiency (8.4 kg/ha-mm). Among the lentil cultivars, IPL 406 recorded higher seed yield (1.8 kg/ha) as well as net return (Rs. 81, 438/ha) as compared to DPL 81The SOC stock was significantly higher under mulching (44.8 Mg/ha) as compared to removal. In lentil, significant influence of treatment on seed yield was recorded due to RSMP. Higher seed yield was obtained under mulching which was 21% higher than residue removal, respectively. The higher seed yield might be due to use of straw mulch that enhances the inherent moisture retention capacity as well as nutrient supplying capacity of the soil, which in turn improved seed yield. Ghosh *et al*. (2009) reported that mulching had positive effect on yield of succeeding mustard crop and registered maximum seed yield. Similarly, the LEY was higher under mulching which is 12.8% higher as compared to removal. Lentil cultivars as well as RSMP had a significant influence on the WUE of succeeding lentil. It was recorded that lentil grown under straw mulching resulted in higher WUE (18%) as compared to that without mulch.

Therefore, from the study conducted it can be concluded that cultivation of lentil (IPL 406) after Shahsarang 1 under rice residue mulching is a recommendable option for higher lentil productivity, soil moisture conservation, WUE, WP, soil health and net return in lowland rice fallow under zero tillage at mid altitude of Meghalaya**.**

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Classification of Indian soil and its recent advances in both plain and hilly region

Kabir Debbarma*

College of Post Graduate Studies, CAU, Umiam, Meghalaya
*Correspondence: kabirdb90@gmail.com

Introduction

A large variety of soils occur in the Indian subcontinent due to transformation and weathering of a wide range of rocks and minerals in both plain and hilly region. Soil development or soil genesis is the result of number of factors known collectively as soil formers. Different soil forming factors are climate, vegetation and topography acting for varying periods on a range of rock formations and parent materials, have given rise to different kinds of soil.

Methodology

The National Bureau of Soil Survey and Land Use Planning, Nagpur has developed a database on soils with field and laboratory studies over the last 30 years. This has generated maps and soil information at different scales, showing area and distribution of various soil groups in different agro ecological sub regions.

Results and Discussion

The 1: 250,000 scale maps shows a threshold soil variation index of 4–5 and 10–25 soil families per m ha for alluvial plains and black soil regions respectively. Progress in basic and fundamental research in Indian soils has been reviewed in terms of soils, their formation related to climate, relief, organisms, parent materials and time.

Evaluation of greengram as dual purpose crop in humid sub-tropical climate in terms of nutrient acquisition and biomass production

Poulami Saha*, Gulab Singh Yadav, Chiranjit Debbarma and Mrinmay Datta.

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura

Correspondence: gpsahapoulami@gmail.com

Introduction

Green gram *(Vigna* radiata L Wilezek), is an important legume that used to enrich soil fertility and combat malnutrition supplying vegetable protein in human diet. Growing of green gram enables the farmers to profitably utilize their land during summer months (April-June) which otherwise remain mostly unused. Photo-insensitive and short duration varieties of green gram (60-70 days) which could easily be accommodated before sowing of rainy season crops taking opportunity of summer rainfall that's are usually available during the period. Green gram could be grown as dual purpose crop as green manure crop after harvest of economic yield. The crops used as green manure are generally turned into soil in order to improve the growth of subsequent crop. To use the crops as green manure has declined because of the use of synthetic inorganic fertilizers. Nowadays, the concerns about sustainability of soil productivity and ecological stability, which come into view with the excessive use of synthetic fertilizers, have become prior. In this respect, use of legume crops as green manure to improve soil fertility and soil physical conditions has received increasing attention (Ray and Gupta 2001). The improvement in soil physical conditions as a result of buildup of organic matter by incorporation of green manure or crop residue is associated with a decrease in bulk density, increase in total pore space, water stable aggregates and hydraulic conductivity of the soil (Boparai *et al*. 1992). Dhaincha (*Sesbania aculeata)* and green gram or mungbean are some of the important legumes which are used as green manure. The legumes, which have short vegetation duration and which are used as green manure show advantages in rice based cropping systems to sustain the productivity of the soil with their high adaptation capability and ability to fix the cavalier nitrogen (Bar *et al*. 2000). Furthermore, the synthetic fertilizers are quite expensive and the essential amount to be applied is high. For these reasons, more study is necessary to find out the better green manure crop suitable to our cropping system. With this objective the present trial was carried out to evaluate efficacy of the use of greengram as dual purpose crop.

Methodology

The field experiments were conducted at Agronomy experimental plot of ICAR Research Complex for North East Region, Tripura Centre, Lembucherra, Tripura (W), India ($23^0$54'24.02" N and $91^0$18'58.35"E and altitude of 162 m ASL (meters above mean sea level) during the crop-growing season (April-June) in 2013 and 2014. The annual rainfall of Lembucherra is 2200 mm. The experiment was laid out in a randomized complete block design and replicated four times. The net plot size was 3 x 3 m^2 (gross plot size 4 x 4 m^2). The treatments consisted of five varieties of green gram viz. T_1-TARM-18, T_2-TRCM-1-6-5-4, T_3-TRCM-2-2-1, T_4-IPM-2/3 and T_5-TMB-37. Two hand weedings were performed at 20 and 45 days after sowing (DAS). Green gram was sown at a spacing of 30 cm row to row and 10 cm plant distance with a seed rate of 30 kg ha^{-1}. Fertilisers applied at the rate of 15, 40 and 30 kg ha^{-1} N, P_2O_5 and K_2O, respectively as basal during land preparation.As the green gram was sown as and when the preceding crops were harvested, the pods of green gram were collected manually at maturity from an area of 9 m^2 and the grain yields were determined.

Results and Discussion

Growth, economic yield and biomass yield were significantly varied among the greengram varieties. All the greengram varieties were mature 60-65 day after sowing (DAS). TRCM-2-2-1 was recorded highest plant height, although TARM-18 was produced maximum number of branches/plant. Greengram varieties IPM-2/3 took minimum number of days for maturity (61 DAS). TRCM-2-2-1 produced significantly higher economic yield and yield attributes than all other varieties. Root nodule and plant dry weight producing capacity of different Greengram varieties were also varied. TARM-18 was produced significantly highest root nodule and plant dry weight at all the growth stages. Among the Greengram varieties, IPM-2/3 recorded significantly higher biomass (fresh/dry) accumulation in shoot, root as well as total over other varieties (Table 1). Total accumulation (root + shoot) of N, P and K in TARM-18 was significantly higher than other varieties and it was remained statistically on par with IPM-2/3 (Table 1). Therefore study suggested the inclusion of short duration greengram varieties TARM-18 in rice based cropping systems for enhancing the productivity and improving the soil health.

Table 1. Total nutrient accumulation and biomass producing capacity of different green gram varieties

Treatment	Total dry biomass (t/ha)	N accumulation (kg/ha)	P accumulation (kg/ha)	K accumulation (kg/ha)
TARM-18	4.48	102.7	10.9	104.7
TRCM-1-6-5-4	4.33	98.4	9.7	100.4
TRCM-2-2-1	3.88	87.8	8.3	89.6
IPM-2/3	4.36	99.5	10.2	101.4
TMB-37	3.86	87.0	7.9	88.2
SEm±	0.13	2.9	0.4	2.9
LSD (*p=0.05*)	0.44	9.6	1.3	9.5

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Maximizing productivity of Chinese Chives through balanced use of nitrogen and potassium, and their mode of application

RK Imotomba and Pangeijam Bijaya

Krishi Vigyan Kendra,Bishnupur District, Manipur

Correspondence: imotombadrrajkumar@gmail.com

Introduction

Chinese chives syn. *Allium* (*Allium tuberosum* Rottler ex-Sprengel) belong to the family Liliaceae is locally known as "Maroi nakuppi" in Manipur has been domesticated since time immemorial in North East India and has been using as a very important vegetable. It is also very rich in minerals and vitamins and has got medicinal properties. In Manipur, it is widely used as flavouring agent in curry making in place of onion and this indigenous spice has become very popular and some of the marginal and sub-marginal farmers had a good source of income simply by cultivating it all the year round. In fact it had a good demand in local market and many farmers may lead to a sustainable agriculture by producing *Allium*. It can grow in wide range of soils where the climate is moderate and humid, but a good harvest can be made from well drained sandy loam soils with high organic content. But there is substantial scope for increasing yield to meet the increasing demands by adoption of fertilizers particularly N and K and their mode of application, therefore, the present investigation was aimed to find out the effect of different levels of N and K and their mode of application on growth and yield of Chinese chives for the agro-climatic condition of Manipur with the following objectives:

1. To study the effect of N and K and their mode of application for increasing the yield.
2. To find out economic return of *Allium tuberosum.*

Methodology

The experiment on "Maximizing productivity of Chinese Chives through balanced use of Nitrogen and Potassium and its mode of application (*Allium tuberosum* Rottler ex-Sprengel)" was conducted at the KVK Bishnupur District, Utlou, Manipur during 2011-12 under clayey soil condition. Soil samples were collected randomly from the experimental site from depth of 20 – 25 cm before starting the experiment to determine the inherent fertility status of the soil and physico-chemical properties were PH -5.5, Available N-313.6 kg/ha, Available P-30.3 kg /ha and Organic carbon 1.41%. The different levels of nitrogen and potassium in the form of urea and muriate of potash were applied according to the mode of application. Mixture of N and K was applied @ 2% (2 g / lit of water).

i. Different levels of nutrients :
   a) Levels of N : N_1 = 60 kg / ha, N_2 =80 kg / ha, N_3 =100 kg / ha
   b) Levels of K : K_1 = 60 kg / ha, K_2 = 80 kg / ha
ii. Mode of application of fertilizer (M)

   M_1 = 8 times of N and K at equal dose.

   M_2 = 2 times of N and K at equal dose.
iii. P @ 70kg / ha was applied as basal along with all the treatments except control.
iv. Control plots – There were control plots where all the treatments were not given with the notation N_o K_o M_o (T13) to compare the effect of other treatments.

Intercultural operation practices such as earthing up, irrigation and weeding were followed whenever necessary. The leaves were harvested when they attained marketable size.

Observation on plant growth: 10 plants from each plot were randomly selected as the sample plants, the different observation were taken from these samples at an interval of 25 days viz. 25, 50, 75 , 100, 125, 150, 175, 200, 225, 150, 175, 200, 225, 250, 275, 300 and 325 DAT.

Result and Discussion

The data on number of leaves at various crop stages revealed that there was significant increase in number of leaves due to fertilizers and their mode of application. Maximum number of leaves (43.12) was associated with application of N and K @ 100 and 80 kg/ha with split application at 8 times at equal dose. There was a sudden declining of number of leaves at 175 DAT. The number of stem per plant was maximum at reproductive stage of the crop. The result indicated an increasing trend in production of number of stem was pronounced with higher dose of fertilizer. The maximum stem no. (8.08) was associated with 100:80 of N and K kg/ha and their split application at 8 times at equal dose. The finding was an agreement with that of Pal and Pandey (1988) that growth of garlic was increased by application of 150kg N, 250kg P and 75 kg K_2O/ha and also at higher doses of Nitrogen produced more no of stem of *Allium* (Singh 1995). The maximum plant height (26.07 cm) was recorded by maximum dose of fertilizers. Leaf area was increased by application of N, K and their mode of application was mainly due to better growth and more production of leaf number which was in conformity with *Gaimeily et al.* (1991) in onion. The highest yield (201.49 q/ha) was recorded with application of 100, 80 kg/ha of N, K and their split application of eight times at equal doses. Low yield (49.50 q/ha) was found in control treatment where, no fertilizer was applied. Similar result of maximum yield was also reported by Wilson (1995) in chives. Marketable yield was significantly influenced by nitrogen and potassium at 100,80 kg/ha with split application of eight times at equal dose. The highest net return (Rs, 1,95,188) with cost benefit ratio1:4.2 of *Allium tuberosum* was obtained with application of N, K @ 100, 80 kg/ha and its split application of eight times of equal dose which was closely followed by split application of 80 kg N/ha and 80 kg K_2O/ha with net return (Rs. 1,86,396) and cost benefit ratio of 1:1.34.

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Effect of nutrient management practices on root architecture associated traits and productivity in garden pea on acid soils of Meghalaya

Samborlang K Wanniang[1], Aditya K Singh*[1], Anup D[2], Krishnappa R*[2], Vishram R[1], Lala IP Ray[1], N Janki Singh[1], D. Thakuria[1], Nishant A Deshmukh[2] and Savita[2]

[1]*College of Post Graduate Studies (CPGS), Central Agricultural University, Umiam, Meghalaya,*
[2]*ICAR Research Complex for NEH Region, Umiam, Meghalaya, India*
*Correspondence: adityakumar1972@yahoo.co.in

Introduction

Garden pea (*Pisum sativum L.*) is a versatile annual cool season legume especially cultivated for fresh nutritious grains in its green pods. These grains are used mostly for vegetable purposes besides some requirement from canning industries. The rest over plant material left after pod picking is a valuable green fodder for milch cattle and other livestock. Green grains are rich source of protein, amino acids, sugars (12%), carbohydrate, vitamins A and C, calcium and phosphorus. Even though the garden pea cultivated extensively in NEH region, studies on NM practices, physiological responses for various NM practices in acid soils are scanty. Farming in North East Hill (NEH) region is highly complex and risk prone. Productivity of most of the crops of the region is low due to a number of constraints viz; undulating topography, faulty land use system, soil erosion, soil acidity and lack of appropriate nutrient management practices (Rajkhowa and Manoj-Kumar 2013). Escalating fertilizer cost, growing environmental concerns and need for long term maintenance of soil health necessitates the development of low cost, eco-friendly integrated nutrient management (INM) practice(s). Further, use of bio fertilizers enhances soil biodiversity by promoting beneficial microbes, which in turn enhances plant growth thereby enhancing the crop yield**.** In this background this study was undertaken to evaluate various physiological parameters including root growth and productivity of garden pea as influenced by different NM practices on mid hill acidic soils of Meghalaya.

Methodology

A field experiment was conducted during *Rabi* 2014 (II fortnight of November 2014 to I fortnight of March 2015) at experimental farm of CPGS (91^0 55.341 E and 25^0 41.429 N) under upland situation of mid hills of Eastern Himalaya with an approximate altitude of 991 m above mean sea level. The soil of the experimental field was acidic (pH: 4.8) containing 1.2% Organic C, 268, 14.6 and 115 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. Total 22 treatments having a different combination of recommended doses of fertilizers (RDF) with FYM and biofertilizers (*Rhizobium* and PSB) were investigated for their effect on root growth and fresh green pod yields (recorded at first picking). RDF (20:50:40 kg/ha of N, P_2O_5 and K_2O, respectively) was applied as per the standard practices in form of urea, single super phosphate (SSP) and muriate of potash (MOP). Applied FYM had 0.73% N, 0.18% P_2O_5, 0.71% K_2O and 0.58% S. Before starting the experiment soil samples were collected randomly at 0-20 cm depth from experimental field to know its initial fertility status. These samples were mixed to prepare a composite true representative sample of experimental site, air dried under shade condition and then sieved through 2 mm sieve. This soil sample was analyzed for determining its pH, SOC, available N, P, and K by following standard protocols. Details of root size and distribution of pea plants (root associated traits) were studied at 55-60DAS (at flowering stage) after uprooting the pea plants from the field by loosening the soil surrounding the root system and washed to remove adhering rhizospheric soil in a smooth flush of water. The fresh and air dried plant roots were scanned using Epson root scanner (Winrhizo^R software) available at Division of Horticulture, ICAR research complex for NEH region, Umiam. However, fresh yield of green pea pods from net plot area was recorded as kg/plot which later converted into q/ha to study the effect of treatments on pea productivity.

Results and Discussion

The root architecture parameters of garden pea assessed at the active growth stage (55-60DAS) increased in terms of improved root surface area, root diameter, root volume and total root length in the treatments having RDF, FYM plus lime application (T4, T6, T7 and T9) compare to those treatments deprived of RDF, FYM, lime application and with control (Table1). This investigation also observed a close relationship between improved root architecture and fresh pod yield in garden pea as an improvement in pea productivity recorded as high fresh yield of green pods in treatments provided with RDF, FYM, and lime application was also noticed. This was probably due to greater availability of soil moisture and essential plant nutrients for plant absorption from large distance and deeper soil layers and could be attributed to enhanced root architecture parameters. The improved root parameters under RDF, FYM and Lime applied treatment were probably due to more production of growth hormones and vitamins because of congenial microbial activity with optimum range of soil pH which is important for optimum pea growth and higher photosynthesis

Table 1. Root architecture parameters of garden pea under different nutrient management practices

T	Nutrient Management Practices	TRL	RSA	RV	RD
T1	FYM	51.8	93.0	15.33	1.74
T2	Rhizobium+PSB	35.2	121.0	9.32	3.52
T3	FYM+Rhizobium+PSB	106.8	153.8	11.78	2.95
T4	RDF+FYM	160.5	217.2	18.91	2.13
T5	RDF+Rhizobium+PSB	122.4	89.4	7.83	2.17
T6	RDF+FYM+Rhizobium+PSB	172.2	238.4	19.32	2.37
T7	RDF+Lime+FYM	200.6	263.2	20.20	1.99
T8	RDF+Lime+Rhizobium+PSB	190.0	115.9	8.02	2.12
T9	RDF+Lime+FYM+Rhizobium+PSB	211.6	278.3	20.03	1.52
T10	50%RDF+Lime+FYM	131.3	181.0	10.93	2.42
T11	50%RDF+Lime+Rhizobium+PSB	64.5	133.7	7.26	3.22
T12	50%RDF+Lime+FYM+Rhizobium+PSB	98.1	133.4	9.28	2.34
T13	75%RDF+Lime+FYM	97.6	134.3	12.32	2.66
T14	75%RDF+Lime+Rhizobium+PSB	127.0	118.9	8.06	2.78
T15	75%RDF+Lime+FYM+Rhizobium+PSB	71.5	118.6	5.26	2.15
T16	75%RDF+FYM	123.5	121.8	7.16	2.26
T17	75%RDF+Rhizobium+PSB	141.2	126.2	10.10	2.60
T18	75%RDF+FYM+Rhizobium+PSB	145.3	172.7	17.66	3.69
T19	50%RDF+FYM	97.0	170.5	10.55	2.91
T20	50%RDF+Rhizobium+PSB	150.5	115.0	8.35	2.69
T21	50%RDF+FYM+Rhizobium+PSB	68.1	103.8	6.44	3.91
T22	Control	75.8	109.5	9.15	4.13
	CD (P=0.05)	18.05	27.97	3.43	1.05

These results are also in corroboration with previous reports illustrating similar association between healthy root and shoot growth with higher biomass accumulation and yield of buckwheat and substantiating yield advantage with the application of organic manures such as FYM, poultry manure (5t/ha) and piggery manure (5t/ha) on root growth and productivity has been investigated in ground nut (Anitha 2013). Values are means of three triplicates. Level of significance was determined by performing univariate 2-way ANOVA with in FRBD using SPSS v. 21. T-Treatments, TRL- Total Root Length(cm/plant), RSA-Root Surface area(cm^2/plant), RV-Root Volume (cm^3/plant), RD-Av. Root diameter (mm/plant). This study indicates improved physiological traits recorded in terms of enhanced root attributes improved the overall growth and yield of garden pea. Therefore application of FYM and biofertilisers with furrow application of lime should be a recommendable option for improving productivity of garden pea in acid soils of Meghalaya

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Effect of integrated plant nutrient supply on productivity, nutrient uptake and profitability of quality protein maize on mid hills of Meghalaya

Samborlang K Wanniang*, AK Singh, AS Panwar[1], Vishram Ram and D Thakuiria

College of Post Graduate Studies, CAU, Umiam, Meghalaya

[1] *ICAR Research Complex for NEH Region, Umiam- Meghalaya*

*Correspondence: samborlang.wanniang23@gmail.com

Introduction

Maize (*Zea mays* L.) is the third important food crop of India after wheat and rice. However, in North Eastern Hilly Region of the country it is the second most important crop after rice accompanied with much lesser productivity (1.6 t /ha) than the national's average of about 2.5 t/ha. As livestock, poultry and many peoples as well of this very region are depending on maize for their dietary protein and unfortunately normal maize has significant flaws; it lacks the full range of amino acids, namely lysine and tryptophan causing serious threats to nutritional insecurity. QPM have 0specific features of having balanced amount of amino acids with high content of lysine and tryptophan, leads to its higher biological value and net protein utilization (Prasanna *et al.* 2001). Adoption of QPM in tribal dominated belts of mid hills of Meghalaya could be a strong support for ensuring food and nutritional security where maize is the second major crop after rice. Hybrids of QPM are very responsive to higher doses of nutrients. Fertilizers are the potential sources for supplying high amount of nutrients in easily available forms. However, complete dependence on fertilizers for supplying entire requirement of nutrients in poor and degraded soil of the risk-prone tribal dominated areas will be a deliberate mistake (Kler and Walia 2006). On the other hand, farmers are facing problems in maintaining soil fertility due to limited availability of farm yard manure (FYM) or compost. Therefore, a field experiment was undertaken to assess the effect of intercropped green manuring and combinations of fertilizers with FYM on productivity, nutrient uptake and profitability of QPM.

Methodology

The field experiment was conducted during *kharif 2011* at Experimental Farm of College of Post Graduate Studies (Central Agricultural University), Umiam, Meghalaya. The experiment was laid out in split plot design with three replications having two treatments of green manuring (sole maize and maize + cowpea green manuring) in main plots and six treatments of combinations of fertilizers with FYM (control, RDF, 50% RDF + 5 t FYM /ha , 50% RDF + 7.5 t FYM/ ha, 75% RDF +2.5 t FYM/ ha and 75% RDF + 5 t FYM ha) in sub plots where RDF was recommended doses of fertilizers (80 kg N + 60 kg P_2O_5 + 40 kg K_2O /ha, respectively). Nutrient composition of FYM on oven dry weight basis was 1.4%N, 0.82% of P and 1.2% of K and it was applied 15 days of sowing. Maize variety HQPM1 was sown on 1 June 2011 at a planting geometry of 60cm x 20cm. One row of locally available cowpea was sown as intercrop in between two row of maize for green manuring purpose. Cowpea was incorporated in soil at 45 days growth stage after chopping in small pieces of 5-10 cm. Crop was harvested on 19 September 2011. Content of nitrogen (N), phosphorus and potassium in maize was analyzed by using standard methods.

Results and Discussion

QPM grown with cowpea for green manuring was recorded higher growth, yield attributes, yield, economic return and nutrient uptake over sole maize (Table 1).

Table 1. Effect of INM practices on growth, yields and economics of QPM

Treatment	Dry matter at harvest (g/plant)	Grain yield (t/ha)	Net return(x 10^3 (Rs/ha)	B:C ratio	Total nutrient uptake (kg/ha)		
					N	P	K
Green manuring							
Sole Maize	178.2	44.21	19.40	1.66	127.42	25.14	83.35
Maize + Cowpea	214.1	53.92	27.46	1.87	157.38	32.69	101.75
CD(P=0.05)	NS	NS	NS	NS	32.24	NS	13.64
Fertilizer and FYM combination							
Control	127.4	35.83	11.95	1.45	88.92	18.72	48.30
RDF	241.8	53.62	29.43	1.99	158.92	35.66	116.24
50% RDF + 5 t FYM	162.4	45.33	18.72	1.60	128.03	25.67	77.64
50% RDF + 7.5 t FYM	214.9	54.99	27.89	1.86	160.25	32.17	106.35
75% RDF + 2.5 t FYM	182.7	48.25	22.28	1.73	142.33	26.76	81.35
75% RDF + 5 t FYM	247.8	56.37	30.30	1.96	175.92	34.53	125.01
CD(P=0.05)	24.16	10.07	10.94	0.35	27.32	6.72	20.77

This increase was to the extent of 20.2% for dry matter/plant, 18.6% for grains/plant, 6.9% for test weight, 22% for grain yield/ha, 18.9% for biological yield, 41.5% for net return, 12.7% for B:C ratio, 23.5% for total N uptake, 30% for total P uptake and 22.2% for total K uptake over sole maize though the significance difference between the two treatments was observed only for number of grains /cob, biological yield and total uptake of nitrogen and potassium only. However, all the above described parameters differ significantly due to application of different combinations of fertilizer with FYM. Maximum dry matter/plant, grains/cob, test weight, grain and biological yield, uptake of N, P and K and net return was recorded from the treatment 75% RDF + FYM 5t/ha, which was closely followed by the treatments RDF and 50% RDF + FYM 7.5t/ha and the difference among these were no significant (Table 1). However, maximum B:C ratio was associated with the RDF treatment and closely followed by 75% RDF + FYM 5t/ha. It can be concluded from present investigation that 25% of recommended dose of fertilizers could easily be substituted by adding 5t/ha FYM without any compromise with yield and return.

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Effect of nutrient sources and planting geometries on productivity and profitability from main crop and ratooning of CAU R3 on mid hills of Meghalaya

Sangita Das, AK Singh*, Vishram Ram, Lala IP Ray, N Janki Singh and Ramkrushna GI[1]

College of Post Graduate Studies, Central Agricultural University, Umiam, Meghalaya
[1]ICAR Research Complex for NEH Region, Umiam- Meghalaya
*Correspondence: adityakumar1972@yahoo.co.in

Introduction

The slogan "*Rice is life*" is most appropriate for North Eastern hilly region of India as this crop plays a vital role in household food and nutritional security and is a means of livelihood for thousands of rural household. However, the region has a net food grain deficiency of 1.6 million tons and approximately one million ton of this is due to rice alone (Datta *et al*. 2006). However, there exists a good potential to make the region self-sufficient for meeting its rice requirement through vertical productivity improvement. In areas where assured rainfall is available after harvesting the main rice crop ratooning could be practiced as an alternate to intensify the rice cropping subjected to prevalence of moderate temperature (30 to 40^{o}c) during flowering to grain filling (Dawn 2007). Ratoon requires 50 to 60 per cent less labour and water with significantly less cost of production due to omitting the operations like land preparation, transplanting or direct seeding and matures much early. On an average, gave yield roughly equivalent to 40 per cent of the main crop, with 40% reduction in crop duration. Early maturing varieties reported to do better as they do not require early seeding and also allow a favorable growth period for the ratoon crop. CAU R3 is one among these rice varieties may be used for growing a better ratoon crop.

Ambrosia artemisiiolfia (ragweed), a profusely growing wide spread weed many parts of NEH region during pre-*kharif* season contains approximately 3% N could be used as green leaf manure for nourishing the crops as an alternate source of plant nutrient for improving soil and crop productivity organic sources of nutrients. Transplanting of main rice at an optimum planting geometry is important for getting higher economic yield from main rice crop as well as its ratoon as the later will solely depend on number of ratooon producing tillers in an unit area left by the main rice Therefore, a field investigation was undertaken to investigate the effect of nutrient sources and planting geometries on main crop and rationing of rice cultivar CAUR3. Searching an alternate of FYM, a very limited organic nutrient source in the NEH region was another purpose of this study.

Methodology

The present field experiment was conducted in split plot design during *kharif* season of 2014 at Experimental Farm of the College of Post Graduate Studies (Central Agriculture University- Imphal), Umiam with three replications. Two sets of treatments including three nutrient sources assigned randomly in main plots and four planting geometry freshly randomized in sub plots. For application of plant nutrients, total quantity of organic sources namely FYM and *Ambrossia* weed biomass was worked equal to recommended doses of N level. The nitrogen, phosphorus, potassium and water content observed in FYM and *Ambrosia* weed biomass was observed as 0.83, 0.52 and 0.95% and 2.09, 0.73, 1.07 and 75%, respectively on dry weight basis. Ambrosia weed biomass was chopped into small pieces of 5-10 cm and incorporated into 10-15 cm soil depth 2 weeks before expected date of transplanting for faster decomposition of weed biomass and conversion of unavailable form of plant nutrients into available forms. Full dose of FYM was also being applied 2 weeks prior to transplanting. In case of inorganic fertilizer treatments, recommended dose of fertilizers i.e. 80:60:40 kg of nitrogen in the form of urea, phosphorus in the form of single super phosphate (SSP) and potassium in the form of murate of potash (MOP) as N, P_2O_5, K_2O ha^{-1} were applied as per standard recommendation. After harvesting of main crop at 15 to 20 cm above the ground level each plots has been cleaned properly by removing the unwanted plants with a care not disturbing the remaining rice stubbles. Thereafter, 50% amounts of plant nutrients of main crop were applied were applied with same source as in main crop. Both the main crop and ratoon were grown as per the standard recommended package of practices except the treatments under investigation. For recording plant population at harvest in farmers' practice, a wooden structure of one m^2 area was used to record the same from centre of each plot.

Results and Discussion

All nutrient sources were at par for grain yield in both main and ratoon crop of CAUR3. In main crop, slightly higher grain yield (approximately 14%) was recorded from inorganic fertilizer and FYM treatments over Ambrosia GLM treatment. However, in ratoon relatively higher grain yield (approximately 13%) was recorded from Ambrosia GLM nutrient source which was followed by FYM and inorganic treatments, respectively. No marked difference in plant population recorded as number of tillers bearing hills/m^2 and grain weight/plant (table1) was the most possible reason for at par grain yield in both the crops of CAUR3. Significantly highest net return and B: C ratio in main crop was computed in inorganic nutrient source which was followed by FYM and Ambrosia GLM. Higher grain yield accompanied with low cost of cultivation was the possible reason for this trend in economic returns. However, comparatively lesser yield in inorganic treatment resulted in at par difference in net return and B: C ratio. Jeet *et al.* (2014) also observed such observation in rice yield and net return due to application of organic and inorganic nutrient sources. Closest planting geometry of 15 cm x 15 cm gave the highest grain yield both in main crop and its ratoon which was significantly superior over the grain yield recorded at all three remaining planting geometries in main crop and over 20 cm x 20 cm and farmers' practice planting geometry in ratoon crop. Significantly higher ear bearing tillers/m2 in closely planted crop was responsible for this yield difference though the grain weight /plant were highest at widest planting. Maximum net return and B:C ratio in both the crops were recorded from closest spaced crop of 15 cm x 15 cm planting geometry which was followed by farmers' practice and 20 cm x 15 cm planting geometry in main and ratoon crop, respectively. Production of second highest grain yield at different treatments in main and ratoon crop was responsible for this trend in economic return.

The experiment concluded that all nutrient sources were equally good for profitable production of CAU R3 when grown for ratoon purposes and green leaf manuring of *Ambrosia* weed biomass could be a good alternate for FYM. However, the crop should be transplanted at closer planting geometry of 15cm x 15cm or alternatively, farmers practice may continue for better yield of this cultivar.

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Direct and residual effect of micronutrient and lime on groundnut-toria cropping system under acidic soil of North-East India

Santanu Das[1,2]*, Anup Das[2], Ramkrushna GI[2], Jayanta Layek[2], Samik Chowdhury[2,3] and Utpal Dey[2]

[1]*College of Post Graduate Studies, CAU, Umiam, Meghalaya,*

[2]*ICAR Research Complex for NEH Region, Umiam, Meghalaya*

[3]*ICAR Research Complex for NEH Region, Kolasib, Mizoram*

*Correspondence: santanudascau@gmail.com

Introduction

Groundnut (*Arachis hypogaea L.*) accounts for more than 40% acreage and 60% production under oilseeds in the country. Groundnut seed contains 44 to 56% oil and 22 to 30% protein on a dry wet basis (Savage and

Keenan 1994). Groundnut is not a traditional crop of the north eastern region (NER). But it is a highly potential crop under existing upland rice/maize based cropping systems in this region. In 2006, it was reported that groundnut in the region is cultivated in an area of about 4,000 ha with a productivity of 1,000 kg/ha which is higher than the national average of 924 kg/ha (Munda *et al*. 2006). *Toria (Brassica campestris var. toria)* is a potential oilseed crop for *rabi* season, which can efficiently utilize residual soil moisture. The main cause for the low production of groundnut is that it is energy rich crop, but grown under energy starved conditions such as acid soils and poor nutrient management practices. The harmful effects of soil acidity can be eliminated by raising pH by adding suitable quantity of lime. Liming helps to provide available Ca to the soil which improves the pegging of the groundnut pods. Compared to macronutrients, micronutrients are required for growth in lower amounts and serve mainly as activators of enzyme reactions. Micronutrients are elements with specific and essential physiological functions in plant metabolism (Epstein 1965). Zn, B and Mo are the important for groundnut nutrition under acid soil of NER. Macro and micro nutrient fertilizers besides supplying nutrients to the current crop, leave substantial residual effect on succeeding crops in the system. Nodulating legumes benefit the succeeding non-legume crops in term of increasing yields in comparison with the yield of non-legumes after non-legumes or non-nodulating lines of legumes.

Methodology

The field experiment was conducted on the terraces of upland Agronomy experimental field, ICAR Research complex for NEH Region, Umiam, Meghalaya during *Kharif* season of 2013. The experiment was laid in factorial randomized block design (FRBD) with six micronutrients treatment viz. control (no micronutrient), Zn @ 5 kg/ha, B @ 1kg/ha , Mo @ 0.5 kg/ha, Zn + Mo, Zn + B + Mo (all the micronutrients were applied through soil application) and two soil amendment practices viz. lime @ 500 kg/ha (furrow application) and no lime application. The plot size was at 12 m^2 with adequate drainage facility. Groundnuts (var: ICGS 76) were sown at the spacing of 30×10 cm^2. N, P and K (30:60:40 kg/ha) were applied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Lime was applied in furrows seven days before sowing and properly mixed with the soil. Toria (var: TS 46) grown just after the harvesting of groundnut during rabi season under residual effect of previously applied treatments in the same plots. The toria crop was sown at the spacing of 30 cm row to row distance with N, P and K (50:60:40 kg/ha) through the same source. The system productivity was calculated by adding the yield of each crop in a cropping system divided by duration of respective crops. It was expressed in kg/ha/day.

Result and Discussion

Result obtained from the study indicated that micronutrients and liming significantly improved all growth, yield and physiological parameters of groundnut and also improve soil health. Whereas, sole application Mo and combined application of Zn + Mo and Zn + B + Mo increased groundnut production and productivity significantly. Hristozkora *et al.* (2006) reported that application of Mo is required for nitrate reductase and glutamine synthesis which is involved at initial steps of nitrate assimilation and enhance crop growth and productivity.

Residual effect of micronutrients and lime had significant effect on growth, yield and physiological parameters of succeeding toria crop. Among all the micronutrients, residual effect of B had prominent influence on growth and productivity of toria. This might be due to auxin metabolism and Increased photosynthesis rate by interaction of Zn and B in soil (Hamsa and Puttaiah 2012). Residual effect of lime maintains soil pH which is an important factor for improving nutrients availability in soil. The system productivity was significantly higher under integration of Zn + B + Mo (Table 1). Liming enhanced system productivity significantly over no liming.

Result of this study suggested that sole application of Mo @ 0.5 kg/ha or its combination with other micronutrients and furrow application of lime @ 500 kg/ha significantly improved production of groundnut. The residual effect of micronutrients and lime applied to groundnut significantly increased productivity of succeeding toria in acidic soil condition of Meghalaya.

Table 1. Direct and residual effect of micronutrient and liming on productivity of groundnut and toria

Treatments	Kernel yield of groundnut (kg/ha) (Direct effect)	Seed yield of toria (kg/ha) (Residual effect)	System productivity (kg/ha/day)
Micronutrient			
Control	1316	390	8.5
Zinc (Zn)	1624	477	10.6
Boron (B)	1562	520	10.4
Molybdenum (Mo)	1720	423	10.7
Zn + Mo	1783	441	11.1
Zn + B + Mo	1797	527	11.6
S.Em±	**24**	**11**	**0.1**
C.D. (*P=0.05*)	**71**	**32**	**0.3**
Soil amendment			
Lime	1756	511	11.3
No Lime	1511	415	9.6
S.Em±	**8**	**4**	**0.0**
C.D. (*P=0.05*)	**24**	**11**	**0.1**

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Effect of tillage and nutrient management practices on productivity and soil quality under rice-rapeseed cropping system in North Eastern Hill Region of India

Savita, Anup Das*, Jayanta Layek, Ramkrushna GI, Krishnappa R, and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: anup_icar@yahoo.com

Introduction

Rice (*Oryza sativa* L.) is one of the most important and staple food crop, feeding more than half of the world populations. Rice is also vital component of human diet in the North Eastern Hill (NEH) region of India (Das *et al*. 2014). Rice cultivation is most challenging in upland ecosystem than lowland mainly due to marginal nature of soil fertility, water management problem, weed infestation, low nutrient use efficiency, low yield and income. Most of the areas under rice remain fallow after harvesting of rice. Rapeseed is a potential oilseed crop suitable for cultivation with residual moisture under rainfed condition. Therefore, an attempt was made to find out the effect of different tillage and nutrient management (NM) practices on soil health and potentials to influence crop productivity in the region. The novelty of this study is based on the hypothesis that *in-situ* management of crop residues, weed biomass and green manure along with reduction in tillage intensity to reverse soil degradation trends and to improve soil quality and thereby increasing crop productivity of rice (*Oryza sativa* L.) –rapeseed (*Brassica campestris* var. Rapeseed) cropping system in marginal upland of NEH region.

Methodology

Field experiments were conducted on rice- rapeseed cropping system during 2012 to 2014 at ICAR Research Complex for NEH region, Umiam, Meghalaya. The experiment was laid out in a factorial randomized block design (FRBD) with three replications. Treatments comprised of two tillage for rice (variety IURON-514)*i.e.*, conservation tillage (CsT) and conventional tillage (CT)as main plots and five NM practices as sub-plots *i.e.*,100% NPK (60:60:40 $N:P_2O_5:K_2O$ kgha^{-1}), 50% NPK (30:30:20 $N:P_2O_5:K_2O$ kgha^{-1}), 50% NPK + *in-situ* residue retention (ISRR) of rice straw@ 5 tha^{-1}, 50% NPK + weed biomass (WB)of *Ambrosia artemisiifolia* @ 10tha^{-1} on fresh weight basis, 50% NPK + *Crotolaria* grown as intercrops in between rows of rice and used as green manure/mulch at 45 days after sowing. Around 8-10 tha^{-1} of *Crotolaria* green biomass was produced and recycled on fresh weight basis. After harvesting of rice, rapeseed(var. TS-46)was sown with recommended doses of nutrients (60:60:40$N:P_2O_5:K_2O$ kgha^{-1})on last week of October under zero tillage in rice fallow maintained with 30cm standing stubble in CsT plots and complete removal of stubbles in CT plots. The composite soil samples were collected from 0-15cm soil depth after harvesting of rapeseed and analyzed for physical, chemical and biological properties following standard procedures. The plant and soil data were statistically analyzed in FRBD using of analysis of variance (ANOVA) and their significance was tested by "F" test (Gomez and Gomez 1984). The difference between the treatment means were tested for their statistical significance with appropriate critical difference (C.D.) value at 5% level of probability (p=0.05).

Results and Discussion

Tillage and NM practices had significant effect on the mean grain yield of rice for three years(Table 1).Grain yield obtained under CsT (3.22tha^{-1}) was significantly higher than that of CT (2.93tha^{-1}). Among NM practices, the highest yield was recorded under 50 % NPK +WB (3.40tha^{-1}) followed by 50 % NPK + GLM (3.33tha^{-1}). The grain yield of rice under 50 % NPK +WB was 19.7% and 32.3% higher than that under 100 % NPK and 50 % NPK, respectively. The average seed yield of rapeseed (5.22 kg ha^{-1}) was significantly higher under 50 % NPK + WB as compared to 50 % NPK alone (4.67 kg ha^{-1}).

The residual effect of tillage and NM practices in rice had significant effect on bulk density (ρb) at 0-15cm soil depth and was significantly higher under CT compared to CsT. Among the different NM practices, 50 % NPK recorded the higher ρb and lower under 50 % NPK + GM. Incorporation of GM might have increased total pore space, which in turn decreased ρb of soil (Joshi *et al.* 1994).The CsT had significantly higher soil organic carbon (SOC), soil microbial biomass carbon (SMBC) and dehydrogenase activity (DHA) compared to CT after three consecutive years of rapeseed cultivation after rice. The SOC, SMBC and DHA of soil was recorded significantly higher under 50 % NPK + GM as compared to 50% NPK/100% NPK but which is statistically at par with 50% NPK + WB and 50% NPK + ISRR. The lower concentration of SOC, SMBC and DHA of soil were observed under 50 % NPK.

Therefore, rice and rapeseed productivity was significantly higher under CsT than that under CT. This study indicates that CsT with WB, GM and ISRR enhanced crop productivity and improved soil quality in upland rice -rapeseed cropping system. The soil health and quality parameters were found to improve substantially due to continuous adoption of CsT as compared to CT.

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Organic Farming and Natural Farming

- Organic inputs
- Nutrient management
- Pest and disease management
- Value addition and certification

Traditional organic agriculture vs. commercial organic agriculture: An overview

P Bhattacharyya*
National Centre of Organic Farming, Min. of Agriculture, Govt. of India
*Correspondence: paritoshb.21@gmail.com (*Ex-Director)

Traditional organic farming

During Neolithic period, 10000 years back, the farming practices were initiated on earth .Use of manure in agriculture began 8000 years ago as reported from Europe. Neolithic farmers used the dung from their herds of cattle, sheep and goat and pigs as a slow release fertilizer for crops. In ancient times, farmers of Mesopotanian valley referred to the use of manure as recorded from old clay tablets (Bhattacharyya 2013).In prehistoric times in India , Organic agriculture and its management techniques were developed what we call Vedic Krishi or Rishi Krishi . Ancient Indian literatures like "Vrikshyayurveda", Krishi – Parashar (400 BC) suggested that crops grown without manure will not give yield and the method of manure from cowdung was explained. In fact, organic agriculture has its roots in traditional practices that evolved in countless villages years after years. Gradually farmers depend on green manures, crop rotation, composts, botanical pesticides etc and continued traditional organic agriculture (Bhattacharyya and Chakraborty 2005) over the years.

Experience from chemical farming

Chemical farming began in 1842, when Single Super Phosphate (SSP) was manufactured and used in agriculture. India set up SSP factory at Ranipet, Tamilnadu in 1906. (Early in 1900, Sir Albert Howard, a British Agronomist, was engaged in developing 'Organic Growing Methods' in North Uttar Pradesh). During Green Revolution Period (1966 – 67), the use of chemical fertilizer got momentum and self-sufficiency in food production was achieved. But within next 5 – 7 years, ill effects of fertilizers and pesticides were realized by farmers themselves. In 1972 farmers discussed the issue in Wardha (Maharastra) meeting. Later Scientists confirmed bad impact of chemicals on crop and soil health. They stressed on sustainable ecofriendly agriculture involving Integrated Nutrient Management (INM) and Integrated Pest Control (IPM). Some emphasized on introduction of organic farming from food safety point of view. There was a call from farmers: "Back to Nature ". In fact, during post Green Revolution, severe decline in soil fertility coupled with multi – nutrient (S, Zn, Mn, B, Mo) deficiency has been observed. During 1974 – 79, 1 Kg of fertilizer used to produce 10 kg foodgrains; now, each kg of fertilizer yields 3 – 5 kg grains. The magic of highly subsidized chemical fertilizer is on the way to be vanished.

Beginning of modern commercial organic farming

Although the modern organic agriculture is based on 4 pillars like Principle of Health , Principle of Ecology, Principle of fairness , Principle of Care,….but it depends on commercial approaches like Standards, Certification and Market Creation. Standard is a Principle of propriety, honesty and integrity or a level of excellence or quality. Various organic standards are available in the world e.g. IFOAM (International Federation for Organic Agriculture Movement), Codex – Alimentarious – WHO , NOP (National Organic Programme , USA), EU Norm ---EEC Regulation 2092/91), JAS (Japanese Agricultural Standard). The Ministry of Commerce, Govt. of India launched the National Programme for Organic Production (NPOP) in 2000 and developed national (NPOP) standard for India with its secretariat APEDA. The most important aspect in modern organic agriculture is Certification Programme which consists of Standard, Inspection and certification. Organic Certification aims at building trust between consumer and organic farmers. There are 25 accredited certifying agencies in India. Recently, the Ministry of Agriculture has notified Participatory Guaranty System (PGS) for domestic organic products with its secretariat at National Centre of Organic Farming (NCOF), Ghaziabad. Modern Organic Farming based on certification is being practiced on 40 million ha. In 167 – 170 countries. Non – certified traditional organic farming is known as " By Default Organic ".On global level, India ranks 15 in respect of certified organic agricultural land (510000 ha) while the total certified organic land in the world is 43091113 ha . In year 2003, the growth organic certified agricultural land was 25.7 % . , but in 2014 it has increased (43.1 %). The current world organic market is USD 68 – 70 billion. India has the largest number of organic producers (650000 Nos.) (IFOAM - FiBL Survey Report, 2014.). About 1.34 million metric tonne of certified organic products were produced during 2012 – 15. India exported 135 organic products during the same period. The organic market potential in India is Rs. 5000 crore roughly.

Scope in North – East Hill (NEH) region

North East Hill (NEH) region of India , comprising Arunachal Pradesh , Manipur, Meghalaya , Mizoram , Nagaland , Tripura and Sikkim has already been recognized as " Organic Farming Region ". The soil of this particular region is rich in organic matter. The consumption of fertilizer and pesticides is low in this zone. By tradition, farmers follow organic practices years after years. Most of their area / crops are organic by default. The livestock population of this area is large. Aromatic rice, ginger, turmeric, tea and organic fruits like passion fruit, citrus, pineapple etc are highly market potential. Accredited certifying agencies have already made MOUs for inspection and certification for farmers of NEH which has erstwhile established in organic market with its full strength. The scope of commercial organic farming in North East Hill states is profuse and these region needs government support for further progress.

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Seasonal abundance of mustard aphid and saw fly in relation to abiotic factors and their eco-friendly management

H Kalita*, RK Avasthe, R Gopi and C Kapoor
ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Sikkim
*Correspondence: dhritisman2007@gmail.com

Introduction

Rapeseed –mustard is an important oleiferous crop and constitutes major source of edible oil for the human consumption and cake as feed for livestock. In Sikkim, the total cultivated area under this crop is around 4380 hectares producing 3500 tonnes with an average yield of 779 kg/ ha (Avasthe *et al*. 2014). More than three dozens of pests are known to be associated with various phenological stages of rapeseed-mustard crops in India (Bakhetia and Sekhon 1989). Among these insect pests, mustard aphid is the most serious and destructive pest and is a major limiting factor for mustard cultivation (Biswas and Das 2000). This pest may reduce about 30-90% yield of mustard without any control measure. In case of severe attack of sawfly, the crop is completely devastated while in severe aphid attack the entire plant gets densely covered with aphids resulting in stunted growth and poor pod with negligible seeds. Weather conditions play the most favorable role for rapid multiplication of aphids [*Lipaphis erysimi* (Kalt.)] and saw fly **[***Athalia lugens proxima* (Klug)]. It has become absolutely imperative to study the population buildup of aphids and saw fly in relation to abiotic factors to determine the effective eco-friendly management strategies. Such study will provide an opportunity to record the pest challenge by manipulating the manageable ecological parameters in the form of planting or harvesting time adjustment, varietal selection, correct time of pesticide application *etc*. Therefore, the present investigation was undertaken with the objectives (a) to study the effect of abiotic factors on the population buildup of mustard aphid and saw fly, determine the potential natural enemies, (b) find out some tolerant/resistant germplasm and (c) evaluate some biopesticides against these two pests.

Methodology

In case of mustard saw fly the number of larvae per plant was recorded at weekly interval from randomly selected 10 plants from each plot. Data on the population of aphids per 10 cm inflorescence from central shoot was recorded at weekly interval by randomly selecting 10 tillers from each plot. The meteorological data were collected regularly. The population data of natural enemies was recorded from central inflorescence of randomly selected 10 plants from each plot. The rate of predation by different natural enemies was studied in the laboratory. Fourteen (14) different germplasm of mustard and rapeseed suitable for Sikkim were grown in the field to identify the germplasm resistant or tolerant against mustard aphid and saw fly. Three rows of each germplasm were raised having 20 plants in each row. The population of saw fly was recorded at vegetative stage at 20 and 30 days after sowing and mustard aphid was recorded at

25% and 50 % flowering stage of the crop. Six different biopesticides *viz*., neem oil 0.03 EC @ 3 ml l^{-1}, neem oil 0.15 EC @ 3 ml l^{-1}, *Beauveria bassiana* 7 g l^{-1}, *Bacillus thuringiensis,* @ 2 g l^{-1}, *Verticillium lecanii* @ 3 ml l^{-1}, petroleum agro-spray @ 10 ml l^{-1} were tested against insect pests of mustard aphid and saw fly by taking Oxydemeton methyl @ 1 ml/l as check and an untreated control. The experiment was conducted in RBD and the treatments were replicated thrice. The first application of treatments was done at vegetative stage when the population of saw fly was observed. Second spray was given when mustard aphid population was observed at the flowering stage and third spray at 15 days interval. The population of mustard aphid and saw fly was recorded before treatment and 7 and 14 days after treatment. The yield of each plot was recorded separately.

Results and Discussion

It was found from the study that the appearance of aphid was noticed first in the 49^{th} and 50^{th} standard week during 2011-12 and 2012-13, respectively and the aphid population reached maximum in the 2^{nd} standard week (49.07 and 63.48 aphids/10 cm central inflorescence) in both the years. Saw fly appeared earlier than aphid during 45^{th} and 46^{th} standard week during 2011-12 and 2012-13, respectively and aattained maximum during 47^{th} standard week (1.57 and 1.42 larvae plant^{-1}) in both the years and there after started declining. The peak aphid population was found at minimum and maximum temperatures of 6.58 and 13.80^{0}C during 2011-12 and 5.34 and 14.12^{0}C during 2012-13, respectively. The population of saw fly reached a peak when minimum and maximum temperatures were 10.44 and 19.72^{0}C during 2011-12 and 10.12 and 19.18 ^{0}C during 2012-13, respectively. The correlation coefficient analysis of the data on aphid population with prevailing abiotic factors indicated a negative association with the maximum temperature (r = **-** 0.67 and -0.64 during 2011-12 and 2012-13, respectively) and minimum temperature (r = **-** 0.68 and- 0.83 during 2011-12 and 2012-13, respectively) whereas saw fly was influenced positively by maximum temperature (r = 0.62 and 0.67 during 2011-12 and 2012-13, respectively) and minimum temperature (r = 0.64 and 0.68 during 2011-12 and 2012-13, respectively) in both the years. The population of natural enemies *viz*., lady bird beetles, *Coccinella septempunctata* and *Menochilus sexmaculata* and Syrphid fly was noticed during flowering stage of the crop (lady bird beetle 0.35-0.70 plant^{-1} and syrphid fly 0.20-0.35 plant^{-1}). Three different species of aphids are associated with mustard crop in Sikkim besides mustard aphid, *Lipaphis erysimi*. But, mustard aphid, *Lipaphis erysimi* is the most dominant species in mustard crop. Other species are Cabbage aphid, *Brevicoryne brassicae, Brachycaudus helichrysi* and bean aphid, *Aphis craccivora.* Amongst 14 germplasms Sikkim Toria-2, Sikkim Sarson Yellow-1, Sikkim Sarson Yellow-3 and TS-38 were less infested by mustard aphid and saw fly in comparison to others. Among the biopesticides, *Bacillus thuringiensis* @ 2g l^{-1} was found to be effective for management of sawfly population (68.60 % larval reduction over control after 14 days of treatment). Two sprays of petroleum agro-spray @ 10 ml l^{-1} were found to be the most effective for controlling aphid population (72.51% reduction of aphid population over control) followed by neem oil 0.15EC @ 3 ml l^{-1} (71.46 % reduction of aphid population over control) with highest yield (0.78 t ha^{-1}) followed by neem oil 0.15EC @ 3 ml l^{-1} (0.76 t ha^{-1}) and were on par with check oxydemeton methyl 25 EC @ 1 ml l^{-1}.

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Influence of integrated organic nutrient management on productivity and profitability of ginger in mid hills of Sikkim

Boniface Lepcha[1], Ravikant Avasthe[2], Raghavendra Singh*[,3], NJ Singh[4] and Pallabi Phukan[5]

[1,4, &5]*Krishi Vigyan Kendra, ICAR Research Complex for NEH Region, Sikkim Centre, Ranipool,*

[2, 3] *ICAR Research Complex for NEH Region, Sikkim Centre, Sikkim*

*Correspondence: raghavenupc@gmail.com

Introduction

Sikkim will become first fully organic state of the country by the end of 2015. Ginger (*Zingiber officinale* Rosc.) is one of the most important cash crops of the state. Productivity of the ginger in the state is very low (5.4 tones/ha). Improper use of farmyard manure as organic nutrient sources alone cannot fulfill the requirement of nutrients demand of the crop is one of the reason for lower productivity (Yadav *et al*. 2014). Hence, an integrated approach is required to fulfill the demand of nutrients to ginger in organic condition. Proper combination of different organic nutrient sources should be worked out to derive the best combination of the inputs for attaining quantity and quality in ginger cv. Bhaise.

Methodology

A field study was conducted at Krishi Vigyan Kendra, Ranipool, East Sikkim at an altitude of 914 m with 27º9' to 27º25' N and 88º27' to 88º56' E during 2012-14. The experiment was laid out in randomized block design with a total of 22 treatment combinations and replicated three times. The integrated approach for supply and use of plant nutrients from all the possible organic sources has been tested for higher crop yields with quality produce. Six different organic nutrient sources viz., farmyard manure (FYM), neem cake, poultry manure, goat manure, pig manure and vermicompost alone and their possible combinations were evaluated in ginger.

Results and Discussion

The results clearly indicated that combined application of 50% FYM + 50% neem cake significantly increased plant height (98.6 cm), leaves/plants (24.5 no.), tillers/clumps (16.2 no.) and leaf size (76.85 cm^2). All the treatment combinations significantly increased length of rhizome finger, diameter of rhizome finger and yield of fresh and cured ginger as compared to control. Combined application of 50% FYM + neem cake 50% recorded maximum fresh (13.5 t/ha) and cured yield (3.65 t/ha), which were at par with 50% FYM + 50% pig manure and 50% FYM + 50% vermicompost. Application of 50% FYM + 50% pig manure exhibited maximum gross return (3.37 lakhs/ha), net return (2.23 lakhs/ha) and cost benefit ratio (2.93) followed by 50% FYM + 50% goat manure treatment.

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Low cost deep litter housing system for pig: An option for sustaining Sikkim organic mission

Brijesh Kumar*, Mahak Singh, RK Avasthe and Sumi Handique

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Sikkim

*Corresponding author: drbrijeshvet02@gmail.com

Small scale pig production under deep litter housing condition is one of the most viable and profitable venture in hill ecosystem and its resource based scientific integration especially with fisheries, horticulture, floriculture and other crops leads to more sustainability and prosperity among the farmers. Remote part of Sikkim which is comparatively less accessible and farming community mostly relies on animal husbandry and horticulture for their livelihood. Agriculture in Sikkim involves cultivation of various tuber crops along with food grains like maize, rice and this is integrated with animal husbandry especially small scale piggery. Women farmers are mostly involved in pig rearing. In the exiting practice of Pig rearing, housing is designed in such way that excreta of pig not being used and mostly washed away. But after intervention of ICAR Sikkim centre through training and demonstration farmers about pig farming under low cost deep litter housing model; they slowly started adopting pig farming under deep litter housing system. In this system various advantages are there input and quality manure for their vegetable production. Apart from that it is also advised the farmers regarding its integration with fish farming and each low cost housing model must contain water harvesting structure. It is validated and recommended for local pig most suitable for resource poor farmers and also then can feed up to 10 percent soft leafy and juicy grasses to their pig. But its palatability gets increased if it is partially cooked. As bedding materials for farmers it is recommended that any soft dry leaves can be used apart from crop residue like paddy straw, chaffed maize stover, rice husk apart from the saw dust. The quality and quantity of manure depends upon type of bedding material and depth of bedding materials used. Generally it depends upon pig population reared on it and depth of bedding materials and its maintenance. Generally one feet depth of bedding materials with twice racking in a day on 7 x12 ft floor with two grower pig or one adult pig work fine for 25 to 30 days. After lifting of old bedding materials, put for decaying for minimum one month after that it could be applied to field or can go to vermi- compost pit for production of vermiwash and vermi-compost. Since State of Sikkim has set the target to achieve fully organic by the end of 2015 and to full fill the bio fertilizer requirement they have initiated the concept of rural composting in that situation pig farming under deep litter housing system work as a good source of organic manure to support Sikkim organic mission and sustain crop production and productivity.

Comparative influence of organic and inorganic amendments on soil quality index under gardenpea-french bean-okra cropping system in the north-western Himalayas

Dibakar Mahanta[1*], TJ Purakayastha[2] and H Biswas[3]

[1]*ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand*

[2]*ICAR-Indian Agricultural Research Institute, New Delhi*

[3]*ICAR-Indian Institute of Soil & Water Conservation, Research Centre, Bellary, Karnataka*

*Correspondence:dibakar_mahanta@yahoo.com

Introduction

Over-exploitation of soils over many decades has resulted in exhaustion of the intensive agricultural production systems and steadily declining productivity has been noticed. The soil quality heavily depends upon nutrient source and their levels of application (Masto *et al*. 2007). The soil quality index, based on a combination of soil physical, chemical and biological properties provide a better indication of soil quality than individual parameters (Bhaduri *et al.* 2014). The soil quality assessment in the north-western Himalayas is very limited. With this background, the present study was investigated for comparative study of soil quality index from organic, inorganic and integrated nutrient sources under gardenpea-french bean-okra cropping system in the north-western Himalayas.

Methodology

The field experiment was conducted during 2008 to 2012 at the experimental farm of ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Uttarakhand. The experiment was initiated in 2002 with gardenpea-french bean system with different levels of manures. The treatments were modified on the basis of P level in 2008. The field experiment consisted of seven treatments. The treatments were four rates of FYM application i.e. 17.5 kg P ha^{-1} (FYM$_{17.5}$), 34.9 kg P ha^{-1} (FYM$_{34.9}$), 52.4 kg P ha^{-1} (FYM$_{52.4}$) and 69.9 kg P ha^{-1} (FYM$_{69.9}$), mineral fertilization as recommended NPK (NPK), integrated nutrient management (INM) (50% recommended NPK + FYM at 5 t ha^{-1} as mineral fertilizer) and unfertilized control treatment (Con). The mineral fertilizers in NPK (recommended level: 20-26.2-33.3 kg N-P-K ha^{-1} for gardenpea, 50-30.6-41.7 kg N-P-K ha^{-1} for french bean and 100-21.8-45.5 kg N-P-K ha^{-1} for okra) was applied at sowing and the sources for N, P and K were urea, single superphosphate and muriate of potash, respectively. Productivity SQI was developed by integration of scores based on soil functions viz. nutrient cycling, physical stability and support, water relations and soil resistance and resilience consisting 16 bio-physico-chemical parameters of soil. The maximum sensitivity of an index to changes in soil quality was exhibited by the Non Linear Weighted Index (NLWI) and was selected for evaluating and comparing the total quality of soil.

Results and Discussion

Application of FYM @ 69.9 kg P/ha showed the highest SQI values indicating that the soil under these cropping systems was in better health than in other nutrient management practices. This study showed that the soil quality under NPK was 42 % degraded for productivity SQI than FYM @ 69.9 kg P/ha and hence should not be continued for long term as it slowly deteriorated the soil quality. With the help of graph in Fig. 2(A), it was estimated that the productivity SQI under NPK and INM can be achieved with application of 5.9 and 25.1 kg P ha^{-1} through FYM, respectively for gardenpea-french bean-okra cropping system. Near perfect relationship of crop productivity with SQI, showed that crop productivity was closely influenced by SQI.

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Standardization of application of organic manure in rearing of common carp fry in red soil base upland acidic water harvesting structures in North Eastern state of Tripura

MK Datta* and R K Saha

College of Fisheries, Central Agricultural University, Lembucherra,Tripura

*Correspondence: mkdatta2005@gmail.com

Introduction

Production of fish is below the ever growing demand of North Eastern region. With more than 90% of population being fish eaters, there is heavy demand for fish but a wide gap exists between supply and demand. Hence, efforts are necessary to increase the present level of production through both horizontal and vertical expansion. Moreover it is well known that more than 80% of soils of North-eastern states of India are acidic and problematic in nature. Accordingly, most of the soils of Tripura are also acidic in nature and undulating in topography and low in productivity). Hence this condition leads to low fish production due to poor productivity (Neogy *et al*. 1994). Limitation of low land for aquaculture attracted the utilization of upland for seasonal aquacultural practices in specially prepared water harvesting structure using locally available organic manures. Not much work has been carried out in standardizing organic manure for seed rearing practices of carps **(***Cyprinus carpio)* which are suitable for upland and acidic water. Accordingly a carp seed rearing experiment was carried out for the farmers of NE region by using unutilized upland.

Methodology

Up land earthen water harvesting structures (av. Size 0.0055ha) with polythene lining were used for the experiments at College of Fisheries, Lembucherra, Tripura. Red soils (7cm thickness) were provided as pond base. Rain water was harvested from upland catchment and used for rearing of carp seed during monsoon. Physico-chemical properties of both soil and water were estimated before manuring. Fish seed were reared following standard procedure of CIFRI, 1985. Physico-chemical, biological and yield parameters were estimated every fortnight .Economics of the experiment was also worked out. Statistical analysis of the yield was carried out following SPSS 15.5 version. Two treatments of organic manureT1(Poultry dung@5000kg ha^{-1}) and T_2(Raw cow dung@10,000kg ha^{-1}) in replicate were utilized and compared pond with no manure(T_3, control). Stocking density of fry of common carp, produced locally, was maintained @ 1 $lakhha^{-1}$. Lime was applied @ $260kgha^{-1}$and supplementary feed (MOC: RB 1: 1 @ 3% biomass) was provided daily once .

Results and Discussion

The results of 45 days period rearing of *Cyprinus carpio,* fry to fingerlings in red soil based upland water harvesting structures with two different treatments and a control exhibited highest survival in raw cow dung manured ponds (T_2 98 %) followed by poultry manured (T_1 97.5 %) and control (T_3 67.5 %). It was observed that both the organic manured treatments were equally effective and the survival of common carp fry to fingerlings was extremely high as compared to normal rearing system in loamy-clay soil base pond. Maximum length (mm) was recorded in T_1(41.200) followed by T_2(40.925) and T_3(35.565). In respect of weight, maximum weight was recorded with T_2(1.245 g) followed by T_1(1.195 g) and T_3(0.534 g). Same trend was also recorded in respect of growth gain and growth percentage. Again the difference in weight attained between the two treatments was insignificant as compared to control. Though poultry manured seed exhibited better growth in length than RCD manured seed unlike growth in weight without much difference between the treatments. In case of increase in length, both the treatments had almost same pattern, but differentiated in weight increase as T_2 exhibited comparatively better weight gain than T_1. The species cultured (common carp) was hardy in nature and thus showed better survival in treated water in spite of poor individual growth.

In water, from the initial acidic pH value (6.6 to 6.8), treatment had enhanced its level in both the experiments (poultry manured 7.13 and RCD manured 7.78). Same way, total alkalinity (mgl^{-1}) initially was low (30.0- 41.0) and eventually elevated in both the treatments (77.5 in T_1 and 101 in T_2) indicating the utility of the treatment practice in productivity enhancement. The pH of the soil was acidic (5.06 to 5.26, mean 5.14±0.04) with higher redox potential (81 to 90.5 mv, mean 84.66±3.018) and low in electrical conductivity. The soil also exhibited high Fe (3.320 to 3.625mg100g^{-1}) and Al (2.164 to 2.585mg 100g^{-1}). Poultry manured nursery ponds (T_1) exhibited initial average GPP and NPP of 0.225 and 0.070; that of RCD manured ponds (T_2) had 0.1687 and 0.056 and control (T_3) as 0.150 and 0.046. The final values wereT_1: 0.206 and 0.037; T_2: 0.150 and 0.093 and T_3: 0.112 and 0.075 respectively.

The results of rearing of common carp (*cyprinus carpio)*, fry to fingerlings in red soil base water harvesting structures for 45 days duration with two treatments of organic manure revealed the highest survival in ponds manured with cow dung (98 %) followed by ponds manured with poultry litter (97.5 %) compared to control (67.5 %), thus proving almost equal effectiveness of the treatments. As no much difference was noticed in respect of growth in length and weight of seed between the two treatments hence it got further confirmed that both the manures were equally effective in acidic ponds water conditions. The cultured species was hardy in nature and found stable in acidic condition with high survival. In respect of increase in length and weight, control exhibited positive significant difference ($p<0.05$) with treatments. In respect of soil and water profile, treatments caused the occurrence of positive changes in major parameters where the acidic water (pH 6.65 to 6.80) got elevated to alkaline side (poultry manured 7.13 and RCD manured 7.78). In turn, total alkalinity (30.0-41.0 mgl^{-1}) got also enhanced (77.5 mgl^{-1} in poultry manured and 101 mgl^{-1} in RCD manured) coupled with reduction in both Fe and Al contents. Fe was recorded from its initial values of 0.413 - 0.892 mgl^{-1} to final values as 0.088 mgl^{-1} in poultry manured and 0.064 mgl^{-1}in RCD manured. Finally the treatments practices resulted in the enhancement of primary productivity along with higher plankton biomass.

Table 1. Growth and survival of *Cyprinus carpio* seed

Treatment	Stocked(No)	Culture Duration (days)	Total harvest (No)	Survival (%)	Initial length (mm)	Final Length (mm)	Growth(mm)	Growth(%)	Increase/day(mm)	Initial weight(g)	Final weight(g)	growth gain (g)	Growth (%)	Weight gain/day (g)
T_1	550	45	536	97.5	19.65	41.2	21.55	109.3	0.478	0.149	1.1955	1.0465	702	0.023
T_2	550	45	539	98.0	19.65	40.925	21.275	108.2	0.4725	0.149	1.2455	1.1235	977	0.024
T_3	550	45	371	67.5	19.65	35.565	15.94	81	0.3535	0.149	0.534	0.3845	358	0.008

As the study had positive impact on amendment of water acidic to alkalinity and yield, hence the methodology as developed for rearing of carp seed successfully with was simple management practices and with moderate inputs, found useful for utilization of upland red acidic soil based water bodies of Tripura particularly and North Eastern region in general.

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Management of rice blast caused by *Pyricularia grisea* using botanicals, bio-control agents and organically permitted fungicides

R Gopi*, RK Avasthe, H Kalita, C Kapoor, R Singh and Subash Babu

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok

*Correspondence: ramaraj.muthu.gopi2@gmail.com

Introduction

Rice (*Oryza sativa* L.) is an important crop that provides staple food and food security to millions of population of the world especially in Asian countries. Rice is affected by many diseases among them blast, caused by *Magnaporthe grisea* (T.T. Hebert) Barr (anamorph = *Pyricularia grisea* (Cooke) Sacc.), is the most important disease of rice (Bonman *et al*. 1991) and appears at all the stages of plant growth (Seebold *et al*. 2004). It attacks stem nodes (nodal blast), leaf (leaf blast) neck (neck blast) and also grains of paddy. The disease results in yield loss as high as 70–80%. There are various cultural, biological and chemical control measures for the management of blast disease. Sikkim in India will be the first to become a completely organic state by 2015. Disease management under organic system is not very easy as in conventional system and information on organic disease management is also very much limited. The disease management in organic system emphasizes use of disease control methods which are eco-friendly such as, biological methods, cultural methods and physical methods. These strategies may not give uniform results in all experimental situations. Therefore, they should be thoroughly studied and standardized considering the location, weather and pathogenic races prevailing in the particular area for the good result.

Methodology

The experiments were conducted during 2013 and 2014 at ICAR Research Farm, Sikkim Centre, Tadong, Gangtok (1350 amsl). The experiment was set in a randomized block design (RBD) with different treatments replicated three times. The treatments included were wettable sulphur @ 0.25%, potassium bicarbonate (AR) 0.25%, copper oxychloride (Blitox 50 WP) @ 0.25%, copper hydroxide (Koside 77 WP)@ 0.25%, copper oxychloride (Blitox 50 WP) @ 0.25% alternated with potassium bicarbonate @ 0.25% , copper oxychloride (Blitox 50 WP) @ 0.25% +63.02\ alternated with wettable sulphur @ 0.25%, potassium bicarbonate @ 0.25% alternated with wettable sulphur @ 0.25% along with tricyclazole (Beam 75 WP) @ 0.1% and untreated control. In another experiment the following botanicals and biocontrol agents were evaluated against blast. Treatments consisted of garlic (*Allium sativum*) 5%, banmara (*Chromolaena odorata*) 5%, turmeric (*Curcuma longa*) 5%, neem oil (*Azadirachta indica*) 3%, onion (*Allium cepa*) 5%, mugwort (*Artemisia vulgaris*) 5%, chilaune (*Schima wallichii*) 5%, seed treatment with *Pseudomonas fluorescens* **@** 10 g/kg seed + spray (0.25%) and seed treatment with *T. viride* @ 4 g/kg seed + spray (0.25%) along with standard fungicide tricyclazole (Beam 75 WP) @ 0.1% and untreated control for comparison.

In each plot 25 plants were selected randomly, labelled and the data on occurrence of blast was recorded one week after the last application of treatments by using the disease rating scale of 0-9 developed by International Rice Research Institute (IRRI. 1996) and the Percent Disease Index (PDI) was calculated using standard formula. The per cent neck blast was recorded 7 days before the crop harvest by counting the number of infected/ healthy panicles from 25 randomly selected hills from each plot. At the harvest time, grain yield (q/ha) was also measured. The data was analyzed statistically using analysis of variance (ANOVA).

$$\text{PDI} = \frac{\text{Sum of individual rating}}{\text{Number of plants examined x Maximum disease grade in the scale}} \times 100$$

Results and Discussion

On the basis of two years average data, the least leaf blast severity (18.47%) and neck blast (18.76%) was found for plots treated with copper oxychloride @ 0.25% closely followed by copper hydroxide @ 0.25% (20.53% and 22.06%). Among the treatments evaluated for average yield for 2013 and 2014, the standard fungicide, tricyclozole @ 0.1% gave maximum yield (30.58 q/ha) followed by copper fungicides copper oxychloride (28.06 q/ha) and copper hydroxide (26.53 q/ha). Among the biological inputs used in the study for the management of blast, *Pseudomonas fluorescens* @ 0.25% talc based formulation was effective in reducing the severity of blast pathogen both in leaf phase (29.57% and 24.70%) and neck phase (28.06 % and 26.76%) during 2013 and 2014 respectively(Table 2). It also increased the yield (24.30 q/ha & 25.50 q/ha) during 2013 and 2014respectively. The two years average data revealed that leaf and neck blast in plots treated with *Pseudomonas fluorescens* @ 0.25% was lowest among the treatments.

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Organic conservation tillage practices: effects on productivity and profitability of vegetable pea under rice – vegetable pea cropping system in Sikkim

Raghavendra Singh*, Subhash Babu, RK Avasthe, GS Yadav and DJ Rajkhowa

ICAR Research Complex for NEH Region Sikkim Centre, Tadong, Gangtok, Sikkim

*Correspondence: raghavenupc@gmail.com

Introduction

Vegetable pea (*Pisum sativum* L.) is cultivated under diverse agro climatic situations (300 m to 2200 amsl) in eastern Himalayas during the *Rabi* season under assured irrigation supply system. However, in rainfed ecosystem of eastern Himalayas especially in Sikkim, after harvesting lowland rice, most of the fields remain fallow mainly due to moisture stress during winter season. In this context, conservation tillage practices are gradually gaining importance as effective mitigation options under changing climate conditions (Das *et al.* 2014). No tillage (NT) and reduced tillage (RT) to have favourable effect on soil properties and crop performance. Tillage practices greatly enhance the labour cost in production systems, resulting in lower economic returns. However, conservation tillage (no or reduced) are effective for reducing water loss from shallow depth soils and improves soil moisture regime as soil porosity, soil infiltration and soil structure are greatly affected by tillage. Upon appropriate residue management, NT and RT systems reduce soil erosion, increase soil aggregate stability, and helps soil carbon sequestration. Adoption of no till practice helps in timely seeding either of the crops in sequence, hence, will lead to increase in productivity as well as cropping intensity in the region. In organic farming, the entire nutrient demand of the crop must be supplied through organic sources. Therefore, farmers mainly depends on-farm nutrient inputs. Hence, they apply very low amount of organic manure due to low and/ or non-availability of FYM. It is presumed that adoption of conservation tillage practices along with nitrogen substitution may enhance the productivity of vegetable pea in any cereal-based cropping system under organic management conditions. In view of the above, field experiments was conducted to identify the most efficient tillage methods and organic nitrogen sources for enhancing productivity and profitability of vegetable pea.

Methodology

The experiment was carried out during *Rabi* seasons of 2014-15 at Research Farm, ICAR Research Complex for NEH Region Sikkim Centre, Tadong, situated at 1300 meters amsl with latitude 27^0 33' N and longitude 88^0 62' E. During the cropping period total of 147.6 mm rainfall was received. The soil of experimental field was clay loam with pH 5.9 (1: 2.5 soil and water ratio), low in N (214.5 kg/ha), high in P (25.60 kg/ha), low in K (185.3 kg/ha) and high organic carbon (1.89%). The experiment was laid in split plot design, assigning three tillage practices *viz.,* conventional (CT), reduced (RT) and no till (NT) in main plots and four organic nitrogen management practices *viz.,* control (FP), 100% N through farmyard manure (FYM) + biofertilizer (BF), 100% N through vermicompost (VC) + BF and 50% N through FYM + 50% N through VC+BF to sub-plots. All the treatments were replicated thrice. The recommended dose of 30 kg N/ha was applied through organic sources as per the manurial treatments. Just after harvesting of rice crop all the amount of organic nitrogen was applied in CT and mixed well in soil with the help of repeated ploughing and tilling. However, in NT and RT a narrow band was made in between rows and the organic manures were applied in these bands as per the treatments. In no till plots, seed was sown on November 04, 2014 while, in RT and CT sowing was done on November 14, 2014, respectively. Seed was sown in rows at spacing of 30 cm x 10 cm, respectively in all the plots receiving different tillage practice. Similarly, in case of NT, manual dibbler (locally made) was used for sowing of crop. Weeding was manually done in all the plots (25 and 40 DAS). Vegetable pea variety TSX -10 was grown as per recommended practices of the region. In no till plots, first picking was done in the month of January during both the years which was about one week earlier than CT and RT. Gross returns were computed based on the green pod and stover yield and their prevailing market prices during the respective crop seasons.

Results and Discussion

Among the tillage practices, no till (NT) recorded significantly longer pod length (8.8 cm), pod/plant (10.7), green pea seed/pod (8.1) and pod weight (8.5 g) over reduce tillage (RT) and conventional tillage (CT). This resulted in significantly higher green pod and stover yield (6.10 and 7.79 t/ha) with NT over CT (5.49 and 7.04 t/ha) and RT (5.85 and 7.45t/ha) practices. NT recorded 10.1 and 4.3% higher green pod yield over CT and RT, respectively. The increase in yields under NT could be related to early sowing (8-11 days earlier than CT and RT), which provided congenial growth conditions for better growth and yield. Higher yield of vegetable pea in Himalayan region with early sown crop was also reported by Mukherjee *et al.* (2013). Application of organic nitrogen sources caused significant effect on yields attributes and yields of vegetable pea (Table 1). Application of 50% RDN through FYM + 50% RDN through VC+BF recorded longer pod length (8.9 cm), pods/plant (11.4), seeds /pod (8.1) and pod weight (8.4 g) followed by100% RDN through vermicompost (VC) + BF. This resulted in significantly higher green pod (6.63 t/ha) and stover yields (7.91 t/ha) over control (FP), 100% RDN through FYM+ biofertilizer (BF), and 100% RDN through VC + BF. This might be due to the combined effect of farmyard manure and vermicompost because of the decomposition and slow nutrient release pattern from FYM and better mineralization, higher occurrence of beneficial microorganisms, growth promoting hormones and enzymes of vermicompost (Banik *et al.,* 2006) leading to adequate and balance nutrient supply throughout the growth period enabled the plants to assimilate sufficient photosynthates and thus, increased the transfer of dry matter to the sink resulting higher yields.

Tillage practices significantly affected the gross returns, net returns and B:C ratio and highest cost of cultivation was incurred with CT (33.3x10^3 `/ha) followed by RT (31.3x$10^3$ `/ha) and NT (29.3x10^3 `/ha), respectively. This caused 13.7 and 6.4 per cent higher cost involvement in CT than ZT and RT, respectively. This was due to more number of tillage operations and labour involvement in CT and RT over NT. With respect to gross returns, net returns, and benefit: cost ratio, among the tillage practices, NT recorded significantly higher gross return (129.7 x10^3 `/ha) than RT (124.4 x$10^3$ `/ha) and CT (116.8 x10^3 `/ha). Further, greater net return (100.4 x$10^3$ `/ha) and B:C ratio (3.42) was obtained with NT and the corresponding value with CT were 83.5 x10^3 `/ha and 2.50, respectively. The maximum net return in NT resulted from substantial saving of labour in tillage operations as well as the higher yield. Organic sources of nutrition had shown significant effect on profitability of vegetable pea *viz.,* gross return, net return and B:C ratio (Table 1). Among the organic nitrogen sources, application of nitrogen through 50% FYM + 50% RDN through VC+BF recorded significantly higher gross return (141.6 x10^3 `/ha), net return (108.6 x$10^3$ `/ha) and B:C ratio (3.42) as compared to control (FP) and 100% RDN through FYM+BF, 100% RDN through VC + BF. This may be attributed to the higher productivity and varied cost of cultivation among the treatments.

It may be concluded that vegetable pea under no-till (NT) is more profitable option in rice – vegetable pea system. Substitution of nitrogen through VC and FYM in equal proportion along with biofertilizers (50% RDN through FYM + 50% RDN through VC+BF) is more productive and remunerative in mid hill ecosystems of Sikkim.

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Biochar from weed biomass: effect on soil health and productivity of maize-pea cropping system in acidic soil of Sikkim under organic nutrition

Shaon Kumar Das*, RK Avasthe, R Singh, S Babu, R Gopi and A Yadav

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok, Sikkim

Correspondence: shaon.iari@gmail.com

Introduction

Biochar is simply carbon rich charcoal-like substance which is created by heating biomass (organic matter) in limited oxygen condition, through a process known as pyrolysis. It is commonly defined as charred organic matter, deliberately applied to soils to sequester carbon and improve soil physical, chemical and biological properties. Locally available weed biomass which is not economically important and caused crop loss can be used as an important source of biomass for preparation of biochar. Thus, if we prepare biochar from locally available weeds then it is possible to reduce the weed population in the agricultural field which is a serious problem in organic agriculture since use of any chemical herbicide is not permitted. Property of biochar used in this experiment is presented in Table 1.

Methodology

Biomass of six locally available weeds (*Ageratum* spp., *Lantana* spp., *Artemisia vulgaris*, *Chromolaena odorata*, *Bidens* spp., *Neyraridia* spp.) were used to prepare biochar. Charring was carried out in a pit ($2 \times 2 \times 3$ ft^3) to keep the process simple, quick and low cost having production efficiency 13.2, 23.2, 15.1, 16.4, 14.6 and 19.6%, respectively.

Results and discussion

To determine the liming potential study was conducted by incubating acidic soil (clay loam) of pH < 5.0 with biochar. The biochar prepared from weeds biomass and dolomite were applied at three rates (0, 2.5, and 5.0 t/ha). Application of *Lantana* spp. biochar had shown a relatively larger increase in soil pH followed by *Ageratum* spp., *Neyraridia* spp., *Artemisia vulgaris*, *Bidens* spp., *Chromolaena odorata*. These weed spp. can be effectively used as potential source of biochar preparation. Amendment type, application rate, and their interaction had significant effects ($p<0.05$) on soil pH. The ameliorating effect of biochar on chemical properties of acidic soil was consistent with their chemical composition. Biochar application had positive effects on crop growth, along with positive effects on nutrient (N, P, K) uptake by crop plants. In the short term, biochar influences root nodule number and localised N_2 fixation per nodule. All the biochar enhanced soil carbon storage in acidic soil. Results showed that the KCl extractable NH_4^+-N concentrations in the five biochar amended acidic soil decreased compared to the unamended soils. Thus, in conclusion, these weed spp. can be effectively used as a potential source of biochar preparation for management of soil acidity in Sikkim.

Maize (green cobs)–*pahenlo dal* (green seeded urd bean)–buckwheat: a resource efficient cropping system for rainfed mid hill ecosystem of Sikkim

Subhash Babu[1], Raghavendra Singh[2], RK Avasthe[3], GS Yadav[4]and DJ Rajkhowa[5] *ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Sikkim*
Correspondence: subhiari@gmail.com

Introduction

Maize is the most important *pre–kharif* crop in Sikkim, accounted 39.93 thousand ha area with an average productivity of 1723.6 kg/ha (2013–14). After harvesting of maize farmers of the state leave their land fallow, due to very less /negligible rainfall in *Rabi* season, which may not be able to support crop cultivation. Therefore, maize–fallow is the predominant cropping sequence in the rainfed region of Sikkim Himalayas resulting in very low cropping intensity (about 118%). Productivity of rainfed mono–cropping system of Sikkim is very low and it is a high risk economic activity. Hence, selection of appropriate crops in maize–based cropping system for harnessing the natural resources in a sustainable manner and achieving the maximum returns under rainfed condition, without considerable modification in farming practices to have self–reliance for food and nutrition. In view of the limited scope for horizontal expansion to augment food production, the alternative is to proceed with vertical growth for increasing the productivity per unit of available land and other resources. It is relevant to focus on the sequential cropping in mono–cropped areas for enhancing agricultural productivity. Therefore, there is need to develop resource efficient cropping systems by inclusion of more number of crops per unit area. Keeping these points in view present investigation was carried out during three consecutive years (2012–15) at Research Farm, ICAR Sikkim Centre to intensifying the maize–based cropping systems for improving the profitability, employment generation and energy use efficiency under organic management in rainfed region of Sikkim Himalayas under NICRA project and one year data (2014–15) on system production efficiency, relative production efficiency and land use efficiency has been presented in this paper.

Methodology

Fixed plot field experiments were undertaken during three consecutive years (2012–13, 2013–14 and 2014–15) at the experimental farm of ICAR Research Complex for NEH Region, Sikkim Centre, Tadong situated at latitude 27°32' N and longitude 88°60' E, at an altitude of 1300 amsl. The soil was clay loam in texture and initial content of pH, organic carbon, available N, P and K was 5.9, 20.6 g/kg, 235.3 kg/ha, 25.30 kg/ha and 204.7 kg/ha, respectively. Five maize–based cropping sequences (CS) *viz.*, maize–fallow, maize–rajmash, maize–toria, maize–buckwheat and maize (green cobs)–*pahenlo dal* (green seeded urd bean)–buckwheat were tested in four times replicated Randomized Block Design (RBD). All the crops in each treatment were grown as per the recommended package of practices of the region (Table 1).

After harvesting of all the crops in sequences, maize equivalent yield (MEY), system production efficiency (SPE), relative production efficiency (RPE) and land use efficiency (LUE) were calculated as per the formulae given below.

MEY = Yx (Px)/Pm , Yx is the yield of crop x (t/ha of economic harvest), Px is the price of crop x, and Pm is the price of maize

$\text{SPE} = \text{Mey (kg/ha)}/365$, MEY is maize equivalent yield of the system

$\text{RPE} = \frac{(\text{EYD}-\text{EYE})}{\text{EYE}} \text{X } 100$, EYD, equivalent yield under diversified system; EYD equivalent yield of existing system

$\text{LUE} = \frac{\text{TDN (i)}}{365} \text{X } 100$, TND (i), total number of days field remained occupied under different crops (i=1….n)

Results and Discussion

In general, inclusion of more number of crops in maize–based system resulted in higher productivity over the farmer's practices (maize–fallow) of the region. However, among the intensified cropping systems maximum maize grain equivalent yield (MEY) was recorded with {maize (green cobs)–*pahenlo dal* (urd bean)–buckwheat} followed by maize–rajmash and maize–*toria* system (Table 1), whereas the lowest MEY (3.26 t/ha) was recorded when the field was left fallow in consequent years after maize harvesting. Correspondingly, maximum system production efficiency (24.57 kg/ha/day) was recorded with maize (green cobs) –*pahenlo dal* (urd bean)–buckwheat system followed by maize–rajmash system. Crop yield, duration and sale price of the produce greatly influenced the system performance (Mukherjee, 2010). Similar results were also reported by Singh *et al.* (2007) with diversified systems over the existing systems. Similarly, relative production efficiency (RPE) was maximum (175.15%) with maize (green cobs) –*pahenlo dal* (urd bean) –buckwheat system followed by maize–rajmash sequence. Land use efficiency (LUE) refers to the utilization of land in temporal dimension for cropping activity was recorded to be higher for the maize (green cobs)–*pahenlo dal* (urd bean)–buckwheat system followed by maize–rajmash. This was due to higher crop duration which in turn recorded the highest LUE and efficient utilization of land over other systems. Similar observation on rice based cropping systems was also reported by Saha and Ghosh (2010). But the lowest LUE was recorded in maize–fallow system as the land was exploited very poorly in this system.

Table 1. Maize grain equivalent yield (MEY), system production efficiency (SPE), relative production efficiency (RPE) and land use efficiency (LUE) of maize based cropping sequences

Treatment	MEY (t/ha)	SPE (kg/ha/day)	RPE (%)	LUE (%)
Maize–Fallow	3.26	8.93	0.00	34.52
Maize–Rajmash	5.92	16.21	81.59	66.30
Maize–Toria	4.98	13.64	52.76	63.83
Maize–Buckwheat	5.28	14.46	61.96	63.01
Maize (green cobs) –*Pahenlo dal* (urd bean) –Buckwheat	8.97	24.57	175.15	81.91
SEm±	0.25	0.36	---	---
LSD (P=0.05)	0.77	1.10	----	---

Thus, on the basis of the above study it may be concluded that diversification of maize–fallow system under rainfed ecosystems of Sikkim Himalayas enhances the system production efficiency and land use efficiency. Therefore, maize (green cobs)–*pahenlo dal* (urd bean)–buckwheat cropping system is recommended for cultivation under rainfed conditions in mid hills of Sikkim Himalayas.

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Effect of organic and inorganic sources of nutrition in crop health and productivity of broccoli in foothills of Tripura

Tridip Bhattacharjee*, Debashish Sen, Th Irenaeus K.S. and Sourav Das
College of Agriculture Tripura, Lembucherra, West Tripura
*Correspondence: tridip4u2@gmail.com

Introduction

Broccoli is an edible green plant in the cabbage family whose large flowerhead is eaten as a vegetable. The cultivation of Sprouting Broccoli (*Brassica oleracea* L var. *italica* Planck) has become increasingly popular among Indian growers for the last couple of years primarily due to its high nutritive values and export potentials. It is cancer preventive; reduce cholesterol, allergic reaction and inflammation; improve bone health, digestion and natural detoxification; protect against chronic disease, and powerful antioxidant (Ouda and Mahadeen 2008). Agro-climatic condition prevailing in Tripura during winter season favours the cultivation extensively in many parts of the state. Moreover, it fetch more price than any other cole crops during the winter season. Yet the cultivation of broccoli has not been exploited commercially and still grown in very limited area especially near the cities. Application of chemical fertilisers and organic nutrition have distinct role in increasing the productivity and improving the shelf life of the curd. Hence, present investigation was designed to find out effect of organic and inorganic sources of nutrition in crop health and productivity of broccoli.

Methodology

The field experiment was carried out at College of Agriculture, Tripura, Lembucherra during 2014-2015 by adopting Randomized Block Design of 14 treatments with three replications. The details of treatment schedules are T_1- cowdung 5 t/ha; T_2- Vermicompost 5 t/ha; T_3- Poultry Manure 5 t/ha; T_4-Cow dung 10 t/ha; T_5-Vermi-compost 10 t/ha; T_6-Poultry manure 10 t/ha; T_7-Recommended Dose of Fertilizer @ 150:60:80 kg/ha; T_8- 2.5 t/ha cowdung + ½ RDF (75:30:40 kg/ha); T_9- 2.5 t/ha vermicompost + ½ RDF (75:30:40 kg/ha); T_{10}- 2.5 t/ha Poultry manure + ½ RDF (75:30:40 kg/ha); T_{11}- cowdung 5 t/ha + ½ RDF (75:30:40 kg/ha); T_{12} - 5 t/ha vermi compost+ ½ RDF (75:30:40 kg/ha); T_{13}- 5 t/ha Poultry manure + ½ RDF (75:30:40 kg/ha), T_{14}-Control. The sources of chemical fertilizers were urea, single super phosphate and muriate of potash for N, P_2O_5 and K_2O, respectively. All the organic manures were applied 15 days before transplanting. The chemical fertilizers were applied just before transplanting of the crop. Five weeks old healthy and disease free broccoli seedlings of hybrid '*Green Magic'* were transplanted on 15.12.2014 with spacing of 60 cm X 45 cm. Five randomly selected plants were taken for recording of characters like plant height, Number of leaves, crop canopy, curd size, economical yield, biological yield and harvesting index. All these above parameters were analyzed statistically.

Results and Discussion

Plant height of broccoli was ranged from 35.2 cm (control) to 46.8 cm (Poultry 5 t/ha + 75:30:40 kg/ha). Average number of leaf per plant was between 14.0 and 14.4 in different levels of organic nutrition while the number increased upto 16.4 in integration of poultry manure and RDF (50%). Canopy area ranged from 2978 cm^2, where 5 t/ha FYM was applied. While canopy area increased upto 67% when different organic sources of nutrition were integrated with RDF. These corroborate the findings of Bakker *et al.* 2009. Economic yield of broccoli curd were between 10.1 t/ha to 14.6 t/ha in organic cultivation of the crop, the yield was 16.6 t/ha in RDF and the highest yield to the tune of 20 t/ha was recorded in the crop managed by integration of poultry manure and RDF (50%). Similar result was also reported by Chatterjee *et al*. 2005. Biological yield of the crop tremendously from 29 t/h to 46.8 t/ha with variation in nutrition source and dose. Harvest index of the crop was the least (34.5%) where 5 t/ha FYM was applied while it increased upto 42.7 % when the crop was fertilised with 75:30:40 kg/ha N, P_2O_5 and K_2O, respectively along with 5 t/ha Poultry manure. Although farmers near the state capital Agartala are recently growing the crop, but there is huge scope for extensive cultivation of broccoli in Tripura. Integrated nutrient management with 5 t/ha Poultry manure or vermicompost or FYM along with 75:30:40 kg/ha N, P_2O_5 and K_2O, respectively gives the highest productivity of broccoli curd in the foothills of Tripura.

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A preliminary report on the effect of vermicompost on the tea production in West Tripura

SKS Jamatia* and PS Chaudhuri[1]

Tripura University, Surjyamaninagar, Tripura

*Correspondence: priya_1956@rediffmail.com

Introduction

Tea (*Camellia sinensis, F.* Theaceae) is an economically important, perennial and intensively managed monoculture tea plantation crop. Tea plantation dates back to 1916 in Tripura which is categorized as a traditional tea growing state producing about 8900 metric tonnes of tea per year so as to designate Tripura as the 5th largest tea producing state following Assam, West Bengal, Tamil Nadu and Kerala. Earthworms represent a major soil macro-fauna of soil invertebrate biomass and have a major influence on the fertility status and structure of soils. So, earthworm population dynamics and the influence of farming practices are of particular interest to organic growers. However, there is scanty information on the application of vermicompost in tea plantation in spite of the fact that tea is an important cash crop of Tripura. Thus, an investigation was undertaken to study the effect of different doses of vermicompost in the tea production in Tripura.

Methodology

The study was conducted from January 2015 to November 2015 in Harishnagar Tea Estate, Bishalgarh, 22 kms away from Agartala city. Vermicompost was collected from Adarini Vermicompost and Research Centre, Bhati Fatikchhera, West Tripura. The experiment was set up using a complete factorial design with 4 different amounts of vermicompost each having 4 replicas. The amout of vermicompost as applied in the experimental plots were T0 (Control), T1 (5 tons ha^{-1} yr^{-1}), T2 (10 tons ha^{-1} yr^{-1}) and T3 (15 tons ha^{-1} yr^{-1}). Tea plants (2 years old) were selected for vermicompost application. During the treatment, each of the doses of vermicompost was applied in three equal parts, three times a year. Evaluation of different plant parameters viz. tea leaf pluckings per plant, leaf length, leaf width, leaf production etc. was assessed. Earthworms were collected by conventional digging and hand sorting method using the quadrate method (Chaudhuri *et al.* 2008) between August 2015 to October 2015. Composite soil samples from each experimental plot were collected for soil analysis. Soil pH was measured in 1:2.5 aqueous solution using digital pH meter. The organic matter was determined by partial oxidation method (Wakley and Black 1934).

Results and Discussion

The application of vermicompost affected significantly the pH of the soil but the effects were depending on the strength of vermicompost doses (Table 1). Highest pH value was observed in treatment plot T3 (pH 4.68). Gradual increase in pH with increasing doses of vermicompost corrobates with the findings of Suthar 2009. The highest value of organic matter was observed in treatment plot T3 (1.89 %) (Table 1). Number of fresh leaf pluckings per plant increased with increase in the dose of vermicompost. Highest leaf plucking was observed in T3 plot (8.52 plucks/ plant) (Table 1). In case of leaf growth parameters T3 plot exhibited best results among all other treatment plots. Treatment plot T3 (15 tons ha^{-1} yr^{-1}) showed the highest productivity of tea leaves during the experimental period (91 tons ha^{-1}). Total tea leaf production increased dramatically from the month of June 2015 to October 2015 (Fig. 1). Increase in tea plant growth and yield may be due to the presence of biologically active plant growth influencing substances (Subler *et al.* 1998).

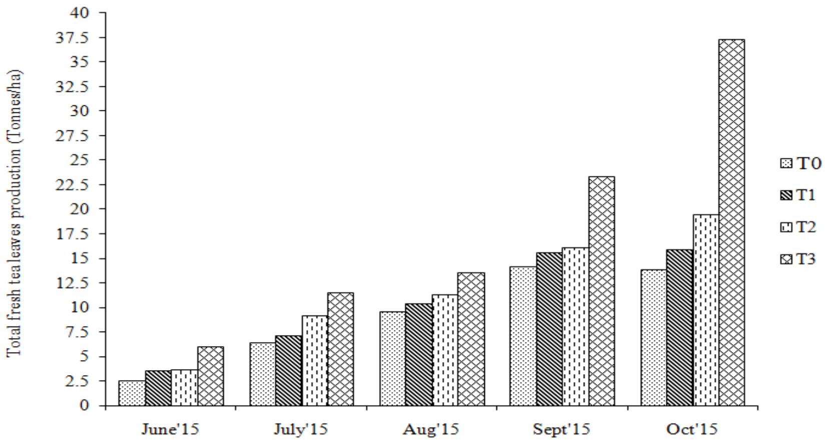

Fig 1. Monthly total production of fresh tea leaves (tonnes/ha) with different doses of vermicompost

A total of only three earthworm species viz. *Pontoscolex corethrurus*, *Metaphire houlleti* and *Drawida assamensis* were collected from the experimental plots. On the basis of relative density, *P. corethrurus* was the most common species (60%) followed by *M. houlleti* (24%) and *D. papillifer* (15%). A significant (< 0.05) but gradual increase in density and biomass of earthworms were observed along with the increasing doses of vermicompost (Table 1). Earthworm density was recorded highest in treatment plot T3 (101.33 ± 33 ind. m^{-2}). Lavelle *et al.* 1998 reported a significant increase in tea production over three consecutive years. Application of vermicompost in the tropical soils of tea agro-ecosysytem promotes plant growth and yield through increase in density and biomass of earthworms and physico-chemical properties of soil.

Table 1. Showing the variations in the tea soil chemical properties and impact of different doses of vermicompost on different tea plant parameters in tea plantation plots

Parameters	Treatment plots				F	P
	Control	T1	T2	T3		
Soil pH	3.72 ± 0.07	3.91 ± 0.09	4.38 ± 0.06	4.68 ± 0.08	28.71	<0.05
Organic matter (%)	0.99 ± 0.03	1.09 ± 0.01	1.34 ± 0.04	1.89 ± 0.05	100.28	<0.05
Avg. leaf length (cm)	6.53 ± 0.16	6.95 ± 0.15	7.81 ± 0.11	8.66 ± 0.09	50.76	<0.05
Avg. Leaf width (cm)	2.60 ± 0.04	2.92 ± 0.14	3.14 ± 0.05	3.55 ± 0.04	20.13	<0.05
No. of leaf pluckings/plant	4.41 ± 0.15	5.61 ± 0.17	6.75 ± 0.17	8.52 ± 0.20	95.67	<0.05
Leaf moisture (%)	71.16 ± 0.78	74.01 ± 0.63	75.14 ± 0.68	77.38 ± 0.71	13.40	<0.05
Total leaf production (tonnes/ha)	46.68 ± 0.03	52.68 ± 003	59.92 ± 0.04	91.72 ± 0.15	8.65	<0.05
Earthworm density (ind. m^{-2})	33.66 ± 3.54	44.33 ± 3.54	72.66 ± 5.53	101.33 ± 3.51	54.32	<0.05
Earthworm biomass (g m^{-2})	9.82 ± 1.22	11.91 ± 1.23	20.21 ± 1.95	26.98 ± 1.48	27.44	<0.05

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Encapsulated bioferilizer: a novel way to deliver microbial consortia in crop production system

Subrata Nath Bhowmik*, M. Datta, Subhankar Ganguly, Moumita Ghosh
ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura
*Correspondence: snb70@yahoo.co.in

Introduction

Microbial consortia comprising of effective strains of *Rhizobium*, *Azotobacter*, *Azospirillum*, phosphate solubilsing bacteria (PSB) along with arbuscular mycorrhizal fungi (AMF) proved immensely beneficial in improving crop productivity (Bhowmik *et al.* 2015). Microbial survival following introduction in the form of biofertilizers to natural soils depends on both abiotic and biotic factors. Inoculum strategies should include application of carrier materials aimed at providing protective niche together with the provision of nutrient sources. It is opined that the encapsulation method helps to increase the survival rate and easy delivery of microbial cultures. It also helps in segregating the microbial cells from adverse environment thereby reducing cell loss. However, research in bioformulation of microbial consortia in immobilised form *via.* entrapment technique in natural polymers is meagre. Here we explored the effectiveness a microbial consortia in conjunction of AMF in crop growth and phosphorus translocation *via.* encapsulation in alginate.

Methodology

Rhizobium, PSM and AMF were used as model microorganisms in the study. The *Rhizobium* and PSB were prepared in YEM and Pikovaskya's media (HIMEDIA, India) respectively for 72 h at 30^{o}C. The cells were harvested at log phase (10^8 cfu/ml) by centrifugation (4^{o}C at 5000*g*). AMF spores were collected by wet sieving and decanting method (Habte and Osorio 2001) and were surface sterilized in a solution contained (per 100 ml sterilized distilled water) 40 mg streptomycin, 2 g chloramines-T Trihydrate and 0.1 ml Tween 80. AMF spore and bacterial biomass along with 2% Rock Phosphate (RP) was mixed in 1.5% solution of sodium alginate which was further poured in a sterile petridish to form a thin layer 2-mm-layer. The mixer was hardened by 0.5 M solution of $CaCl_2$ and after 30 min was washed with sterile distilled water. Alginate material cut into 3x2 mm pieces. A set of similar composition maintained concurrently upon sterilisation at 15 psi (121^{o}C) for 15 min. *Leucaena leucocephala* was the test plant. Three-day-old seedlings obtained from surface-sterilized-seeds were transplanted to 150-ml-capacity pots (one per pot). The experiment consisted of five treatments: control (C); co-immobilised bacterial cells of *Rhizobium* +PSB+ RP (IRPR); sterile co-immobilised bacterial cells of *Rhizobium* +PSB+ RP (S-IRPR). The treatments IRPR and S-IRPR were tested both in the presence and absence of AMF. Each mycorrhizal treatment received 8-10 spores/g soil. Bacterial cells were applied at a rate of $1.7x10^6$ per g soil. *L. leucocephala* plants were grown in greenhouse under a 13-h light; 11-h dark (i.e. day/night cycle of 16/8), 29/24^{o}C, and 80% relative humidity. The pots were weighed and watered to field capacity. Plants were harvested after 21 days of growth. Shoot and root dry weights were recorded after drying at 70^{o}C to constant weight. Total P per leaflet/ leaf was measured by the method of Habte and Osorio (2001).

Results and Discussion

All the parameters under investigation increased with the application of immobilized microbial consortia above control. However, increment in dry weight of shoot, root along with P per leaflet was maximum with immobilized mycorrhiza in conjunction with *Rhizobium*, PSB and RP. The P thus solubilised by PSB from RP was efficiently translocated by mycorrhiza to the plant which on turn accelerated the N fixation and ultimately gained dry weight yield in shoot. Synergistic effect of AMF with *Rhizobium* and PSB on yield of crops is at par to the early reports (Saxena *et al*. 1997). Alginate polymer alone had insignificant influence on the parameters tested as compared to the control. n Our results show that alginate encapsulation technology may be effective approach for preparing biofertilizer formulations for microbial consortia comprising of AMF + P-solubilizing microorganisms + N-fixing microorganisms for managed and natural ecosystem in general and for fragile ecosystem in particular. Further studies are needed to develop efficient inoculant system that may be stored before application.

Table 1. Effect of treatments on shoot, root weight and total phosphorus concentracftion

Treatment	Dry weight (g)				Total P per leaflet/leaf (µg)	
	Shoot		Root			
	Non AMF	AMF	Non AMF	AMF	Non AMF	AMF
IRPR*	0.32	0.50	0.19	0.20	0.82	0.94
S-IRPR	0.28	0.31	0.18	0.19	0.30	0.76
Control	0.25	-	0.17	-	0.21	-

* IRPR = co-immobilised bacterial cells of *Rhizobium* +PSB+ RP; S-IRPR = sterile co- immobilised bacterial cells of *Rhizobium* +PSB+ RP

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Earthworm resource in the waste deposit sites of West Tripura

Susmita Debnath and P.S. Chaudhuri*
Tripura University, Surjyamaninagar, Tripura
*Correspondence: priya_1956@rediffmail.com

Introduction

Earthworms are one of the major macro-fauna and key component of soil biota. They are also the major decomposers of soil ecosystem contributing to the recycling of nutrients to be utilized by plants. Composting of organic wastes through the activities of earthworms to form vermicompost a process called vermicomposting, is at present a major field of earthworm research. Effective use of earthworm species in organic waste management requires a detailed understanding of biology and ecology of potentially useful species . Reports are available on the distribution of tropical earthworms in different habitat viz. deciduous forest, plain grassland, forest, mixed forest (Bhadauria *et al*. 2000), tropical rain forest (Fragoso and Lavelle 1987) etc. However, literature on the occurence of earthworm species in waste deposit sites is scanty. On the basis of the above fact, the aim of the present investigation is to study of the distribution of earthworms and their ecological requirements in different waste deposit sites in and around West Tripura. Such study is important in order to select earthworm species those can tolerate high organic matter content in their habitats.

Methodology

The study was conducted during April 2015 to September 2015 in various waste deposit sites viz. municipal solid waste, cow dung heaps, poultry wastes, and partly decomposed saw dust wastes. Earthworms were sampled by conventional digging (25cm x 25cm x 15 cm) and hand sorting method (Anderson and Ingram 1993). The data were used to calculate earthworm density (ind.m^{-2}), biomass (fresh weight, g.m^{-2}), index of general diversity (Shannon and Weiner 1963), and index of dominance (Simpson 1949). Collected soil samples were used to determine temperature, moisture, pH, organic matter, water holding capacity and bulk density of soils.

Results and Discussion

Our present survey revealed occurrence of 12 species of earthworms under 4 families viz. Megascolicidae [*Lampitto mauritti* Kingberg, *Perionyx excavatus* Perrier, *Metaphire houlleti* (Perrier), *Metaphire posthuma* (Vailant), *Polypheretima elongata* (Perrier)], Octochaetidae [*Eutyphoeus gammiei* Beddard, *Lennogaster chittagongensis* (Stephenson), *Dichogaster bolaui* (Michaelasen), *Octochaetona beatrix* (Beddard)]. Moniligastridae [*Drawida assamensis* Stephenson, *Drawida papillifer papillifer* Gates], Glossoscolecidae [*Pontoscolex corethrurus* (Muller)]. Occurrence of earthworm species in different waste deposit sites is given at Table 1. Interestingly ,*P.excavatus* and *D.balaui* were distributed in all types of waste deposit sites.

Table 1. Occurrence of earthworm species in different waste depositing sites West Tripura.

Earthworm species	HABITAT			
Megascolicidae	MSW	CD	PW	SD
M. houlleti,	+	+	+	-
L. mauritti	+	+	+	-
M. posthuma	+	+	-	+
P. excavatus	+	+	+	+
P. elongata	-	-	-	+
Octochaetidae				
L. chittagongensis	-	+	+	+
D. bolaui	+	+	+	+
E. gammiei	-	+	-	+
O. beatrix	-	+	+	+
Moniligastridae				
D. assamensis	-	-	-	+
D. papillifer papillifer	-	-	+	+
Glossoscolecidae				
***P.** corethrurus*	-	+	+	+

Abbrv : MSW- Municipal solid waste, CD- Cow dung heap, PW- Poultry litter waste, SD- Saw dust waste

Out of 12 species only 3 species were epigeic (*D. bolaui*, *P. excavatus*, *L. chittagongensis*), 3 species were anecic (*M. houlleti, L. mauritti, D. papillifer papillifer*), and rest 6 species were of endogeic category. Of all the species recorded, 5 were exotic (*M. houlleti*, *M. posthuma*, *P. corethrurus*, *D. bolaui*, *P. elongata*, *L. mauritti*) and rest native to the Indian sub- continent. In general, earthworm species in waste deposit sites experienced mean soil temperature 30.34 ± 1 °C, moisture 31.27 ± 0.8 %, pH 7.2 ± .52 , organic matter 5 ± .9 g%, water holding capacity 47.77 ± 1.4 %, bulk density 0.71 ± 0.13g cm^{-3}. Density (107.3 ± 4.53 ind. m^{-2}) and biomass (79 ± 4 g m^{-2}) of earthworm species in waste deposit sites were within the reported range of earthworm communities from different land use systems of Tripura. In the waste deposit sites of West Tripura, Shannon Diversity Index and Simpson Index of dominance were 1.77 and 0.72 respectively.

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Improved Shifting Cultivation Practices

- Cropping system and Agroforestry
- Soil and Water Conservation
- Farming systems for shifting cultivation

Crop diversification for managing farm problems and exploring the opportunities for livelihood security of small holders in hill and mountain regions

DS Rana, Anil K Choudhary and KS Rana
Indian Agricultural Research Institute, New Delhi

Crop diversification through intervention of legumes as well as integrated crop, soil, nutrient and pest management are some of the viable options to cope up with the emerging challenges in Indian agriculture. Crop diversification has potential for nutritional security, mitigation and adaptation to climate change, for pest management, risk reduction and for export/import balance. In hilly areas, mal-nourishment in terms of protein, iron zinc, calorie requirements etc. are the major problems and crop diversification can go a long way in solving these problems. Soil and water erosion is another major problem of the hilly areas and this can be addressed properly through crop diversification. In some parts of the hilly areas, farmers have abandoned agriculture due to monkey menace. Crop production in these areas can be revived through crop diversification. Climate change is considered as one of the major environmental problems of the 21st century. Hilly areas are more vulnerable to climate change and clear cut evidence of climate change are available from the hilly areas. Keeping in view the expected changes in climate/weather parameters in future, there is a need to diversify the cropping system with crops and varieties which are sustainable under the changing climate. Hilly areas face the problems of both excess water and moisture scarcity for crop production and there is a need to identify suitable crops and cropping systems for these situations. Organic farming is the another viable opportunity in hilly tracts where by default the hill farmers are practicing low input agriculture mainly based on organic resources. Overall, this paper stresse upon crop diversification options for hill and mountain agriculture so as to enhance the employment opportunity, food-nutrition-livelihood security, and also address the farm related problems like low fertility, soil erosion, rainfed farming risks, monkey menace and other wild animal conflicts arising in the hill and mountain fragile ecosystems.

Comprehensive agronomic intervention for sustaining jhum cultivation in North East India

SS Rathore*
ICAR-IARI Pusa, New Delhi
*Correspondence: rathore_agron@yahoo.com

Introduction

Shifting cultivation is regarded as the first step in transition from food gathering/hunting to food production. Shifting cultivation in the past was environmentally sound, and acceptable mode of livelihood of the upland people when the population size was small and virgin forest was existing in plenty. Traditional shifting cultivation systems were able to maintain subsistence crop yields at a low but sustained level for centuries; if fallow length was respected. Jhum enables multiple cropping of several crops which provide a balanced diet and also offers some form of crop insurance to the farmers in the incident of failure of some crops. This system of food production might have worked well in the past when a balance was maintained between population and soil fertility as a result of a longer fallow cycle of 20 to 30 years. In area of high demographic growth and increasing land shortages, intensification of slash and burn system can be highly detrimental. The efforts to replace shifting cultivation with continuous arable cropping have caused terrible soil degradation. The agronomic interventions for fertility restoration of exhausted shifting cultivation lands, weed management, fallow management, alternate land use systems, soil and water conservation and water harvesting including suitable use of hill springs can play great role in enhancing the output per unit of area in shifting cultivation.

Agronomic intervention for enhancing productivity of jhum land

The declining productivity of shifting cultivation is the main threat for sustainability of shifting cultivation agriculture, which needs urgent measures for improvement. The agronomic intervention for restoration of soil fertility, weed management, soil and water conservation and bio diversity management are the potential options in this regard. With the growing human population and decreasing land – man ratio, loss of forest cover, decreasing shifting cultivation cycle, changing rural lifestyle, increasing demand of food products, jhum land needs to be ameliorating for enhancement of its productivity.

Restoration soil fertility of shifting cultivation areas

One of the main reasons for rotation of land in shifting cultivation is the exhaustion of soil fertility and search of new fertile land. The on farm use of resources to restore the soil fertility is highly effective and there are good means as inclusion of legumes in inter cropping , mixed cropping, strip cropping or hedge row system. The factor which keeps people at the level of shifting cultivation is in the first place the rapidity with which tropical soils lose their fertility (i.e. their lack of retaining capacity of plant nutrients) and undergo undesirable changes in physical conditions. These difficulties can be split into several factors: low absorption capacity of exchangeable bases of the soils clay fractions; the tendency of these clays to immobilize phosphates; the heavy percolation rates of tropical rains through generally very porous soils and the resulting leaching of plant nutrients; the rapid destruction of organic matter by bacterial action under condition of high temperatures, and so on.

Legumes for restoration of soil fertility

Introduction of leguminous cover crops are gaining interest among farmers and researchers alike for its multipurpose nature in enhancing soil productivity, weed suppression, providing food to humans and feeds to animals besides added cash incomes. Velvet bean in Honduras is reported to contribute some 60 kg N/ha (Flores 1992). It is not only N fixed by legumes but some amount of P also fixed by legumes by release of P –solublising acids in the soils. The amount of N and P fixed by different leguminous crops has been depicted in the table 1. After a legume crop matures its nodules disintegrate and release the bacteria they contain into the soil. These bacteria become a source of infection for subsequent legume crops, but the population declines gradually in the absence of suitable roots to nodulate and multiply on.

Ash/ burning to supplement soil nutrients

Slash-and-burn clearing of forest typically results in an increase in soil nutrient availability. Throughout the tropics, ash from consumed vegetation has been accepted as the primary nutrient source for this increase. Slash burning resulted in large transformations of non-plant-available P and N in soil into mineral forms readily available to plants (Giardina *et al.* 2000). Soil exchangeable Ca, Mg, and K increased with fire severity, while exchangeable acidity and Al decreased two week after the burn. Soil C and N were reduced at high burn severity only. Phosphorus showed an increase in availability at low to medium fire severity and a decrease in availability at the most intense burn levels (Tanaka *et al.* 2001). An important reason for burning the slashed vegetation in shifting cultivation systems is the release of nutrients. The relative effectiveness of ash-P was 0.67 or 67%, and the substitution rate 1.5. This implies that for the uptake of a unit of P about 1.5 times as much ash-P as fertilizer-P should be applied. The effectiveness of ash as liming material was 0.59 compared to Ca $(OH)_2$, hence 1.7 times as much ash as $Ca(OH)_2$ is needed to establish a same increase in pH.

Alder based cropping system

The Alder (*Alnus nepalensis)* -based *jhum* system is an outstanding model of sustainable land-use intensification evolved through numerous years of testing without the want of outside technologies. In North east India most of the farmers cultivate *jhum* fields for two years within a 10 years cycle (1:4 ratio of cropping to fallow), while Alder-based *jhum* system allows crop harvests in two out of every four years (1:1 ratio of cropping to fallow). Another unique advantage about alder system is that under short *jhum* cycles a number of crops can be produced in a sustainable way, and even produce saleable surplus items of food. At least there are 57 different edible crops produced along with primary crops of rice, maize, Job's tears and potato (Technical Report 2001).

Soil organic carbon management

Many tropical soils under shifting cultivation are poor in inorganic nutrients and rely on the recycling of nutrients from soil organic matter to maintain fertility. In undisturbed rainforests such nutrients are recycled via the litter; 'slash-and-burn' agriculture, meanwhile, depends on the mineralization of organic nutrients from the plant remains or on (short-lived) inputs from ash. Traditional shifting cultivation systems have utilised the SOM built up during the fallow phase to supply nutrients for the cultivation phase of some 4-6 years. Components critical for the understanding of SOM balances and transformations are residue inputs under native and agricultural vegetation, rates and controls of SOM mineralization under cultivation, controls on SOM accretion under fallow vegetation, and the quality of SOM with respect to nutrient supply (Tiessen 2001). Long-term experiments indicate that losses of up to 0.69 t carbon/ha/yr in the soil surface layers are common. The strategies required must include direct soil organic carbon (SOC) replenishment through addition of organic materials, notably manures, wastes, residues and plant litter; biomass transfer; incorporation of improved fallows in the farming systems. Indirect contribution to SOM replenishment or recapitalization may be achieved through inorganic fertilizations and amendments; legume integration in the production system; and combined inorganic and organic inputs (Nandwa 2001).

Mulching as source of nutrients

Mulching is the agronomic practice of covering the soil surface either by live /dead plants or with other materials like plastic sheets. The live mulch of leguminous herbs helps in nutrient enrichment of the soil. The Tephrosia mulching as fallow of Tephrosia, internal mulching using pruned Tephrosia biomass and upland rice with external mulching using Tephrosia biomass prevented nutrient losses by erosion effectively. There was a trend that the less labile P-pools (NaOH-P) were reallocated into the more labile P-pools (Bicarb-P) in the soil. Burning released significant amount of the inorganic P-pools. Sufficient quantity and quality of the Tephrosia mulching material was recorded with organic input to crop export ratios for N and P were >1. For five consecutive crops, mulching of kudzu (*Pueraria phaseoloides*) at the rate of 8 tons fresh material/ha/crop produced yields which were 90% of the crops receiving complete inorganic fertilization and liming. The beneficial effects of incorporating kudzu as green manure were associated with the amounts of N, P, K, Ca, and Mg released from the decomposing material, decreased AI saturation, and possibly enhanced nutrient accumulation due to less moisture stress and lower hulk density (Wade and Sanchez 1983).

Weed Management

Weeds are the major problem in shifting cultivation due to upland agro ecosystem conditions. There are perennial weeds which become noxious; to control them by some of agronomic practices are very useful. Thatch grass grows abandoned *jhum* fields. A thatch infested *jhum* area is normally abandoned by the farmers after the first year cropping as it makes farm operations difficult and expensive to continue well into the second year. There are reports of control of thatch grass to a very large extent (about 50 %) by planting cassava in the first cropping season. Based on indigenous knowledge and works done in various institutions, velvet bean is used to prevent the growth of thatch grass. The same species is reportedly used in many other countries as a cover crop, green manuring and to prevent the growth of thatch grass (Buckles and Perales 1997). One of the innovative method indigenous to the farmers is using of wild sunflower, which smothers the *Imperata* in just two years time. The extremely acidic soils conditions in many of shifting cultivation areas help in controlling the weeds though use of common salt. The commercial weedicides like 2,4-D and the conventional common salt are all Sodium (Na) based. Like common salt, application of Na salt of 2, 4-D can kill even sedges up to 90% besides increasing yield significantly. The farmers in north eastern region of India have been using common salt (Sodium Chloride) for controlling the broad-leaved weeds in their *jhum* fields. Common salt is probably the most effective herbicide (for broad-leaved weeds), while it does not effect the rice plant.

Improved fallow management

Fallowing is an integral part of the cropping system under shifting cultivation as it allows the forest to recover. Currently main area of shifting cultivation research consists improving fallow by substituting natural fallow vegetation with improved plants. These embrace short improved fallows with fast growing, nitrogen fixing trees, multipurpose tree species interspersed into cropped area. (agroforestry, alley farming etc); very short improved legumes fallows that can fulfill the functions of the traditional long fallow (organic matter, N. etc). Use of location specific suitable legumes as improved fallow should increase N accumulation, suppress weed growth, increase grain yield and reduce labour requirements. The importance of micro climatic factors, however, makes it advisable that fallow regrowth be tested under local conditions in relation to soil type, forest type, to determine the limiting factors in the restoration of fertility species composition could then conceivably manipulated to promote more rapid regeneration. Short lived trees producing tree crops could be maintained during fallow and then felled and before swidden use. Local shade loving crops, such as ginger, yam, turmeric, cardamom and pepper can be grown among trees, increasing the income of farmers during tree gestation period. Cover crops like velvet bean, rice bean or rubber bean can be used to smother weeds, improve soil fertility, control soil erosion and conserve moisture. This enriched fallow can either become a permanent perennial crop system, or have an extended period, in which commercially significant tree species offer earnings as well as their socio-economic and environmental benefits.

Alternate and use systems

The multi-disciplinary research programmes aimed at developing alternative land management practices have identified several viable land use models following their evaluation in terms of their long term runoff, production potentials, soil and nutrient losses, yield behavior, biotic and biotic changes and so on. For the conservation of natural resources and to save the farmers from misery there is dire need to diversify the cropping pattern by introducing alternative crops. Watershed based farming system, appropriate soil conservation measures, mixed land use of agri-horti-silvi-pastoral system, subsidiary source of income through livestock rearing, creation of water harvesting and silt retention structure at lower reaches - these are the important distinguishing features of the suggested agricultural strategy on the hill slopes. Farm productivity was sustainably enhanced with intervention of farming system approach under jhumland (Rathore and Bhatt 2008).

Soil and water conservation measures

The soil conservation measures like contour trenches, contour bunds, bench terraces, half moon terrace, grassed water way, safely disposing off the excess runoff to the foot hills with non-erosive velocity should be integral part of the watershed based farming system. The soil loss under shifting cultivation is very high and can be suitably minimized by following appropriate farming systems. Contour trenches, contour bunds, bench terraces, half-moon terrace, vegetative bunds and grassed waterway are some of the important soil and water conservation measures in shifting cultivated areas.

Spring water can be used through several techniques such as diversion into channels, storage in tanks or even development of artificial spring by excavating, long subterranean galleries. Bamboos are used to convey and distribute water to irrigate betel leaf and black pepper crops in areacanut orchards or in mixed orchards in the Khasi hills and Jaintia hills in Meghalaya. Water harvesting can be used to minimize water loss and to augment water supplies in watershed systems. Dugout- cum embankment type pond, small earth dams can be used in large scale for water storage in the North Eastern Hills Region. Experiences on water harvesting in dugout-cum-embankment type of pond in hilly region of North East India clearly indicated the feasibility of harvesting runoff from watersheds to an extent of 38 % of monsoon rainfall.

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Technological interventions for natural resource conservation and livelihood improvement of Jhumias in Meghalaya

KP Mohapatra*, Anup Das, RK Singh, NA Desmukh, DJ Rajkhowa, K. Surchand Singh, T Ramesh, G Kadirvel, Satish Chandra, Anirudh Roy, Puran Chandra, Rajappa, JJ and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: kpmbbsr@rediffmail.com

Slash-and burn systems or widely known as Jhum cultivation in India, is an age old agricultural system practiced many parts of the tropics. In original form where very long fallow periods were observed it was never an unsustainable system. In this system the plant nutrients are gradually released into the soil, added from the atmosphere or accumulated in the vegetation and in the soil during the fallow period. After clearing from natural vegetation by slashing and burning the area is cropped for 1 or 2 years and then allowed to revert to natural vegetation. After some years, the area may be cleared and cropped again. It is estimated that fallow lengths of 15-20 years or more are necessary to prevent soil erosion, loss of fertility and loss of water balance, as well as to allow for forest regeneration. These conditions are normally associated with population densities of less than 20 to 30 persons per km^2. However, with reduction in fallow period to less than five years (in many pplaces it has come down to as low as 2 years), the soil does not get sufficient time to recuperate and regain its ability to support vegetation. This leads to accelerated soil erosion and subsequent land degradation. The land degradation affects the livelihood of the Jhumias who are heavily dependent on Jhum cultivation. Many earlier attempts to stop Jhum cultivation through lucrative schemes have not met with much success as Jhum is not only a cultivation practice but a way of life in the tribal culture in the north east. Therefore, the better way would be to improve the Jhum system with respect to its productivity, faster regeneration and rehabilitation, lesser land degradation and increasing the length of cultivability of the land atleast by 1 to 2 years. The way forward therefore would be to manage the fertility of the soil through better management of cropping technology that suits the tribal farmers. Keeping this in view, a project was taken in Sonidan village of Ribhoi district of Meghalaya to improve the Jhum cultivation and the livelihood of Jhumias, the people who practice jhum cultivation. Integrated approach of Jhum improvement was adopted. Soil and water conservation measures, improved varieties, improved nutrition were introduced. For landless farmers, micro enterprises such as mushroom, poultry, honey bee etc were introduced. Improved technology could achieve 25 to 30% increase in food grains production such as in maize, upland rice. The subsidiary interventions for land less farmers could generate Rs 18,000 to 20, 000 to support their livelihood. Soil and water conservation measures could reduce soil loss and run off by 5 times.

Shifting cultivation: population dynamics of Arbuscular Mycorrhizal fungi as influenced by burning practices with a possible approach to remedial measures for improvement

Subrata Nath Bhowmik*, M Datta
ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura, India
*Correspondence: snb70@yahoo.co.in

Introduction

Arbuscular mycorrhizal fungi (AMF) are obligate biotrophic fungi forming symbiotic relationship with the roots of many plants. AM fungi can increase the rate of plant survival; reduce plant stress and increase plant nutrients acquisition, increase carbon and nitrogen deposition into soil (Almas *et al*. 2004). The mycorrhizal colonization and subsequent spore multiplication are solely influenced by edaphic conditions such as soil composition, temperature, pH, moisture, cation exchange capacity (Bagyaraj 1986). However, reports on optimization of AMF population in shifting cultivation (synonymously called *Jhum*) sites thus vulnerable to fluctuations of soil properties due to burning practices and fallow periods are meager. Here we explored correlation of soil nutrients with AMF spore population with a possible approach to remedial measures for improvement.

Methodology

The study sites are located at Nagaland, Assam, Mizoram India. Study sites showing different degrees of fallow periods namely 5 years, 10 years and 20 years were selected for the present study. Sampling was carried out in between February to March 2014. Soil samples were collected from 1sq m grids for five samples each making a composite sample of approx. 200 g. Soil samples were collected at a depth of 0 - 15 cm from thirty points before and two weeks after burning and stored in plastic bags, transported within 24 h to the Laboratory, air dried on an open bench for 72 h, and then stored in a refrigerator until analysis. All analyses were carried out on air-dried soil samples sieved through a 2mm mesh. The oven dry method was used to determine the moisture content of the soil samples. pH was measured by glass electrode and using a suspension of 10 g soil in 25 ml of de-ionized water or 1N KCl solution. Organic carbon was measured by Walkley-Black method. Available nitrogen was estimated by Kjeldahl method using K_2SO_4 and $CuSO_4$ as catalysts. Available phosphorus was measured by the Bray's method. Exchangeable cations were extracted from soil samples with 1N ammonium acetate at pH 7.0 and analyzed using atomic absorption spectroscopy for calcium and flame photometry for potassium. The spore density was measured by Wet-seiving and decanting method (Habte and Osorio 2001).The core experiments had 10 replications, and the results were represented as mean ±SD. The data were analyzed statistically using ANOVA and CD value ($P \leq 0.05$) was analysed using statistical analysis system (SPSS, version 13). To investigate the effect of resident nutrients on growth of AMF sample data of varied *jhum* sites were pooled and regression analysis graph were constructed.

Results and Discussion

The table 1 in general reveals that the nutrients like soil organic carbon (SOC), available nitrogen and available phosphorous have a positive impact on spore multiplication of AMF. The trend of correlation between AMF spore and nutrients is- SOC (0.43) > phosphorous (0.39) > nitrogen (0.27). Soil organic carbon and available nitrogen decreases immediately after burning and are speculated to be the prime factors for limiting of AMF spore multiplication. The negative effect on chemical properties of soil associated with conversion stage is related to organic matter and SOC. However, potassium (-0.47) and calcium (-0.48) are inversely correlated to spore multiplication of AMF. Burning of organic matter increases K, Ca. This is because of release of alkaline cations (K,Ca) bound to the organic matter that on turn increases the pH of burned soils in shifting cultivation land with an obvious decline of AMF spore density.

Table 1. The correlation analysis between AMF spore population and soil nutrients of *Jhum*

	pH	OC (%)	N (kg/h)	P (kg/h)	K (kg/h)	Ca (kg/h)	No. of spores per 100 g soil
pH	1						
OC (%)	-0.101	1					
N(kg/h)	-0.451	0.374	1				
P(kg/h)	-0.284	0.233	0.150	1			
K(kg/h)	0.476	-0.444	-0.280	-0.497	1		
Ca(kg/h)	0.476	-0.261	-0.386	-0.224	0.364	1	
No. of spores per 100 g soil	-0.158	0.428	0.268	0.388	-0.466	-0.479	1

Promoting optimum levels of mycorrhizal development on young, rapidly growing plants is an important challenge in shifting cultivation sites. The effects observed in this work suggest that increment of organic matter in the degraded soils of the *Jhum* can be advantageous to mitigate this constraint. The possible approach to remedial measures for improvement is to drastically check the huge quantum of soil erosion through introduction of vegetative barriers, agro-forestry and improved fallow management systems.

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Effect of altitude and slope on radiation absorption, growth and yield of *jhum*-land rice at Ri-Bhoi district of Meghalaya

US Saikia, T Ramesh, M Lyngdoh, Santanu Das, E Shylla, Arvind Kumar, B Goswami and Suresh Das

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: ussaikia73@gmail.com

Introduction

Northeastern India, includes Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. The region is known for its inaccessible land configuration, fragility, excessive sloping land with rolling topography, rich forest cover, and biotic and abiotic diversity. Due to the undulating topography and high mountains, the net sown area in the region is only 2.82% that of the country. Shifting cultivation or *jhum*—the dominant land-use practice of the hilly part of this region—in its more traditional and cultural integrated form is an ecological and economically viable system of agriculture as long as population densities were low and *jhum* cycles were long enough to maintain soil fertility (Assam Agricultural University 1992). Presently, it is estimated that the number of people practicing shifting cultivation are around 367,000 tribal families in the North East India and the area affected by this practice is 385,400 ha annually (Patiram and Verma 2001). On an average, an area of 3,869 km^2 is put under shifting cultivation every year. Though *jhum* has been recognized with many faults and drawbacks, the international center for Integrated Mountain Development (ICIMOD) recognized *jhum* cultivation as a good practice in terms of farming, forestry, soil and water conservation and bio-diversity management (Kerkhoff and Sharma 2006). Due to lack of any other viable way of livelihood, now policies have got a paradigm shift from *jhum* eradication to *jhum* improvement.

The major crops grown in *jhum* lands are rice, maize, millets, sesame, cotton, ginger, cucumber, pumpkin, bottle gourd, mellon etc. The abandoned *jhum* fallow areas recovers or rejuvenates into secondary forest from copies, underground rhizomes, root and suckers and the soil seed bank in varying span of time. In modern agriculture there is immense need of study of the micro-climate of any crop and develop relationships between micro-climatic variables and crop growth and development parameters. Though these information are readily available in case of settled agriculture but very rare in case of shifting agriculture practiced in sloppy lands. Hence, this study was taken up with respect to upland rice cultivated in *jhum* lands to characterize the micro-climate and their relative impact on realization of economic yield.

Methodology

The study was conducted in Umeit village of Ri-bhoi district of Meghalaya under DST-SERB project 2014-2015 (25◦41'N; 91◦63' E; 980 m above mean sea level). A three dimensional digital elevation map of the experimental area has been presented in Fig 1. The experimental plot has average elevation of 914, 913 and 912 m above msl at top, middle and bottom, respectively, with average slopes of 23.6, 23.4 and 34.6%, respectively, in the same order. The field has the south west (SW) exposure. Upland high yielding rice cultivar Bhalum-3 was direct seeded in lines in the 2nd week of June and harvested in the 3rd week of October. Only external input provided to the soil was FYM @ 5 t/ha, which was applied one day before sowing. Observations were taken for maximum LAI, absorption pattern of photosynthetically active radiation (PAR) at flowering stage, grain, straw and total biological yield and their variation with respect to altitude and slope have been analyzed in RBD. Further analysis was carried out to study influence of plant absorbed PAR and LAI on grain and straw yield of rice.

Results and Discussion

Result obtained from the study indicated that different altitude and slope have influenced the soil nutrient status, maximum LAI, Absorbed PAR (%) and yield of rice. The middle part of the field exhibited higher values of organic carbon and available K, whereas pH and available P were at par with the other two levels of the field. This might be due to lower magnitude of slope in the middle level compared to other two. Among different nutrients, the change in levels of available N was noticeable. The change might have occurred due to plant uptake or washing out down the slope. The top and middle parts of the field lost available N by an average 34 kg/ha, where as the bottom portion gained 68 kg/ha as compared to the available N level before sowing.

With respect to influence of different altitude and slope, no significant influence of them on maximum leaf area index was found (Table 1). The middle portion of the field recorded highest value of maximum LAI (1.99), followed by bottom (1.73) and top (1.47) portions. In response to the LAI values, PAR absorption was found highest in middle portion (84.3%), followed by bottom (74.2%) and top (66.8%). Higher magnitude of radiation absorption might be linked with the higher LAI in the middle and bottom portions of the field. Though LAI did not differ significantly irrespective of slope and altitudes, but the radiation absorption was significantly influenced by the LAI at 5% level of significance. The LAI is always one of the most important yield parameter, which influenced the radiation absorption and there by grain, straw and total biological yields. Significantly higher grain (4.2 t/ha), straw (3.8 t/ha) and total biological yields (8.0 t/ha) were recorded at middle portion of the field, which is at an altitude of 913 m above msl with an average slope of 23.4%.

Table 1. LAI, absorbed PAR and yield of rice at different levels of altitude and slope

Altitude (m), Slope (%)	LAI	Absorbed PAR (%)	Grain yield (t/ha)	Straw Yield (t/ha)	Biological Yield (t/ha)
Top (914, 23.6)	1.47a	66.8c	2.5a	2.8b	5.3b
Middle (913, 23.4)	1.99a	84.3a	4.2c	3.8a	8.0a
Bottom (912, 34.6)	1.73a	74.2b	3.5b	2.4b	5.9b
C.V. (%)	13.4	2.8	4.9	7.1	4.2
LSD ($p<0.05$)	0.53	4.7	0.38	0.49	0.61

Regression equation developed between maximum LAI and absorbed PAR to predict grain yield, which has been given below.

$$\text{Grain yield} = -3.134 + 1.065\,\text{LAI} + 0.842\text{absPAR} \quad (R^2 = 0.97^{**})$$

The equation suggests a very highly significant (P<0.01) relationship among the dependent and independent parameters. This is further asserting the positive relationships of the parameters as found and presented in earlier part of the discussion. Though it is generally advised that cropping should not be done above 15% slope to avoid excessive soil erosion, but in absence of viable alternative people are practicing agriculture in much higher slopes, say 23 to 34%, in this present case. Hence, to draw maximum sustainable benefit out of the available natural resources we need to know the crop response under different levels slope and altitude, particularly in high rainfall *jhum-lands* of the region. The outcomes are likely to contribute to the cause of overall *jhum* improvement program.

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Sustainable rice production in shifting cultivation : a case study

Jayanta Layek*, Anup Das, Ramkrushna GI, Anirudha Roy, Bibhas Verma, AS Panwar and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalay

*Correspondence: jayanta.icar@gmail.com

Introduction

In the hilly tracts of Northeast India, jhuming/shifting cultivation is the dominant economic activity Due to reduction of *jhum* cycle from 20-30 years to 2–3 years (Arunachalam 2002; Borthakur 1992), land degradation, soil erosion and soil fertility depletion is taking place at a massive scale. Rice occupies majority of the area under jhum and entirely rainfed. The resource poor tribal farmers of the North-east India have been deprived of the modern technologies of cultivation including externally managed inputs to augment the low rice production. The low, negligible or no profit associated bush-fallow agriculture or jhum/shifting cultivating is still the only option owing to their socio-economic condition and physiographic location. Growing local varieties, broadcasting seeds in slopy land, no fertilizer or manure application and lack of pest and disease management practices are the major constraints of jhum rice where productivity hardly goes beyond 1 t/ha. Suitable crop establishment method, soil fertility management and suitable rice varieties can ensure sustainable production and incomes of poor and marginal *jhum* farmers.

Materials and methods

A participatory research was conducted in the farmers' *jhum* field of Sonidan village, Ri-Bhoi District, Meghalaya during 2013 to 2015 to identify suitable rice varieties/lines and improved agronomic management practices for improving productivity and sustainable soil health. Five local rice varieties and six improved varieties were evaluated under both farmers' and improved management practices. Under farmer's practice, seeds are broadcasted in the sloping land after spading, no manure/fertilizer are being applied, no pesticide applied and there was no water management practices. However, under improved practice seeds were sown in line across the slope at 25 cm spacing, 50% recommended dose of fertilizers (RDF) @30:30:20 kg N, P_2O_5, K_2O /ha were given. The full dose of P, K and 50% of N was applied at basal, whereas rest 50% of N was applied in two equal splits at 30 and 60 days after sowing (DAS). Two local rice varieties and two improved varieties were evaluated under three different crop establishment techniques. Under farmer's practice, seeds of rice were randomly broadcasted in sloppy land. In dibbling method, farmers made small pit or hole with the help of bamboo dibbler or small spade and then put 5-8 seeds and covered with the soil. However, under improved method of line sowing, small furrow were made across the slope and along the contour at 25cm spacing with the help of manual furrow opener. Nitrogen and phosphorus deficiencies are the most important nutrient disorders in upland conditions. Therefore, application of chemical fertilizers can be a good practice to fulfil the upland rice nutrient requirements provided, the system is economical. In our studies, one local rice varieties and two improved varieties were evaluated under following six different nutrient management practices.

Results and Discussion

Under improved agronomic management practices, both local and high yielding rice varieties performed well. The highest rice yield was obtained under IURON 514 (3.28 t/ha) followed by Bhalum -2 (3.11 t/ha) and RCM -5 (2.96 t/ha). On an average, 65% and 112% yield enhancement was recorded with local and high yielding rice varieties, respectively, when grown under improved agronomic management practices as compared to farmers' practice (control). Sowing in lines 25 cm apart across the slope in *jhum* land as well as dibbling resulted in significant enhancement in rice yield as compared to broadcasting. The highest yield of Mannar and IURON 514 was recorded with line sowing (2.42 and 2.96 t/ha, respectively) as compared to dibbling (2.05 and 2.34 t/ha) and broadcasting (1.60 and 1.71 t/ha). Plant-available nitrogen is likely to be a limiting factor in shifting cultivation as the low temperature thresholds of N causes volatilization and limits the transfer of mineral N from the aboveground biomass to the soil after burning (Romanya´ *et al*. 2001). In our studies, one local rice varieties (Manna) and two improved varieties (Bhalum 1 & IURON 514) were evaluated under six different nutrient management practices. Application of 50% recommended dose of nutrients (RDN) (30:30:20 kg N:P_2O_5:K_2O/ha) either through fertilizer or fertilizer+FYM both recorded 40 to 60% enhancement in rice yield in *jhum* field. Foliar spray of DAP twice at 30 and 60 days after sowing resulted in 20 to 35 % yield enhancement in rice across the varieties as compared to farmers' practice (no manure or fertilizer). In can be concluded that high yielding rice varieties like IURON 514, Bhalum 1, Bhalum 2, RC Maniphou 6, etc. can be successfully grown in jhum field with higher productivity under improved agronomic management practices. Application of minimum amount (50% RDF) fertilizer, spraying of DAP @ 2% at flowering stage and adoption of line sowing across the slopes or dibbling/chutki method in recommended for sustainable yield. Legumes like groundnut, soybean, rice bean etc. and hedge row species (*Tephrosis* sp.) at suitable interval should be grown for reducing soil and nutrient loss, soil fertility build up and improving carrying capacity of the soil.

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Crop diversification: an alternative option for livelihood improvement of Jhumias under Longleng District of Nagaland

Manoj Kumar*, K Lily Rangnamei, P Chowdhury, Patu K Zeliang, KL Meena, Bidyut C Deka, and Rakesh Kumar

Krishi Vigyan Kendra, Longleng, Nagaland
ICAR Research Complex for NEH Region, Nagaland centre, Jharnapani, Nagaland
*Correspondence: mkumar_cprs@yahoo.co.in

Introduction

Rice is most important crop in *Jhum* field of Longleng district of Nagaland. About 12% of the total geographical area of the district is under *Jhum* rice. Mixed cropping is practiced in *Jhum* farming where rice is predominant crop. Rice productivity in *Jhum* is very low (1.6 t) mainly due to poor cultivation practices, no input cultivation, lack of soil and water conservation measures, use of low yielding varieties etc. Rice is cultivated during

February-March to July-August leaving rest of the period of the year as fallow. Whereas the rainfall in the region continues up to the end of October and residual moisture remains in the field till December. Thus there is potential for growing a *pre-rabi* crop for which would increase cropping intensity, per unit productivity and income of the *Jhumias*. Keeping this in mind field crop such as pea, *toria* and vegetable crop such as tomato and cabbage were grown in rice fallow for additional income of the *Jhumias.*

Methodology

Krishi Vigyan Kendra, Longleng is situated at 26° 26' 0'' N Latitude, 94° 52' 0'' E Longitude with altitude of 1366 m MSL. The soil is generally high in soil organic carbon, low to medium in available N and K and low to medium in available P. The study was carried out by Krishi Vigyan Kendra, Longleng during 2013-14 and 2014-2015in 5 different villages in Longleng District covering 20 nos. of farmers. Farmers were from Hukphang, Pongching, Orangkong, Pongo and Yongam villages of the district covering an area of 3 ha during the year 2013-14 and 2 ha in 2014-15.Tomato, pea, cabbage and *toria* were sown as second crop after harvesting of rice. pea and toriawere sown in residual soil moisture whereas tomato and cabbage was given irrigation first one week lifesaving irrigation during entire crop cycle. All the recommended cultural practices for achieving maximum grain yield were followed. Rice equivalent yield (REY) was estimated as per prevailing market price. For comparison among the different cropping sequences the yield of all the crops in the sequences were converted into rice equivalent yield on price basis, productivity in terms of Kg/ha/day was calculated dividing the production of the sequence by 365 days and profitability in terms of Rs./ha./day was obtained by net return of the sequence divided by the total duration of the sequence (Rautaray 2005).The economics and rice equivalent yield were computed at prevailing market price rate during both the year of different commodities. The analysis of variance (Panse and Sukhatme 1978) method was followed to statistically analyze the various data. The significance of different sources of variations was tested by error mean square of Fisher Snedecor's 'F' test at probability level (P= 0.05).

Results and Discussion

From the two years data, result revealed that rice yield was ranges from 1.75 -1.95 q/ha (mean: 1.86 t/ha) at farmers field. From rice crop farmers are getting net return of Rs. 5600/- with benefit cost ratio is 1.37. Mean (2 year) yield of pea, tomato, *toria* and cabbage were recorded 4.5, 16. 62, 0.6 and 20.3 t/ha respectively. Das *et al*. (2010) also reported that cabbage and tomato were recorded maximum yield in rice fallow. After introduction of second crop at farmers field, Rice Equivalent Yield (REY) of pea, tomato, *toria*, and cabbage were recorded 9.25, 26.9, 3.58 and 30.63 t/ha respectively (Table 1). System productivity in terms of REY was recorded 11.2, 28.72, 5.33, and 32.5 t/ha under rice-pea, rice-tomato and rice-*toria* and rice-cabbage sequences respectively. Maximum production efficiency (kg/ha/day) and economic efficiency (Rs./ha/day) were recorded 83.91 and 687 in the rice-cabbage cropping sequence followed by rice-tomato (73.66, 582.71) compared to other cropping sequences.

Table 1. Productivity of main and component crop, Rice equivalent yield (REY) and Economics of different cropping sequences

Cropping sequence	Main crop (Rice) Yield (t/ha)	2nd crop yield (t/ha)	REY (t/ha)	System yield in terms of REY(t/ha)	*PE (Kg/ha/day)	**SP (Rs/ha/day)	Net return (Rs/ha)	B:C
Rice-pea	1.95	4.5	9.25	11.20	25.34	176.58	64450	2.33
Rice-toria	1.75	0.6	3.58	5.33	9.81	42.74	15600	1.50
Rice-tomato	1.83	16.6	26.9	28.72	73.66	582.71	212690	2.94
Rice - cabbage	1.87	20.3	30.63	32.5	83.91	687.00	250754	3.14
CD($P=0.05$)	NS	0.96	0.65	0.86	7.0	14.9	-	-

*Production efficiency (PE), **System profitability(SP)

Net return was recorded Rs. 250754, 212690, 15600 and 64450 with B:C ratio was 3.22, 2.81,1.39 and 3.70 in rice-cabbage, rice-tomato, rice-pea, and rice- *toria* respectively under different crop sequences. Maximum system profitability was also recorded 687 Rs./ha/day in rice-cabbage followed by rice tomato (582.7 Rs./ha/day) than other sequences. This might be due to maximum yield was recorded of cabbage and tomato. From the data it was observed that farmers get more profit when the cabbage was taken as second crop after rice and it was followed by rice-tomato. Manoj *et al*., 2014 also reported that rice -cabbage /rice-tomato recorded maximum productivity and profitability compared to other rice based cropping sequences.

Therefore, it could be concluded that vegetable crop such as cabbage and tomato is an option for growing in residual soil moisture just after harvesting of rice for getting additional income of the farmers for their livelihood improvement.

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Varietal performance of transplanted rapeseed and mustard in hilly tract of Tripura

Md Hedayetullah[1], U Giri[2], D Saha[2], A Saha[2] and D Sen[2]

[1]*Bidhan Chandra Krishi Viswavidyalaya, Kalyani Nadia, West Bengal*

[2]*College of Agriculture, Tripura, Lembucherra, West Tripura*

*Correspondence: hedaye.bckv@gmail.com

Introduction

Rapeseed and mustard is an important oil seed crop in India next to groundnut. Transplanted mustard gives more yield compared to the direct seeded mustard and also crop can be harvested one week earlier. The total crop duration including nursery no extra time is required. It is advantageous to the farmers who take second crop as mustard just after harvesting of paddy or others *kharif* crops. Farmers can adopt this method to take a second crops where time is limited for sowing mustard to compensate 12-15 days nursery time period. Therefore, our objective of this current study was to assess the yield performance and early harvest of five mustard cultivars under acidic soil condition in hilly tract of Tripura.

Methodology

An experiment was conducted at the Crop Museum Farm, College of Agriculture, Tripura during the period from November 2014 to March 2015 to study the effect of varietal performance of transplanted mustard under acidic condition. The treatments included five varieties viz. Jhumka, B-9, Bhabani, PPS-1 and Pitambari. The experiment was laid out in a Randomized Block Design with four replications. Plant samples were collected at an interval of 30 days after sowing from three randomly selected locations in each. Ten plant samples were uprooted randomly from each plot under different treatments to determine the growth attributes like plant height and dry matter accumulation per plant and yield attributes like no of siliqua per plant, length of siliqua, no of seeds per siliqua and seed yield. Similarly, 10 plants from each plot were randomly selected. The plant height was recorded from the base above the ground to the tip of the stem using a scale. The total number of filled siliqua per plant was recorded at harvest, while the total number of seeds per siliqua was recorded by randomly selecting10 siliqua from each plant per plot at harvest. The seed grain yield of each 1 m×1 m plot segmented from the 5 m×5 m plot was recorded by harvesting plants, followed by sun-drying, threshing and cleaning on the threshing floor. The seed yield was recorded in q ha^{-1}. For interpreting the effect of different treatments under different cases, for comparison of F values and at 5% level of Significance, Fisher and Yates Table were followed.

Results and Discussion

The highest plant height (137 cm) was observed in Jhumka treatment at harvest stage followed by PPS-1 treatment. The maximum dry matter accumulation (34.63 g) per plant was obtained in PPS-1 variety followed by pitambari variety. Lipu *et al* (2013) also reported that the similar trend of growth attributes. The maximum number (334 nos.) of siliqua per plant was observed in Bhabani variety but length of siliqua was measured less (5.95 cm) compared to others treatment.

Table 1. Effect of rapeseed and mustard varieties on yield attributes at harvest stage

Treatments	No of siliqua $plant^{-1}$	Length of siliqua (cm)	No of seeds $siliqua^{-1}$	Seed yield kg ha^{-1}
Jhumka	166.40	6.40	17.00	469
B-9	164.50	6.95	15.25	532
Bhabani	334.00	5.95	17.83	508
PPS-1	139.00	6.60	19.88	668
Pitambari	132.75	7.70	27.63	523
CD (5%)	**28.32**	**0.93**	**3.77**	**104**

The maximum number of seeds per siliqua (27.63 nos) was obtained in Pitambari treatment where lowest was observed in B-9 variety. The maximum seed yield (668 kg ha^{-1}) was obtained PPS-1 variety and lowest yield (469 kg ha^{-1}) was obtained in Jhumka variety (Table 1). The similar results were also found by Alam and Rahman (2006) and Mamun (2005). Our present investigation revealed that the best variety of the five mustard varieties under the acidic hilly soil was PPS-1 based on attributes of growth, morphophysiology and yield.

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Post forest fire soil management options in hill agroecosystem of North Eastern India

Prabha Moirangthem*****, S Hazarika, BC Verma, Manoj Kumar, Ramesh T and SV Ngachan
ICAR Research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: prabsmoirang@gmail.com

Introduction

Since time immemorial, forests have been an integral part of human ecosystem, playing a vital role in stabilizing the hydrology regulating stream flows, protect land from erosion, reduce flooding in adjacent areas and reduce siltation. However, forest wildfires along with deforestation and the consequent land degradation associated therewith may disturb this balance. Every year the world including India faces forest fires affecting million of hectares of forest leading hampering biodiversity, ecosystem functioning and landscape stability. The number and severity of wildfires has increased during the past decade and the rise is likely to continue, owing to shifting cultivation practiced in some part of the country, and other effects of changing climate. Erratic rainfall, extensive dry spells during winters, early summers and decrease in annual rainfall in recent past due to climate change has increased incidence of forest fires. Forest Fire: NE Scenario: The major cause of forest fire in the NE region pertains to the slash and burn shifting cultivation/Jhum. Nationally, an estimated 4.35 million ha is affected by fire as part of shifting cultivation which is especially significant with the growth of population and decrease in the land and person ratio, with decrease fallow period for regeneration from the initial 30 years to two years (Chandra *et al*. 2015).

Table 1. Forest Fire Incidences in North Eastern States during 2008-2014 (India State of Forest Report)

State	2008-09	2009-10	2010-11	2011-12	2012-13	2013-2014
Arunachal Pradesh	786	576	485	560	501	535
Assam	1901	2511	1322	2172	1608	2536
Manipur	1477	2487	1275	1507	1303	1774
Meghalaya	1010	1743	879	911	804	1123
Mizoram	3434	4675	1691	2218	2259	2189
Nagaland	984	1654	780	927	846	886
Sikkim	1	5	1	3	0	0
Tripura	717	1127	634	1233	588	1160
Total	10310	14778	7067	9531	7909	10203

Impact of Forest Fire on Soil: The adage *"Fire is a good servant but a bad master"* is equally valid for forest fire too. Limited and controlled forest fires are known to be useful. However, uncontrolled forest fire may destroy forest. Nearly 37.1% of the total geographical area in Northeast India is under the threat of land degradation, erosion being the major cause. Studies on steep slopes (44–53%) have indicated the soil loss to the tune of 40.9 t/ha and the corresponding nutrient losses per hectare are 702.9 kg of organic carbon, 63.5 kg of P and 5.9 kg of K. In general, tolerable soil loss (*T*) value is 11.2Mg/ha/yr. According to one estimate annual loss of top soil, N,P and K is 88346, 10669, 0.372, and 6051 thousand tones in the region (Chandra *et al*. 2015). The combination of rain splash and overland flow on soils with reduced aggregate stability and low surface cover can increase soil erosion rates by manifold over background levels (DeGomez 2011; Robichaud *et al*. 2013). Soil heating changes its properties resulting in a massive volatilization of simple nitrogenous compounds, mainly nitrate and ammonium and to some extent sulphur, phosphorus, and other ions (FFDM Series-1, 2012), changes in soil colour, texture, pH, bulk density, and water holding capacity, significantly altering microbes that affect large-scale processes such as nutrient cycling (Chandra *et al*. 2015). Management Options: Few strategies which may find suitable for different land situation, elevation, and topography prevailing in this region, are

Short term strategies

a)*Seeding and fertilization:* The first step and the most common practice is reseeding grass in the severely burned areas. It has been regarded as the most cost-effective method to promote rapid infiltration of water, keep soil on hillsopes. Generally, fast-growing non-native grass species are used owing to low cost and readily availability. Application of chemical fertilizer has occasionally been reported to enhance the growth. ***b)*** *Erosion Barrier treatment:*

These are designed to slow runoff, create localized ponds, increase infiltration, and store eroded sediment. Common barriers include contour-felled logs, straw wattles, contour trenches, and straw bales; *c) Mulching:* Mulching after wildfires is a common and most effective treatment designed to protect bare ground from raindrop impact and reduce post-fire increases in runoff and erosion rates. Rice or cereal straw is most commonly applied to hillsopes. Use of only weed-free hay straw is recommended. Short-term studies have reported reductions in erosion rates of 48 to 99% in the first two post-fire years, with the greatest reductions obtained when the wheat straw mulch provided 70% or more ground cover; *d) Hydromulch:* Combinations of short fibers etc., tackifier, suspension agent, seed, and/or fertilizer that are mixed with water to form slurry and dry mulches made from forest materials, have been developed, tested as post-fire hillsope treatments. These structures are wind-resistant—a desirable characteristic for use on exposed hillsopes (Robichaud *et al*. 2013); *e) Sediment Barriers:* these include *Silt Fence and Contour log terraces.* Silt fences are made of woven wire and a fabric filter cloth trapping sediment from runoff and are not suitable for concentrated flows occurring in small rills or gullies while contour log terraces provide a barrier to runoff from heavy rainstorms. Dead trees are felled, limbed, and placed on the contour perpendicular to the direction of the slope. Logs are placed in an alternating fashion so the runoff no longer has a straight down slope path to follow; *f) Straw wattles:* these consist of straw, coconut fibers, mulch or other similar materials bound into a tight tubular roll of natural or degradable synthetic containment mesh. These are used along burned slopes vulnerable to erosion and are anchored onto the slope along the contour, perpendicular to the flow of water; *g) Water bars and culverts:* The two most common structures to channelize runoff are culverts and water bars. Water bars are berms of soil or bedded logs that channel water off roads and trails to avoid the creation of gullies and can be diverted to culverts which must be installed properly at the correct locations.

Long term strategies

a)Multipurpose Trees: With greater surface cover, constant leaf litter fall, and extensive root system increased soil organic C by 96.2%, porosity by 10.9%, aggregate stability by 24.0%, and available soil moisture by 33.2% ,reduced bulk density and erosion ratio by 15.9 and 39.5%, respectively. *P. kesiya, M. oblonga* and *Alnus nepalensis* were found suitable as bioameliorant in this region; *b) Agro forestry Interventions:* Effect of various AFS like silvi-pastoral, silvi-horticulture, agri-horti-silvipastoral has been reported to show positive response on soil fertility indices. Data indicated that mixed land use systems with appropriate soil conservation measures, namely, bench terraces, contour trenches, and so forth, were the most effective in retaining 90–100% annual rainfall; *c) Resource Conservation Techniques:* conservation tillage, *In-Situ* residue management, zero tillage, Pasture Development, organic farming etc. are proved to increase the soil health (Saha *et al*. 2012). Mechanical soil and water conservation measures along with resource conservation practices are required for controlling soil erosion, retaining maximum rainfall within the slope and safe disposal of excess runoff from the top to the foot hills.

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Performance of different local rice cultivars under upland rainfed condition of Nagaland

T Gohain and Sentirenla Changkija

School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland
Correspondence: tankeswar1968@gmail.com

Introduction

In India, rice (*Oryza sativa* L.) is being cultivated in more than 42 million ha and occupies 23.3% of gross cropped area of the country. The population of India is still growing by two million every year and may increase by another 30 million over the next 20 years. On the other hand, rice area is decreasing day by day due to high population pressure. Therefore, attempts should be taken to increase the yield per unit area through use of comparatively better performing varieties along with judicial fertilizer management. Upland rice is typically grown without fertilization in slash-and-burn systems in the mountainous region of Northeastern India by resource-poor farmers for subsistence.

The North Eastern region is also home to a large number of aromatic and quality rice varieties. In fact, the whole region is considered as a veritable treasure trove of different land races of rice. Traditional varieties though low in production, it is still favored by farmers in many regions of the world because they are better adapted to local field condition and they adapt to the changing environment and farming practices of the particular area. In Nagaland rice is the primary food crop and is cultivated in an area of 18.33 thousand hectares producing 40.51thousand tonnes with a productivity of only 2.21 t ha^{-1} (Anonymous 2013). The production is often low due to lack of knowledge about the management practices. Since variety is an important parameter for yield exploitation and, an adequate and balance supply of plant nutrients is a prerequisite to maximize crop production, these two factors assume great significant for crop production. Keeping in view 150 local rice cultivars from throughout Nagaland state had been collected under UGC major research project and most promising cultivars are growing under scientific management practices and finally most promising cultivars will be tested for fertilizer responsiveness.

Methodology

The investigation was conducted during the *kharif* -2013 in the experiment farm of Department of Agronomy, SASRD, Medziphema to study the "Performance of local rice cultivars under upland rainfed condition of Nagaland". The soil of experimental field was sandy loam and well drained. The experiment was conducted in Randomized Block Design with three equal blocks and each block was divided into ten equal plots of 4m × 3m size, consisting of 30 plots in total. Ten rice cultivars *viz.*, V1- SARS 1, V2- SARS 2, V3- SARS 4, V4- SARS 5, V5- SARS 41, V6- SARS 48, V7- SARS 49, V8- Naga special, V9- Manipur special and V10- Inglongkiri were sown on 16th June, 2013. The seed rate of 80 kg ha^{-1} was used and seeds were treated with Malathion powder @ 12 g plot^{-1} for controlling insect pests. The observations were recorded on randomly selected 5 samples and their mean was taken for analysis at 15, 30, 45 and 60 DAS. Observations to be recorded under growth parameters included plant height and number of tillers m^{-2} and under yield attributes number of panicles m^{-2}, length of panicle (cm), number of grains per panicle, test weight (g), grain yield (q ha^{-1}), straw yield (q ha^{-1}), and harvest index (%) were recorded. Crop was harvested at physiological maturity, threshed and plot-wise yields were recorded.

Results and Discussion

Rice cultivar 'SARS 49 recorded significantly highest plant height (141.22 cm) and the shortest was recorded in the cultivar Naga special (101.44 cm). The highest number of tillers was recorded in 'SARS 49' (575) and the lowest in'SARS 48' (200). The performance of different rice cultivars on length of panicle (cm) was found to be statistically significant (Table 1). Cultivar 'SARS 41' recorded the highest panicle length (29.83 cm) and the lowest (22.10 cm) was recorded with Naga special. Results revealed non-significant variation regarding the panicle weight among the different local rice cultivars. The local rice cultivars however, showed significant variation regarding the number of grains per panicle. The highest number of grains per panicle (328) was observed with 'SARS 41' which was followed by 'SARS 4' (301), 'SARS 5' (279), SARS 49 (236) and SARS 48 (234) respectively and the lowest with Inglongkiri (109). The test weight was found to be significant with the different rice cultivars. The highest test weight (30.37 g) was observed with 'SARS 1' which was followed by Inglongkiri (26.23 g) and the lowest (15.44 g) in 'SARS 41'. Standard rice cultivars showed significant variation among them in respect to grain yield. The highest grain yield (22.20 q ha^{-1}) was recorded with the cultivar 'SARS 41' which was at par with 'SARS 4' (21.47 q ha^{-1}) and 'SARS 41' (20.00 q ha^{-1}) respectively and the lowest grain yield (9.67 q ha^{-1}) was recorded with 'SARS 2'.

The performance of different local rice cultivars was found to have a non-significant variation between them. The highest biological yield was recorded with the cultivar SARS 41(96.40 q ha^{-1}), followed by cultivar 'SARS 48' (90.36 q ha^{-1}) and the lowest (41.56 q ha^{-1}) was recorded with cultivar Naga special. Results revealed that the harvest index among the different local rice cultivars was found to have non-significant variation. The highest harvest index (32.76 %) was recorded in cultivar 'SARS 5' while the lowest harvest index (15.61%) was recorded in cultivar 'SARS 2'.Enhanced yield under aerobic culture with a suitable cultivar was owing to the fact that production of significantly more productive tillers lead to accumulation of more photosynthates, resulting in higher grain yield of rice under aerobic culture. Performance of different cultivars under upland condition with variation in yield was reported by Bouman *et al*. (2005) using different N levels, which was due to enhanced stature of yield attributes, forming larger sink size coupled with efficient translocation of photosynthates to the sink.

Table 1. Growth and yield attributing characters of different local rice cultivars under upland condition

Rice cultivars	Plant height at harvest (cm)	Tillers m^{-2} (60DAS)	Length of panicle (cm)	Grains per panicle	Test weight (g)	Grain yield (q ha^{-1})	Harvest index (%)
V1-SARS 1	120.77	316.75	28.26	186	30.37	17.77	20.47
V2-SARS 2	126.55	408.25	27.00	172	23.56	9.67	15.61
V3-SARS 4	118.44	441.75	26.40	301	22.71	21.47	25.48
V4-SARS 5	135.44	225.00	28.10	279	16.11	17.40	32.76
V5-SARS 41	137.33	358.25	29.83	328	15.44	22.20	23.79
V6-SARS 48	133.77	200.00	28.13	234	19.75	20.00	27.70
V7-SARS 49	141.22	575.00	28.70	236	19.42	16.67	18.27
V8-Naga special	101.44	350.00	22.10	160	23.03	13.67	22.85
V9-Manipur special	123.66	350.00	25.20	180	19.75	11.83	23.47
V10-Inglongkiri	108.33	441.75	25.37	109	26.23	13.33	24.35
SEm±	6.98	14.60	1.41	24.70	2.25	2.17	4.26
CD (P=0.05)	20.76	NS	4.18	73.38	6.68	6.45	NS

SARS-State Agricultural Research Station, Nagaland. SARS-1:Sungmangtsuk, SARS-2:Longkumtsuk, SARS-4: Tangmotsuk, SARS-5:Manen, SARS-41:Shiko, SARS-48:Mange, SARS-49:Tangakezeie

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Farm Mechanization and Secondary Agriculture

- Mechanization for hills and small holders
- Processing and value addition
- Energy management in agriculture
- Entrepreneurship development

Status and scope of secondary agriculture for livelihood improvement in NEH region of India

RK Singh*, Arvind Kumar and SV Ngachan
ICAR Research Complex for NEH Region, Umiam, Meghalaya
**Correspondence: rksinghars@gmail.com*

Introduction

Postharvest processing, generally termed as secondary agriculture, creates facilities for primary processing and adds value to the basic agro commodities which gives opportunity to the farmers to get better returns from their harvest. The need for development of secondary agriculture has been mainly due to consumers demand for value added products like ready-to-eat, ready-to-serve, convenience food and functional food in the market. Easy availability of processed food items to the consumers through organized retailers has further encouraged secondary agriculture sector. Therefore, the demand of consumers creating market opportunities for endproducts of primary agriculture has driven the need for growth of secondary sector.

Consumption pattern and preference for value added products

Due to modernization and awareness programmes, the consumption pattern of the consumers is changing towards high value processed products. As per the NSSO data the chicken consumption has increased by 400 per cent followed by eggs (108 per cent), banana (57 per cent), vegetables (45 per cent), apple (43 per cent), mango (44 per cent), fish (32 per cent) and milk (7 per cent). On the other hand consumption of all the cereals had gone down by 14 per cent during the same period (Government of India 2011). In India, only around 8 per cent of the country's total agricultural produce is processed for value addition. The highest value addition is seen in milk (35 per cent) followed by marine (26 per cent), poultry (6 per cent) and fruits and vegetables (2.2 per cent). The low level of value addition may be due to non-availability of raw material suitable for processing, seasonal production, lack of adequate post-harvest infrastructure such as processing, cold chain, transportation and proper storage facilities.

Sufficient production of raw materials in primary sector

India ranks first in world for millets and pulses production and second in world production of both rice and wheat second in oil seeds. Growth in registered Food Processing Industry (FPI) is high at 13.2 per cent per annum than unregistered FPI (1.5 per cent). This indicates that the industry is responding to the market demand and coming up in a big way. The assessment of harvest and post-harvest losses conducted by Central Institute for Postharvest Engineering and Technology (CIPHET) in 2010 indicates that cumulative loss is highest in fruits (6-18%) followed by vegetables (6-12.5%), cereals (4.3-6.1%), pulses (4.3-6.1%), oilseeds (6.0%), poultry (3.7%), fish (2.9%), and meat (2.3%) (Government of India 2011). These losses can be minimised by creating effective value chain through increased participation of the organised sector.

Rural entrepreneurship – an effective linkage between primary and secondary agriculture

Seed production and processing can be taken at a decentralised level, making use of technical backup of research institutes, universities and private companies. The seed cluster concept that has emerged in Hyderabad, Bangalore, Nashik and Terai regions can be replicated in the north-eastern regions also. Mechanisation is an essential component and can help in moving the human resource dependent on primary agriculture to other profitable sectors. Some studies have indicated that in the recent years, the farm labour availability has come down due to its absorption in public sector employment generation programmes like MGNREGS and migration to other sectors. There is scope of shifting the excess labour in the 'primary agriculture' to 'secondary agriculture' profitably with proper capacity building. The falling labour productivity can also be tackled through selective mechanisation. The location of food processing industries in rural areas can contribute to the utilization of local production and reduce the lengthy supply chain by establishing direct linkage with producers. This can result in greater price realisation for producers on the one hand and cheaper raw material to the processors on the other.

Opportunities of secondary agriculture in the NEH Region

Postharvest losses of food grains in this region are higher than other parts of the country. There are good prospects of processing agricultural produce and by-products in the production catchments of this region using improved post-harvest techniques. This will ensure loss reduction, add value to farm produce, maintain better quality and employment generation, which in turn will contribute to enhancement of skill of rural entrepreneurs and workers. The quantum of loss has been according to a study conducted by Deka *et al.* 2004 (Table 1&2) is presented below.

Table 1. Post-harvest losses of some horticultural produce

Crop	Post-harvest loss (%)	Approximate monetary loss/ year (Rs. in crores)
Banana	22.00	128.34
Orange	13.95	4.33
Pineapple	9.25	19.33
Cauliflower	15.75	11.03
Tomato	25.25	41.99
Ginger	10.50	11.66

A large quantity of fruits and vegetables (10-25 per cent annually) gets damaged during the process of handling, transportation and marketing. The highest monetary loss is recorded in banana and lowest in oranges (Table 1). This has reflected the drainage of hard earned revenues.

Table 2. Post-harvest losses (%) of horticultural crops at various stages of handling

Crop	Harvesting	Grading	Transportation	Marketing/Storage		Total loss
				Wholesaler	Retailer	
Orange	3.25	0.75	1.25	1.20	7.50	13.95
Pineapple	1.73	0.54	1.95	2.66	2.37	9.25
Banana	Nil	Nil	10.00	5.00	7.00	22.00
Ginger	1.5	2.25	1.50	2.75	2.50	10.50
Tomato	0.75	3.75	11.00	2.50	7.25	25.25
Cauliflower	Nil	2.75	7.50	1.75	3.75	15.75
Spine Gourd	Nil	8.30	4.30	1.80	2.70	17.10
Pointed Gourd	Nil	5.40	7.50	1.90	2.10	16.90

(Source: Deka *et al.* 2004)

The post-harvest losses vary from crop to crop and stages of post-harvest handling (Table 2). The maximum post-harvest losses were recorded during transportation and marketing of tomato and banana.

The shelf life of Khasi mandarin fruits can be increased by harvesting at optimum maturity and treating with stay-fresh wax. Pineapple harvested at appropriate stage and wrapped with shrinkable polyethylene remains fresh for longer duration. Most of the Banana ripens in three to five days after harvesting. To delay the ripening of fruits vacuum packaging or cold room (12^0 C) storage may be adopted. A number of value added products from jackfruits such as powder, pickle, nectar, jelly, canned bulbs, leather etc. can be prepared. The shelf-life of passion fruits can be extended by treating with liquid paraffin wax and packing in corrugated fiber board (CFB) boxes using high-density polyethylene pad. The passion fruit is preserved either by heat processing or freezing. The fruits can be processed to prepare several products like juice, squash, cordial, nectar, juice concentrate, carbonated beverages etc. The weight loss of ginger rhizomes can be minimized by waxing. The ginger slices of 3-4 mm thickness can be preserved for 8-9 months in acidified brine solution without any deterioration. Several value added products like ginger candy, powder, paste, oil, oleoresin etc can be prepared from ginger. Soybean is a legume crop of short duration and miracle food cultivated extensively in all the uplands in India including the hilly areas. It provides energy, protein, oil and milk products and fodder in addition to enriching the soil. Techniques have been developed for processing raw soybean in to various value added food products such as soy milk, soy paneer (tofu), soy fortified biscuits, roasted soy nut etc. All these value added products can be prepared at home scale level.

Scope of food processing industry in the North Eastern Region

Agricultural and horticultural produce based Food Processing Industries can help in reducing post harvest losses and generating employment, especially in rural areas. At present, the industry accounts for nearly 19% of total industrial outputs, generates 18% of industrial GDP and employs 19% of the industrial labour force. Due to cultivation of a wide variety of fruits and vegetables there has been more emphasis on food processing industries in the northeast region. A number of food processing units have come up in recent past and likely to grow more in near future. There also exists scope for production and processing of organic food (dried fruits and nuts, processed fruits and vegetables, spices, herbs, oil crops and derived products etc.) and non-food items such as cut flowers and pot plants having global market.

Human resource development for boosting Secondary Agriculture sector

Agriculture extension service received a greater attention in the 1960s and 1970s in India but during the last 10 years it is on the decline. A decade after the end of the Training and Visit (T&V) System, the Department of Agriculture, the main extension agency, is looking for afresh model, direction and approach. At the same time, the nature of Indian agriculture is becoming more and more complex. New opportunities (and threats) for trade in international markets join older concerns of supporting the rural economy where agricultural production and employment support the livelihoods of many of the poorest in the society. The extension agencies and staff should be trained in new extension methods, developing educational materials using electronic technology including Geographic Information System (GIS).

Due to agro-climatic condition and lack of appropriate post-harvest processing facilities in the NEH region the post-harvest losses are more and farmers are not getting the proper return. Secondary agriculture can help in increasing the share of agriculture in the national GDP. The Government is making all out efforts to increase the level of processing from 8% to 20% and share of global trade from 1.5% to 3% by 2015. Processing and value additions to fruits, vegetables and cereals will not only reduce their post-harvest losses of 18, 12 and 6%, respectively but also can provide better livelihood to 52% of workforce engaged in agriculture sector. Thus, secondary agriculture is a viable option for nutritional and livelihood security of the people of the NEH region.

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Pollination an essential component of sustainable hill agriculture

RK Thakur[1*] and AK Singh[2]
IARI, Pusa New Delhi
*Correspondence: rkt_apic@rediffmail.com

Introduction

Pollination is one of the most essential ecosystem services effectual for crop productivity and human livelihoods. Pollination, the process of transferring pollens from anther to stigma for plant reproduction, has direct impact on crop productivity. Conservation and management of pollinators is still ignored in the agriculture development program by the policy makers. Extinct of existing diversity may have adverse impact on agro-ecosystem and so also sustainable agriculture development. In agricultural ecosystem, many agricultural crops are dependent on insects for their pollination, and assisted pollination may have to be done when natural pollination is insufficient in order to reduce potential yield loss. About 80% of the world's flowering plant species are dedicated on animal pollination, mostly by insect (FA0 2007). The United Nations reported on the economics of ecosystems and biodiversity that insect pollination was valued at £134 billion. Amongst insects, undoubtedly honey bees are ultimate pollinators because they are active the whole year for pollination; do not hibernate, works longer periods daily than other pollinators, number of worker bees per colony is also higher than the other insects, dense hairs on the corbicula for carrying abundant pollens and their average foraging rate and meticulous handling of flowers are much advance than other pollinators. Bees are dominant pollinators in tropical region because their food sources are totally dependent upon flower (Michner 2007). *Apis* spp. have been considered to be most effectual pollinator for many plant species but unfortunately they are drastically declining due to CCD (colony collapse disorder) causing global concern for pollination services. The extent of our reliance on single species for such an important service is risky. In the contrast of sole species of honey bee, there are at least 17000 species of native and wild bees worldwide (Michener 2007).

Insect pollinators and sustainable agriculture

The knowledge of the biology and ecology of insect pollinators, as well as providing appropriate nesting habitat, and ensuring the availability of alternative forage sources or artificial feeding to sustain populations during dearth period are key factors to sustain pollinators. It involves the process of securing pollinators effectively to agricultural pollination through the conservation and augmentation support of wild pollinators. At the global level, the Convention on Biological Diversity has identified the importance of pollinators with the establishment of the International Initiative for the Conservation and Sustainable Use of Pollinators (International Pollinators Initiative-IPI) in 2000, facilitated and coordinated by FAO. Encouragement of wild pollinators, domestication of unused potential pollinators and more environmentally sensitive human exploitation of the world are needed as part of conservation, forestry, agro forestry, sustainable agriculture and development. Evidently, the need for insect pollination has made the bees a vital component in crop production technologies and sustainable development of agriculture. As wild ecosystems are increasingly converted to more human dominated uses to meet the compelling demands of food security, it is critical for us to understand what pollination services are most important for food security and how we can meticulously execute pollinator services in sustainable farming systems. For improved awareness among mankind community, vibrant programs are required to urge the policy-makers, researchers, extension workers, farmers, etc.

Insect pollinators essential for biodiversity

The alarming decline of health and population of pollinators have a significant threat to the integrity of biodiversity. About 75% of genetically bio-diverse agricultural crops have been lost since the beginning of 20th century from the earth and 25% of the world species were endangered in 1980 and which will be extinct by 2015 (FAO 1993).

An estimated 62% of the flowering plants may be suffering with reduced regeneration from seeds as a result of pollinator scarcity. The number of commercially managed bee colonies in US has declined from 5.9 million in 1940 to 4.3 million in 1985 and 2.7 million in 1995 (Maheshwari 2003). Although more than 750,000 insect pollinators have been described (Grimaldi and Engel 2005), possibly as many as 30 million more await discovery and formal description (Erwin 2004). The major pollinators belong to the order Hymenoptera and out of this, majority belongs to Apidae family. Other animals such as bats, birds, butterflies, moths, flies and beetles also play key roles in pollination. The diversity of pollinators and pollination systems are conspicuous. Most of the 25,000–30,000 species of bees (Hymenoptera: Apidae) are effective pollinators, and together with moths, flies, wasps, beetles and butterflies, make up the majority of pollinating species. Vertebrate pollinators include bats, non-flying mammals (several species of monkey, rodents, lemur and tree squirrels etc.) and birds (hummingbirds, sunbirds, honeycreepers and some parrot species) (Abrol 2012). More diverse communities of pollinators in agricultural systems also have greater total abundances and rates of visitation to crop flowers (Chacoff and Aizen 2006). Out of 100 principal crops of the world which are the main source of food, only 15% are pollinated by domestic bees (mostly honey bees, bumble bees and alfalfa leafcutter bees), while at least 80% are pollinated by wild bees and other wildlife, although wild bees have generally shown a decline in trend of diversity, abundance and services with agricultural intensification (Tscharntke *et al*. 2005). The 25,000 different bee species, size and habit significantly differ from each other and differ accordingly in the plants they visit and pollinate, however the co- evolution of pollinators also depends upon the related fauna.

How to overcome

- Plant- pollinator relationships should be understood as an ecosystem service for sustainable agriculture. This includes a concerted plan to overcome the taxonomic impediment.
- Conservation of natural ecosystem/ buffer zone as a congenial niche for pollinators to optimize pollinator services in agro ecosystems. Particular attention should be paid to protection of appropriate nesting sites.
- Judicious use of agro-chemicals; if it is necessary than select safer chemicals but application should be avoided in blooming period and it may be applied at evening time when pollinator activity becomes lower or near to cessation.
- Farming practices; minimum admissible tillage of soils will assist pollinator populations.
- Negative impacts on pollinators caused by human interventions should be minimized; this includes use of agrochemicals, and disturbance of habitat and niche.
- Pollinators congenial farming practices should promote to conserve its abundance and diversity

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Growing Dendrobium is remunerative in lower altitudes of hills

D Barman*, Rajkumar and DR Singh
ICAR-National Research Centre for Orchids, Pakyong, Sikkim
*Correspondence: dbarmannrco@gmail.com

Dendrobium is one of the leading cut flower as well as flowering potted plants among orchids, due to their magnificent flowers of great delicacy and beauty, wide range in flower colour, size and shape, year round availability and long vase life. It was reported that the genus has about 1100 species and numerous hybrids and more reporting year after year. The leading countries USA, Netherlands, Thailand, Malaysia, Philippines etc. are the major producer of Dendrobium in the world. In India, there are 116 species of Dendrobiums are available of which majority are found in North East. In our country, Dendrobium hybrids are commercially grown in South India mainly Karnataka, Kerala, Tamil Nadu and some parts of Maharashtra. They can be easily grown in the temperature ranges between 15^0C to 30^0C; with light intensity of 2500 to 3000 foot candle for a period of 12 to 15 hours every day and 50 to 90% humidity year round. In hills, Dendrobiums can be grown to produce a year round cut flower in the lower altitudes where favourable climatic prevails. As Cymbidium flowers in the winter season during November to March and those of Dendrobiums flowers from May to November. So as to fulfil the gap between the rest periods of Cymbidium some of the important hybrids of dendrobiums can be cultivated in this region. Growing of Dendrobiums in the hills is found successful with the evaluation of sixteen Dendrobium hybrids viz. Bangkok Blue, Madam Pink, Earsakul, Lervia, Madam Pompadour, Triple Pink, Emma White, Thongchai Gold, Big White 4N, Big White Jumbo, Dang Saard, Erika, July and Kating Dang, Fatima and Channel in three locations of Sikkim viz. Pakyong (1400 msl), Ranipool (1000 msl) and Jorethang (500 msl). The study reveals that most of the hybrids produce flowers after 2.5 years at all places. However the maximum production was recorded from lower altitude. The production is less as compared to other Dendrobium producing area. However the qualities of flowers are far better in hills. It could be concluded that hybrids of Dendrobium, a warm loving orchid can be grown successfully at lower altitude of hills as commercial flower where Cymbidium cannot be cultivated.

Farm mechanization in hill and small landholders: issues, opportunities and challenges

Amaresh Sarkar*
College of Agriculture Tripura, Lembucherra, Agartala, Tripura
*Correspondence: E-mail: amaresh.sarkar@gmail.com

Introduction

Hill and Small land holdings play important role in raising agricultural productivity and poverty reduction. India is a predominantly an agricultural economy with 65 % of her population living in villages and earn their livelihood through agriculture and allied activities. Agriculture is the main occupation of the tribal people living in the hilly regions. In this paper attempt has been made to review the issues, opportunities and challenges of farm mechanization in hill and small land holdings.

Issues of farm mechanization in hills and small land holdings

North Eastern hill region of India is predominantly includes undulating rocky steep slopes. The low soil depth holds lower water content and use of groundwater for irrigation in the region is impossible. The rate of growth, in animal operated machinery, has remained low as compared to tractor or power operated machinery. Small and marginal farmers are mostly uses the animate power sources. Larger machineries are uneconomical for marginal, small farmers and hill slopes. The package may vary soil to soil and plane to hills.

The Limiting factors of farm mechanization in hills and small land holdings are as follow: Undulated hilly rain fed areas, lack of irrigation facilities, lack of soil and moisture conservation practices, less investment capacity of farmers, high cost of machines, locally non-availability of improved tools and machineries, manufactures finds difficulty to travel and sell small tools and machineries in the geographically remote villages, poor road networks in the hills, majority of small cultivators are poor who are not in a position to purchase the costly machineries, lack of motivation among the farmers for cultivation, lack of regular institutional supervision, inadequacy of farm power and machinery with the hill and small farmers.

Opportunities of farm mechanization in hills and small land holdings

Efficient machinery helps in increasing productivity and enabling the farmers to raise a second crop. Raising more crops with high productivity is the focus of meeting the increasing future food requirement of population. The various advantages are as follow: Timeliness operations, increases crop quality and crop quantity per unit land, improves comfortability and safety, judicious utilization of water, efficient utilization of pest control chemicals and fertilizer, promoting custom hire and Service centers for machinery, testing and demonstration, subsidized technology transfer of new tools and implements and machines by the ICAR institutes and state agricultural universities, protected cultivation for small and marginal farmers specially in hill regions. Poor marginal farmers should have facility to hire small improved tools and machineries for efficiently cultivating their lands (Kulakarni 2010). A package for complete mechanization of hill and small lands holding is summarized in Table 1.

Challenges of farm mechanization in hills and small land holdings

As the population is increasing, the food demand is also increasing day by day but the average farm size is continuously shrinkages (Mehta *et al.* 2014). The small farmers are facing several challenges in the access to several inputs and marketing. The various challenges of farm mechanization in hills and small land holdings are as follows: Access to assured irrigation facilities, access to fertilizers, access to high yielding varieties (HYV) seeds, access to credit and insurance, access to extension services, access to improved tools, implements and machineries, access to pesticides, access to competitive market value of produced crops, access to soil and moisture conservation, encouraging village craftsmen for fabricating improved hand tools and implements, encouraging small land holding farmer for adopting small tools and implements, access to improved and reliability of farm tools and machineries, encouraging manufacturer to sell small tools and machineries in the remote villages, meeting the increasing food demand as the population is increasing.

Table 1. Package for complete mechanization of hill and small lands holdings

Agricultural operations	Tools/ equipment /machines (unit =1)
Ploughing	Mini tractor (15-20 hp); Single bottom mould board plough for plane land nor single bottom disc plough for sloppy, stony or rooty land; Power tiller (9-12hp); Wooden leveler (15 kg weight)
Seedbed preparation	Single bottom bund former
Seed sowing	Single row manual seed drill
Planting	Hand digger for vegetable seed/planting
Irrigation system	Water tank based gravity drip irrigation system; solar water pump (1-2 hp)
Soil and moisture conservation	Spade (for construction of field border bund)
Water drainage	Cement concrete rectangular farm water drainage inlet; Cement concrete rectangular farm water drainage outlet
Weeding	Single row power weeder (6 hp); Hand hoe
Pest control	Hand sprayer; Hand duster
Harvesting	Powered paddy cutter (5-6 hp); Sickle for vegetable harvest; Scissors for fruits harvest; Hand hoe for root harvest
Threshing	Paddle paddy thresher
Winnowing	Paddle paddy winnower
Paddy Parboiling	Aluminum containers (25-30 liter capacity)
Drying	Solar cabinet dryer for seed, fruits and vegetable drying
Milling	Powered mini-rice mill (5-6 hp)

Results and Discussion

Small and marginal farmers in India are about 80%.the future of sustainable agriculture growth and food security in India depends on the performance of small and marginal farmers. These farmers have low marketable surplus. Many bankers view is that these two categories of farmer are needy their credit is high risk due to small land holdings size. In reality, the marginal and small farmers resort to borrow from non-institutional sources at high rate of interest. They made distress sales just after the harvest locally due to pressing requirement of money. Mechanical equipments which have higher output capacity may cuts down the number of operations to be performed for increasing the cropping intensity (Singh 2005). The use of farm mechanization generates employment opportunities both on farms and farm-allied sectors. Central and state government need to promote improved tools, machineries and institutional support for hill small land holders. All categories of farmers need to facilitate forward and backward linkages with banks and institutions like KVK, Agricultural Universities etc. Keeping view of several issues in hilly and small land holdings, protected cultivation needs to be promoted especially in hill regions.

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Foraging plants of *Apis cerana* and floral dearth in Nagaland

AK Singh*

AICRP (Honey Bees & Pollinators)
Nagaland University, Medziphema, Nagaland
*Correspondence: dr.akhileshento@rediffmail.com

Introduction

Beekeeping is one of the most promising ventures for peasantry in Nagaland. The honeybees visit flowering plants to obtain their food; nectar and pollen. Usually, high volume and higher sugar concentration nectar is preferred by bees to avoid wasting more energy and time. All foraging plant species do not contribute equal amount of food source for beekeeping. The beekeeper seeks to place his colonies in the niche where sufficient quantity of bee flora exists throughout the year, within the economical flight range of honeybee. Floral dearth refers to that time when honeybee suffers from scarcity of nectar and pollen due to unavailability of blooms of bee flora. Bee floras and their pollinators are greatly affected by environmental variables (Kearns and Inouye 1993). The extensive knowledge about local floral calendar is a key for successful beekeeping. Every region has its own honey flow and floral dearth periods. Since the practice of modern beekeeping is relatively new in India, the compilations of bee-flora list are still far from complete. Hence, present study was envisaged to identify the existing bee-flora resources and prepare floral calendar to determine honey flow period and floral dearth of Nagaland.

Methodology

A survey was carried out to identify prevailing bee-flora resources which serve as nectar and pollen sources to *Apis cerana* and their blooming period. The study was accomplished at Medziphema, Nagaland which is located in the foot hills of Pauna hills of Himalayan range. The visual observations were made on blooming bee floras visited by *A. cerana* and recorded at weekly interval during April 2011 to March 2014. The floras were categorized in to nectar producing flora or pollen producing flora or both nectar and pollen producing flora. Thereafter, the volume of nectar and pollen produced were meticulously observed and categorized in three categories; N1, N2, N3, P1, P2 and P3 as per volume of nectar and pollen.

Results and discussion

The *A. cerana* visited 69 bee flora species. Among these, nectar from 5 floras; *Anacardium occidentale, Cocos nucifera, Rhus semialata, Cajnus cazan* and *Grevillea robusta* whereas collected only pollen from 5 floras; *Psidium guajava, Abelmoschus esculentus, Zea maize, Oryza sativa* and *Mimosa pudica* and both nectar and pollen collected from 59 bee floras. The monthly abundance of bee flora were 23, 23, 30, 25, 26, 18, 12, 12, 12, 14, 13 and 21 during January, February, March, April, May, June, July, August, September, October, November and December respectively. The same result was recorded in 2012- 13 and 2013-14. The perusal of data reveals that the flowering period of highest bee flora, blooms during January to May and December, considered as honey flow period. The minimum bee flora blooms during July to September considered as floral dearth period. The same result was recorded in 2012- 13 and 2013- 14. Similar findings regarding forage plants viz., that *Citrus sinensis, Ageratum conyzoides*,., *Eucalyptus* spp., *Litchi sinensis*,. and *Rosa macrophylla* (Noor *et al.* 2009) also exist in literature.

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Evaluation of *Bosmina tripurae* (Zooplankton: Cladocera) as a new candidate fish food organism for aquaculture

Anamika Biswas, Ratan K Saha* and Himadri Saha
College of Fisheries, Central Agricultural University, Lembucherra, Tripura
*Correspondence: ratankumarsaha123@rediffmail.com

Introduction

Many zooplankton species constitute an integral part of the food chain in the aquatic ecosystems as most of the fishes and prawn larvae feed on them. *Artemia nauplii* has been a popular larval feed used by aquaculturists for long time. But the high cost of *Artemia* cysts has led to the aquaculturists to search for alternative suitable zooplankton which could be easily reared in large scale. Some zooplankton species such as *Bosmina coregoni*, *Daphnia magna, Ceriodaphnia quadrangular*, *Moina mongoloca* were found to use as live food and to replace *Artemia* because of its high cost. Among zooplankton, small sized Cladocera such as *Bosmina sp*., *D.carinata* and *M. australiensis* are commonly used as live food in freshwater aquaculture industries because fish larvae prefers small cladocerans in their early days of life. It was found that Bosminids are the main food item for young whitefish and roach. It was found that the percentage of carbohydrate, protein, lipid in *B. coregoni* and *B. longirostris* were high in comparison to many other cladocerans. A new cladoceran species *Bosmina* (*Sinobosmina*) *tripurae,* belongs to the order Bosminidae is abundant in Tripura, Tamil Nadu, Madhya Pradesh and Assam of India. There is an increasing interest in production of locally available species as a cheap and nutritionally valuable fish food as *Moina* for aquaculture practices in different parts of the world. However, in India, aquaculture lacks the technology to produce live feed of high nutritional value to increase fish survival rate, during the first days of life and zooplankton source for the rearing of fish larvae always remain a major limitation. It was found that mass culture of *Bosmina* and its nutritional profile have not been standardized and studied yet. With this background the present research work focused on mass culture technique of *B. tripurae*, assess its proximate composition and tried this Cladocera on raising fry of fish, *Carassius auratus*, as it has high commercial value in ornamental fish market.

Methodology

Investigation was carried out in three steps in the laboratory of Aquatic Animal Health and Environment Department, College of Fisheries, CAU, Lembucherra, Tripura, India. We undertook a series of preliminary feeding trials using number of algal species to determine the most suitable diet for *B. tripurae.* Our results confirmed that *Chlorella* sp. is most suitable for *B. tripurae.* For batch culture of *Chlorella,* cow dung and poultry manure (2:1) were used @ 0.12 g l^{-1} (standardized in a preliminary study) in 300 l Fiber Reinforced Plastics (FRP) Tanks. All the tanks were maintained at 26-28˚C, 12 l: 12 D light regime with 17,000-20,000 lux. Five FRP tanks were used and the cultures were maintained with aeration. Live zooplankton were collected using plankton net (65µm) from a pond named S-4 (latitude 23˚54.327'North and longitude 91˚18.493' East), near the College of Fisheries, CAU, Lembucherra, West Tripura, India. For population growth study, *B. tripurae* was isolated under Zoom Stereo Microscope (Olympus, Model No. SZ51) and acclimatized in laboratory condition for ten generations. Then *B. tripurae* was inoculated in FRP tanksat the rate of 100 No l^{-1}. The numbers of *B. tripurae* were recorded daily. Quantitative analysis was done by Sedgwick-Rafter plankton counting cell to know the mean abundance as No l^{-1}.All the cultures were operated concurrently for 5 cycles to demonstrate the reliability and the productivity of our method. The physicochemical parameters of the culture medium were pH 6.50± 0.02, alkalinity 53.20 ±0.80 mg l^{-1}, total hardness 90.60 ± 0.01 mg l^{-1}, dissolved oxygen 6.17 ± 0.73 mg l^{-1} and ammonia 0.06±0.00 mg l^{-1}.

For analysis of proximate composition, *B. tripurae* (pure culture of *B. tripurae*) were collected from FRP tank and washed repeatedly with distilled water, filtered with Whatman filter papers (Qualigens 640de, Equivalent paper No. 42, diameter 12 .5 cm) and dried them in air at room temperature. The dried organisms were transferred to eppendorff tubes and stored in a common freezer with silica gel in complete darkness to avoid lipid photo-oxidation.Live zooplankton was collected from S-4 pond and stored following the similar method as *B. tripurae*. For estimation of lipids filtered animals were transferred to eppendorff tubes and kept in deep freezer at -40°C until further use. The nitrogen content of dried samples were analysed by Kjeltec Auto-analyzer (Kel Plus supra LX from Pelican equipments). Crude protein was calculated from total nitrogen content as described in AOAC (2005). All experiments were done by triplicates and results are expressed as mean±SE.

For evaluation of potentialities of *B. tripurae*, these were transferred from FRP tanks to 40 litre (60.96 cm x 30.48 cm x 30.48 cm) aquariums for rearing of *Caraasius auratus* larvae. Fish larvae were stocked at the rate of 10 No l^{-1}. To obtain a comparison result of survivability we have another set of fish larvae feeding with mixed zooplankton collected from nature with plankton net (65µm mesh size). Total zooplankton abundance was maintained around 50-60 ind. l^{-1}. All the experiments were conducted in triplicate.

Results and Discussion

In the present study it was found that *B. tripurae*, fed with *Chlorella* sp. at $2×10^4$ cell ml^{-1}, reached growth peak in 5th days of culture. The carbohydrate content of *B. tripurae* (19.37±1.14%) was higher than *B. coregoni* (8.9±1.3%), *D. magna* (17.9), *D. longispina* (12.2%) and mixed zooplankton (7.0%).The present study have also showed that the protein content of *B. tripurae* was higher (55.81±4.52%) than *Daphnia magna* (39.24%) *and Daphnia carinata* (54.30%), *Ceriodaphni aquadrangula* (54%) and some of free-living copepods (23.00%). Protein content of *B. tripurae* was also higher than *Ceriodaphni areticulata*, *Simocephalus* sp. and mixed zooplankton. Fat content of *B. tripurae* was much higher 15.20±2.45%, than *Daphnia magna* (lipid 4.98%), *Ceriodaphniaquadrangula*12.3%.

After 30 days of post hatching *C. auratus* larvae produced 378.33±10.14 fry fed with *B. tripurae* and 293.33±17.64 fry fed with mixed zooplankton. *C. auratus* larvae have shown better survival rate (94.58±2.53 %), fed with *B. tripurae* compared to the larvae fed with mixed zooplankton (73.33±4.41 %). There was significant difference ($P< 0.05$) in the survivability rate of *C. auratus*fed with two treatments. Length increment was 3.75±0.25mm to 10.5±0.5mm after 30 days of culture in the laboratory conditions. This may be due to large sized copepods were present in higher abundance in collected live zooplankton sample, may cause feeding interferences in early days of lifeof *C. auratus* larvae as Cyprinid fish prefer small sized protozons and rotifers at larval stage while larger planktonic organisms like cladocerans and copepods at fry and fingerling stage. Again, cladocerans are characterized by lower mobility than copepods, therefore easily captured by juveniles of planktivorous fishes.

Therefore, *B. tripurae* as live food appeared to be suitable for survivability, compared to the mixed zooplankton. It can be considered as promising species for feeding fish larvae and fingerlings in large-scale cultivation as *Moina australiensis* and *Daphnia carinata*, commonly used in freshwater aquaculture industries. They can be used as additional components in the diets of planktonic organisms used directly as natural food or indirectly as inoculums in culture ponds to increase system productivity.

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Status and scope of farm mechanization in NEH region of India

Arvind Kumar*, Hijam Jiten Singh, RK Singh and BK Sethy

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: arvindkr30@yahoo.com

Technology for mechanization of agriculture is expanding rapidly in the recent times to the extent that the farmers of northeastern hill region also talk about 'tractors & power tillers' as a part of mechanization of hill agriculture. It is because of the improving road network along with other infrastructural facilities in the region which has mostly hilly terrain with wide variation in slopes and altitude. The northeastern hill region is characterized by difficult terrain, wide variation in slopes and altitudes, land tenure systems and cultivation practices. For historical reasons, the region has remained behind the mainstream of the country in agriculture and many areas. Permanent cultivation in the plains and shifting cultivation in the hills are the two predominant patterns of prevailing land use. The extent of farm mechanization is considered to be the indicator of the quality of farm life. Mechanization of farm helps in reduction of human drudgery besides ensuring the timeliness of operation and solving the problem of scarcity of labour during peak season. It is an important means of increasing agricultural productivity through efficient utilization of biological and chemical inputs besides helping to achieve timeliness of operations and improving the quality of crop. In valley lands, plateaus and wider bench terraces commercially available farm implements and machines can be used. To accelerate the large-scale adoption of these modern farm machines the support services- repair and maintenance, spares and skilled operators which are vital for the process of mechanization need to be made available wherever required in real time. Although the farmers in the north eastern hill region are still using mostly hand tools and few animal drawn equipment for all the operations in the field but the number of power tillers is also on the increase. The power tiller is mostly used for ploughing & puddling paddy fields in lowlands and terraces. The factors like size of land holding, age, sex, education and occupation have important bearing on the level of mechanization.

Availability of adequate farm power is a prerequisite for mechanization which ensures timeliness in field operation essential for optimum productivity. The average farm power available in the region is low (0.67 kW/ha) compared with national average of 1.66 kW/ha. The lowest is in Arunachal Pradesh (0.20 kW/ha) and highest (1.06 kW/ha) in the Meghalaya state. The shortfall in farm power has to be met from electro-mechanical sources such as engines, motors, power tillers and small tractors. The Division of Agricultural Engineering of ICAR Research Complex for NEH Region, Umiam has been working on design, development and testing of farm tools and implements suitable for the region in order to reduce the cost of operation and drudgery level, achieve timeliness of field operations, increase output and improve the quality of hill agriculture. There are variety of improved farm tools and equipments suitable for hill agriculture. The improved mould board plough and light ridger plough give up to 80% inversion as compared to only 37% inversion in case of traditional wooden plough. Use of improved animal drawn puddler saves up to 66% labour and 88% operating time as compared with traditional puddling with bullock drawn country plough. Wheel hoe used for weeding and intercultural operations can save 70-75% on labour and operating time and 80% on cost of operation in comparison to traditional methods.

Design, development and testing of implements including evaluation of those used in similar conditions, elsewhere, are needed. Emphasis should be given on the design and development of manually operated tools and implements to suit the need of hill slope cultivation. For increasing production, productivity and profitability with reduced cost of production and drudgery, it is essential to have improved tools, implements and machines suitable to different farm power sources available in the region. Mould Board Plough, light ridger plough and animal drawn puddlers having 0.03 ha/hr field capacity with a cost saving of 46% can be adopted for land preparation. For sowing and planting operation equipments like metallic tip dibbler, manual seed drill, adjustable row marker, zero tillage row maker, direct paddy drum seeder and walk behind paddy transplanter can be adopted based on field conditions. With metallic tip dibbler seeds can be sown up to 7 cm depth as compared to only 3-4 cm by wooden stick. It can cover about 0.10 ha/day at 40 cm row-to-row spacing. Adjustable row marker having field capacity of 0.2 ha/h at 60 cm spacing and 0.06 ha/h at 20 cm spacing can be used for sowing seeds at appropriate spacing. Manually operated seed drills with different metering mechanism are available for sowing paddy, linseed, mustard, maize and groundnut in rows at desired seed rates. Field capacity of these seed drills vary from 0.03 to 0.05 ha/h and saves about 50% cost of operation as compared to traditional method of sowing behind country plough. For weeding and intercultural operations long handle weeders, wheel hoe, cono weeder, and small power weeder can be adopted. Long handle weeders are available in different design such as; hand fork, circular and straight blade type, garden rake, etc. It can save labour to the extent of 60 to 65% over traditional methods. The field capacity of these ergonomically designed weeders vary from 0.01-0.02 ha/hr according to land conditions. Plant protection equipments may include hand compression sprayer, foot sprayer, portable power sprayer cum duster, power tiller operated orchard sprayer. Serrated sickle, self-propelled vertical conveyer reaper, and reaper attachment for power tiller can be economically adopted for harvesting different crops on small farms. VCR with 1.0 m long cutter bar is well suited for terraced and valley lands. It saves up to 52% on labour requirement and 90% on operating time compared to manual harvesting with sickle. Suitable equipments for threshing, shelling and cleaning may include pedal paddy thresher, maize sheller, groundnut decorticator and hand operated winnower.

Agriculture of the hilly region demands a set of machine, which is small in size, light in weight and has the capability to do maximum possible operations. These equipments should be such that it could be taken uphill or down the slope by two - three persons by lifting it and carrying it physically. It must be able to operate in the narrow terraces and deep valley low land where bigger machinery is unable to reach and perform the operation. The required machine should have more field capacity than the manual and reduce the drudgery of operation. The power tiller is a useful power source for the NEH region since it can be used for ploughing, puddling, interculture, basin making, spraying and transportation in paddy cultivation. The conventional and light weight power tiller and small size self-propelled reaper, paddy transplanter and auger digger have great potential in the region. The positive aspects of the traditional methods cannot be over sighted due to their convenience and independence. What is required in the region is to give a new look to the traditional methods/tools through modification by identification of the mechanization gaps based on cropping systems prevalent in different regions. Changing socio-psychology and economy of the region is affecting the agriculture in general and use of farm machinery in particular. Mechanization should not be an end in itself, it should be the means to enhance production & productivity and reduce drudgery of farm workers. Therefore, selective mechanization for identified gaps, proper extension infrastructure coupled with training, demonstration and publicity, and financial support are needed to further improve the mechanization status of the region.

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Medicinal and economic importance of Indian trumpet flower in the hilly areas of Tripura – a review

E Reang[1*], HL Devi[2], KS Th Irenaeus[1] and K Debbarma[1]

[1] *College of Agriculture, Tripura, Lembucherra, Tripura*

[2] *ICAR RC for NEH Region, Tripura centre, lembucherra, Tripura*

*Correspondence: ezekielreang12@gmail.com

Introduction

The rich biodiversity in the northeastern region not only sustained the ecological balance, but also the population over the years in various ways. Even before the dawn of modernity, plant based natural resource has been a key source of livelihood. The state of Tripura in particular is endowed with nature's bounty in the form of variety of plant species ranging from creeper, shrubs, climbers to tall trees, which have been useful in some way or the other. The Indian trumpet flower (*Oroxylum indicum* Vent.) belonging to the family bignoniaceae is an important traditional crop of Tripura and its usage dates back to antiquity. The trees are small to medium sized, deciduous. The externally reddish purple flowers are borne on large erect racemes. The sword shaped fruit is a flat capsule, measuring about 0.3 to 1.0 m in length and 5.0 to 10.0 cm in breadth. The seeds are numerous and winged. It flowers during the month of June- July and blooms at night, emitting a stinky odor. The fruiting occurs during the month of November. The fruit is used as vegetable, the bark, leaves and the roots possess medicinal values, which are used to treat various ailments. It is also used as ornamental tree due to peculiarity in its shape. The species is endemic to South East Asian region and in India it is distributed in the Eastern and Western Ghats, foot hills of Himalayas and the Northeastern region. The phenolic compounds like baicalein, oroxylin A, and chrysin present in this species have shown therapeutic potential in some areas such as anti-cancer (Lambertini *et al*. 2004), anti-inflamatory, anti-ulcer and anti- dysenteric.

Scope of cultivation in hilly parts of Tripura

Seventy percent of the total geographical area of Tripura is covered with hilly areas or undulating topography and cultivation is mostly rainfed. In spite of so much effort, large sections of the people are unable to afford quality health care and are still dependant on plant based traditional healing system. By and large, the economic condition of the people in rural areas is poor. The menace of climate change further aggravates the situation. In view of this it imperative to develop a climate smart production strategy that not only caters to food, medicinal and economic need but also adapts well with the changing climate. Under Tripura condition the *O. indicum* is found both under wild and domesticated condition and can be seen in backyard of homes. This crop is hardy and comes up well with little care. The tender fruits are burnt and the darkened outer skin is removed leaving the green tender pulp, which is consumed as vegetable in preparation of *Gudok* a local delicacy. The matured fruits are fibrous and are used for preparation of special dish called *Chakhui*, a dish prepared using soda that softens the pulp. According to the report of task force on conservation and sustainable utilization of medicinal plants, Planning commission, Government of India (2000) the estimated demand of *Oroxylum indicum* in South India is 500 kg per.

The *Oroxylum indicum* is suitable for cultivation under hilly areas of Tripura where irrigation facilities are usually absent. It is common tree vegetable cum medicinal plant and well known among the locals. However organized and large scale cultivation is lacking in spite of its various uses. Detailed research is required to standardize cultivation practice. Currently there is growing interest in the plant among the pharmacological researchers due to the presence of bioactive compounds that has led to over exploitation of the species under wild condition, to the extent of endangering in the state of Kerala (Ravikumar and Ved 2000) and vulnerable in the state Karnataka (Rajasekharan and Ganesham 2004). To meet the growing demand and to conserve the species large scale cultivation is the viable option. Large scale cultivation will not only provide food and improve economy in the hilly areas but also help in development of pharmaceutical industries. The crop has high potential to be commercial crop if promoted and popularized.

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Mechanization options for conservation agriculture in North East India

Hijam Jiten Singh*, Arvind Kumar, BK Sethy and RK Singh

ICAR Research Complex for NEH Region, Umiam, Meghalaya, India

*Correspondence: hijam_jiten@yahoo.co.in

Introduction

Agriculture in north east India, because of its diversities in topography, altitude and climatic conditions, offers scope for cultivation of a wide variety of agricultural crops. Long-term conventional agriculture, which is characterized by plough and hoe-based agriculture often results in soil degradation, organic matter depletion and increased production cost. Sloppy farmlands suffering from moderate to severe soil erosion have accelerated land degradation, which has caused permanent, irreversible loss of land productivity. Conservation agriculture (CA) has been proposed to reverse this degradation in an effort to move towards sustainable cropping systems. CA is a crop production system based on minimum soil disturbance, surface crop residue retention and species diversification through crop rotations and associations. To achieve the implementation of CA, there is a range of options for planting through soil surface residues and these include machines designed for manual, draught animal, two-wheel and four-wheel tractor power sources. However, farm equipment for the region must suit the terrain and small farm sizes. Largely, agricultural operations are labour intensive and performed manually. Existing locally evolved tools give low output and involve excessive drudgery. Thus, this paper reflects the various mechanization options and classifies them into manual, animal power, two-wheel and four wheel tractors operations.

Methodology

Manual and animal power equipment is usually small, light-weighted, simple in design and easily manufactured, utilized and maintained. This equipment is invariably used on small farms and hilly areas. Li seeder is a typical manual seeder for no-till seeding of maize and soybean. Jab planter is the most common manual planting tool for row crops in no-till areas suitable for smallholder farmers. This machine enable to seed into mulch-covered no-tilled soil effectively. Jambo direct seeder, animal traction direct seeder and angled single disc seed drill are common animal power seeders. They were designed to manage residue whilst seeding and fertilizing in no-tilled soils, so they normally have discs to cut through the surface residue and furrow openers to place the fertilizer and seed. However, disc penetration in wet residue and hard soil can be a limitation. No till planters for two-wheeled tractors are becoming increasingly demanded in Asian and African CA systems. The ACIAR Rogro and strip-tillage machines were on view. ACIAR-Rogro tined seed drill is a three-row tined planter with adjustable row spacing. Attempt has been made on alternative soil engaging components, in addition to the standard chisel tine that has been fitted to date. These include double offset and single disc openers adjustable for offset and tilt. CA planters suitable for smaller farms include the Turbo Happy Seeder and chain-driven residue management system planters.

The machine has been designed specifically to deal with heavy rice residue (up to 10 ton/ha) and to direct seed wheat into this immediately after the rice harvest. Burning the straw is the other option and this produces both atmospheric pollution and loss of soil organic matter. The Turbo Happy Seeder has a set of straw management flails immediately in front of the chisel tine openers. These clear the straw and allow direct seeding to take place before the residue falls back to cover the soil. National zero-till multicrop planter is attached behind a 2WT rotary tiller with the aid of clamps. There is also an option towards selection of tine and disc openers such as Stubble Star double disc opener, 'Daybreak' single disc opener technology etc. to reduce soil disturbance during the seeding process. The discs of stubble star double notched disc opener are angled at 7° to each other and have an undercut angle of 3.5° to improve soil conditions in the base of the furrow.

Table 1. Comparison of manual and animal-driven seeders

Machine	Utility	Power	Efficiency	Features
Li seeder	Maize, soybean	Human	0.2-0.3ha/day	Separate plant seed and fertilizer; good performance in wet soil
Jab planter	Maize	Human	0.5 ha/day	Plant from a standing position; adjustable seeding rates; minimal soil disturbance
Animal traction direct planter	Maize, beans	Animal	1.5ha/day	Suitable for drilling seed & fertilizer simultaneously
Jambo direct seeder	Maize, soybeans	Animal	2 ha/day	Good residue handling capacity
Angled single disc seed drill	Maize	Animal		A two-row seed drill; heavy

Results and Discussion

Mechanization is a major input to CA and well-functioning equipment must be on the market for wider adoption. For small and medium scale farmers there are advances in manual, draught animal powered and tractor powered options (especially with 2WTs). Although a variety of no-till equipment has been developed and fabricated, some improvements can be made to suit a range of crops and soils. To address the problems of hilly terrain, small farm size, and economic constraints of the region, the no-till seeders need to be light weighted, simple, affordable, and suited to low power source.

Yield evaluation of oyster mushroom strains in Meghalaya

Baiswar P*, Ngachan SV and Chandra S

ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya

*Correspondence: pbaiswar@yahoo.com

Six strains of *Pleurotus* sp. (PL-14-01 to 06) were evaluated in mushroom house during December 2014 to February 2015. These cultures were received from Directorate of Mushroom Research, Solan, HP. Paddy straw was used as substrate with ~70% moisture. There were five replications with 6 bags of each strain. Average relative humidity during the period of experimentation was 84.7%, minimum temperature was 12.9 ºC and maximum temperature 18.2 ºC (averages based on morning and evening values). The strain PL-14-02 was found to be best in terms of yield (106.7 kg/100 kg dry substrate) followed by PL-14-03, 04 and 05 which were statistically at par. The strains PL-14-01 and 06 recorded the lowest yield (41.8 kg/100 kg dry substrate). Average fruit body weight of the strain Pl-14-02 was 29.1 g.

Synthesis of bio-oil from byproducts of chickpea through bench scale pyrolysis

Sandip Mandal*, VK Bhargava, PK Jena, S Gangil and AK Dubey

Central Institute of Agricultural Engineering, Bhopal, Madya Pradesh

*Correspondence: smandal2604@gmail.com

Introduction

Bio-oil is a liquid fuel produced through thermo-chemical processes from biomass materials such as agricultural crops, biomass, municipal wastes, and agricultural and forestry by-products (Demirbas, 2007). Bio-oil has a great potential for use as fuel oil in industry, or as transport fuel and considered as one kind of new inexpensive, clean and green bio-energies (Xu *et al*. 2011). Many researchers have conducted fast pyrolysis study of different biomass materials in different reactor systems and found bio-oil yield up to 80 wt.% of the biomass input with heating value ranging from 14 to 18 MJ/kg. Bio-oil yield in pyrolysis process is greatly affected by process conditions and properties of biomass. Most important process conditions are temperature, heating rate and residence time and prevailing values are: temperatures of about 500 °C, heating rates >10^3 °C/s and vapor residence time <2 s (Heo *et al.* 2010). In the present study, bench scale pyrolysis of by-products of chickpea (*Cicer arietinum* L.) was carried out to optimize the process parameters.

Methodology

By-products here defined as the any product came out of threshing machine other than grains. It was collected from the threshing yard of ICAR-CIAE, Bhopal, MP, India and grinded by a hammer mill. The powder was screened through 1.70 mm screen and then dried naturally and kept in a sealed polythene bag before further processing. Pyrolysis of chickpea waste was carried out in a bench scale reactor as shown in Fig 1. The reactor had an internal diameter and height of 75 and 300 mm, respectively. The main reactor was heated electrically. The temperature of the experimental system was adjusted using a temperature controller and was monitored using a K-type thermocouple. The condensable phase (bio-oil) of the pyrolysis vapor was collected using a stainless steel condenser that maintained a temperature of 25 °C which was achieved by circulating water by a pump.

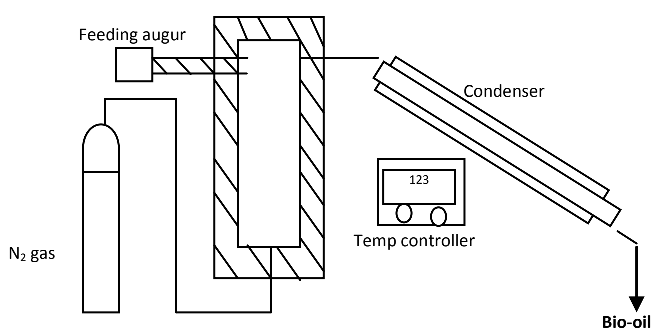

Fig 1. Schematic diagram of the experimental setup

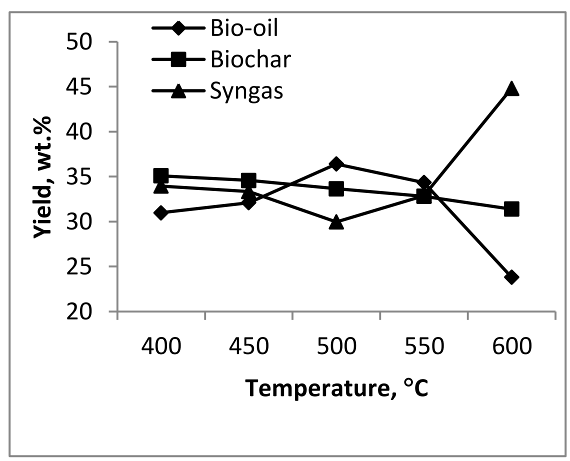

Fig 2. Product distribution as a function of pyrolysis temperature: at a feed size of 1.7 mm, flow rate of 5 L/min, feeding rate of 2.5 g/min and in a nitrogen atmosphere.

Results and Discussion

The product distribution of bio-oil, biochar and syngas has been presented in Fig 2. It shows that yield of biochar has decreased with increasing temperature which is obvious and supported by many earlier studies that with increasing temperature more biomass carbon is converted to gaseous phase (Bridgwater, 2007). Biochar yield was found 35.09 % at 400 °C which constantly lowered to 31.38 % at 600 °C. Bio-oil is the condensable phase of the pyrolysis vapors. Bio-oil yield was maximum (36.4 %) at 500 °C and decreased with the higher temperatures. This was may be due to the secondary reactions occurred of the heavy-molecular-weight compounds in the pyrolysis vapors, which is known to become active at temperatures over 500 °C (Heo *et al*. 2010). Similar result was found for wood that is highest bio-oil yield in the typical temperature range of 500-520 °C (Bridgwater 1999). Overall bio-oil yield was lesser than fast pyrolysis process due to longer residence time of about 10 min and lower heat transfer rate due to absence of any heating media. This can be improved by adoption of fluidized bed reactor where heat transfer rate is higher and residence time is lesser. As bio-oil is the condensed part of gas, eventually yield of syngas was lowest (29.95 %) at 500 °C and increased after 500 °C up to 44.82 % at 600 °C. it was observed that bio-oil produced at all temperature range contained higher amount of moisture. However, the study shows that there is ample opportunity to produce renewable liquid fuel from the waste of chickpea. Further study is necessary to increase bio-oil yield and reduce gas yield.

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Quality evaluation of fibre properties of banana grown in north-east Himalayan areas

Deb Prasad Ray [1*], Debasis Sen[2] and Pradipta Banerjee [1]
[1]*ICAR-National Institute of Research on Jute & Allied Fibre Technology, West Bengal*
[2]*College of Agriculture, Lembuchhera, Tripura,*
*Correspondence: drdebprasadray@gmail.com

The North-East region in India is the richest source of biodiversity and gifted with a deluge variety of natural fibres. Among all the natural fibres banana is a chief source as it is extracted from the waste resource material, pseudo stem after the harvesting of the crop. Banana is a popular horticultural crop in North Eastern Hill region of Genus Musa. Maximum genetic variability of *Musa acuminate* and *M. Balbisiana* occurs in North-East India. *M. Flaviflora* is localized to Manipur and Meghalaya. There are other species found in Sikkim and Khasi Hills, which need systematic collection and conservation. There is a huge scope of exploitation of these species through extraction and characterization of fibres. However, the fibre properties of these different species of banana have not been evaluated so far. Therefore an attempt has been made to extract and characterize banana fibres of different species from the North East regions. This paper presents composition of different layers of banana pseudostem sheath and detailed characteristics of fibres from mechanical extraction. Cellulose, hemicelluloses, lignin, pectin and ash were determined by chemical analysis of pseudostem sheaths. Lignocellulose constitutes about 60% to 80% dry weight of the banana pseudostem sheath, in which cellulose accounts for about 52%. Fourier Transform Infra-Red Spectroscopy and scanning electron microscopy (SEM) studies revealed the superficial chemistry and surface morphology of the extracted fibres. The characterization of pseudo stems fibres through FT-IR confirms the presence of cellulose, hemicelluloses and lignin.

Status of farm mechanization at Longleng district of Nagaland

P Chowdhury[1*], BC Deka[2], KL Meena[1], Manoj Kumar[1] and Sanjay Ray[3]

[1]*KVK Longleng, Nagaland,*
[2]*ICAR Research Complex for NEH Region, Jharnapani, Nagaland,*
[3]*KVK, Wokha, Nagaland*
*Correspondence: pulakabha@yahoo.com

Introduction

Longleng District is a strip of mountainous territory having no plains and situated in the northern Nagaland. Geographically, Longleng district situated under the 26°26'0" N latitude and 94°52'0"E Longitude and altitude varies from 260 to 1306m above msl. Topographically Longleng is divided into three regions, namely; a) Chingmei Range in the Northern part, b) Shemong Range in the Middle part and c) Yingnyu Range in the Southern part. The Phom people are using very few improved hand tools and implements. They are mainly using dao, sickle, saw, axe, spade, spear, weeder, basket, spear etc. in their day to day life and agriculture. Phom people use their spear for hunting purpose as well as during folk dance and display a pair of spear in front of the community centre and their houses.

Methodology

The objective of the study was to bring a pen picture of mechanization status of Longleng district and to introduce ergonomically efficient tools and implements to reduce drudgery in agricultural operations. A survey was conducted in the district using a questionnaire prepared for this purpose. Whole questionnaire was grouped into different subgroups namely general information, agriculture, crop varieties, flora and fauna, agricultural tools and implements, size of the implements, raw materials used etc. A random sampling method was followed during the selection of farm family. A total 100nos. of farm family were contacted for the study.

Result and Discussion

During the survey on farm mechanization in Longleng district, we have found following indigenous farm tools and implements used in day to day life and agricultural operations. The farm mechanization was very rare and negligible in the district. Keeping this in view, Front line demonstration on farm mechanization was conducted during 2013-14 and 2014-15. Mechanization was intervened in line sowing, weeding, shelling of maize and dehusking of groundnut to reduce drudgery in agricultural operations. Due to non availibity of improved tools and implements in the district, Krishi Vigyan Kendra (KVK), Longleng has introduced several implements like Maize Sheller (with and without stand), Adjustable row marker (ARM), Wheel Hoe (single tyne) and Groungnut decorticator under Front line demonstration of farm mechanization for evaluation of sheeling capacity, field capacity, weeding efficiency, field efficiency respectively. The ergonomical evaluation of farm women under soybean cultivation with the use of Wheel Hoe and dehusking of groundnut with the use of Groundnut decorticator was also done under Front line demostration (FLD) on farm mechanization.

Farm mechanization at Longleng is very little and negligible. For creating an awareness and interest in farm mechanization, implements like Maize Sheller, Adjustable Row Marker (ARM), Wheel Hoe was introduced in Longleng district. Front line demonstration (FLD) on farm implements were done for evaluation of field capacity, field efficiency, weeding efficiency and shelling capacity of Adjustable Row Marker, Wheel Hoe, and Maize Sheller respectively. Shovel (Belcha), Gaiti (Hotok yongh) and Karahi/Tagar- (Hou-o-kong) was also introduced for excavation work of rainwater harvesting structure-*Jalkund*. This type of FLD has created a mass awareness among the farmers of Longleng district and made them interested in introducing these implements in their field. Keeping in view of farmer's interest, some implements were distributed to reduce their drudgery in maize shelling, line sowing and weeding in Soybean, Maize, Mustard, French bean and Pea cultivation. FLD study evaluated that manual shelling capacity has increased from 3-5kg/hr to 15-22kg/hr after the intervention of Maize Sheller. The manual field capacity has increased from 0.12ha/day to 0.26ha/day and 0.40ha/day to 1.40ha/day due to intervention of Adjustable Row Marker in mustard and soybean cultivation respectively. The weeding efficiency of small kudali (Hapho) has increased from 40% to 70% due to intervention of Wheel Hoe. Decortications efficiency has been increased from 45% in manual kernel peeling to 85% with the use of groundnut decorticator.

Table 1. Evaluation results of Front Line Demonstration (FLD) on Farm Mechanization

FLD Theme	Technology demonstrated	Data on parameters		% change in parameters	Remarks
		Demonstration	Local check		
Drudgery Reduction	Maize Sheller	Shelling capacity 15-22 kg/hr	Shelling capacity 3-5 kg/hr	362.5 %	3.6 times labour saving per hectare
Drudgery Reduction	Adjustable Row marker in mustard cultivation	Field Capacity 0.26ha/day	Field capacity 0.12ha/day	116.0%	1.2times less labour per hectare
Drudgery Reduction	Adjustable Row marker in soybean cultivation	Field capacity= 1.4 ha/day	Field capacity= 0.4 ha/day	133.0 %	Less labour requirement up to 18-20 man-h/ha
Drudgery Reduction	Wheel Hoe in soybean cultivation	Field Capacity 0.25ha/day	Field Capacity 0.10ha/day	150.0%	1.5times less labour required per hectare
	Demo: Wheel Hoe, Local check: Small Kudali (Hapho)	Weeding Efficiency 70%	Weeding Efficiency 40%	175.0%	
Drudgery Reduction	Groundnut Decorticator	Decortications Efficiency: 85%	Decortications Efficiency: 45%	188.8%	2times labour saving per hour

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Scope for agricultural mechanization in Manipur

L Kanta Singh[1]*, S Roma Devi[2], Lydia Zimik[1], SK Raman[1] and Kh Hera Singh[1]
[1] *KVK Imphal West, ICAR Research Complex for NEH Region, Manipur Centre*
[2] *KVK Churachandpur, ICAR Research Complex for NEH Region, Manipur Centre*
*Correspondence: kanta_lai@yahoo.co.in

Introduction

Manipur is essentially an agricultural state and agriculture is the mainstay of the state's economy with about 76 % of the working population in the state directly or indirectly depending on agriculture for employment and livelihood. The size of the cultivated area is, however, only 7.24% of the total geographical area of the state and of this total cultivated area, 56.88% is confined to the valley. The average percent of female cultivator /farm labourer to male cultivator /farm labourer in Manipur is 44.43% (Anonymous 2014). In order to achieved such food demand it is imperative to focus on improving the intensity of farm mechanization in the state.

Methodology

Manipur is one of the smallest state of India located in northeast part of the country. Manipur contributes about 0.7236 Mham (million hectare metre) of water resources to country's total water budget of 400 Mham. The improved tools and equipments were used as a part of on farm trial (OFT) and front line demonstration (FLD) under activities of Krishi Vigyan Kendra, Imphal West, Manipur. Paddy drum seeder was used for sowing of pre-germinated paddy seeds directly on puddle fields. The cono weeder was used for removing weeds between rows of paddy crop. Cono weeder can smoothly in the paddy fields and it is easy to operate. Peddle operated thresher was used for threshing of paddy in the study area (Pandey *et al*. 2006). Rice is the main and staple crop of Manipur. District-wise wet rice cultivation (WRC) area were collected from Statistical Year Book Manipur (2013). Cost of cultivation of rice in Imphal West district of Manipur was obtained from Krishi Vigyan Kendra, Imphal West, Manipur.

Results and Discussion

Three different improved tools and equipments namely paddy drum seeder, cono weeder and paddy threshers were used. The seed requirement in traditional farming was 50% more by using paddy drum seeder, where about Rs. 500.00 per hectare could be saved in seed material. Transplantation cost in traditional farming was estimated as Rs. 9200.00 per hectare, but the activity of transplantation is replaced by seeding using paddy drum seeder with only cost of Rs. 460.00 per hectare. Weeding cost in traditional farming was calculated at Rs. 9200.00 per hectare using 40 man-days whereas only 7 man-days per hectare was required for weeding in improved mechanised farming system spending only Rs. 1610.00 per hectare. The amount saved by using improved mechanised farming is more than the 50%. During the study in threshing and winnowing portion of the agricultural activities, maximum amount of Rs. 8750.00 per hectare could be saved over the traditional farming followed by seeding using paddy drum seeder could save Rs. 8740.00 per hectare against the transplanting manually. By using cono weeder a total amount of Rs. 7590.00 per hectare could save over the manual weeding. By using paddy drum seeder seed requirement could reduce 50% over the traditional farming. The cost of cultivation of rice could be further reduced by mechanizing other activities.

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Post-harvest life of gerbera as influenced by BA and GA_3

S Shil, D Nath, D Dey and A Chakraborty
KVK, West Tripura, Chebri, Khowai, Tripura
Correspondence: dkvkwesttripura@gmail.com

Introduction

Gerbera (*Gerbera jamesonii*) popularly known as Transvaal Daisy or Barberton Daisy, widely used as a decorative garden plant. *Gerbera jamesonii* is a member of the Compositae family. It is in considerable demand in both domestic and export markets. Besides floral arrangements, gerbera is widely used in bouquets and in dry flower crafts. The cut Gerbera flowers have a long vase-life provided treated adequately immediately after harvest and fetches premium market prices. The flowers are hardy and stand the rigors of transportation admirably.

Several commercial floral preservatives have been formulated for gerberas. Some farmers dip the flower heads for a few minutes in 0.1 m benzyl adenine (BA) to maintain flower weight and senescence (Dole and Wilkins 1999). Gibberellic acid did not delay leaf senescence in most plant species and its content in tissues was not correlated with senescence. Although Gerbera cut flowers are grown by only a few farmers, the demands of flowers are usually remain higher particularly during festivals. Due to the high temperatures and high humidity, the post-harvest vase-life of gerbera is very less. The short post-harvest vase-life is mainly due to inadequate knowledge about the flower gerbera and in general, handling, transportation and marketing of this cut flowers are somewhat difficult.

Research on the post-harvest handling of cut flowers need to be undertaken, because floriculture and post-harvest handling and preservation of cut-flowers in general and gerbera in particular, are at an infant stage. Therefore, any treatment that will maintain the flower quality after harvest and increase the vase life of cut flowers will enhance its production.

Methodology

The experiment was carried out with Gerbera cv. Palmbeach. As soon as the stems were cut they were weighed and were subjected to pulsing treatment with freshly prepared chlorine solution (100 ppm) from sodium hypochlorite (4%) and $AgNO_3$ solution (100 ppm) separately. After 24 hours of pulsing treatment all the cut stems of gerbera flowers were then kept in vase preservative solutions comprising (T_1: Gibberellic acid (20 ppm) T_2: Gibberellic acid (10 ppm) $T_{3:}$ Gibberellic acid (5 ppm) and $T_{4:}$ Control) five nos. of replication taken and Completely Randomized Design has been followed. Experiment was started early in the morning and after every 24 hours; the observations are recorded on different parameter: Stem length, Flower weight, Days taken for discoloration of the petals, Days taken for drooping of flower heads, Days taken for petal fall, Vase life in days etc.

Result and Discussion

The result of the experiment showed that pulsing with silver nitrate (100 ppm) is more effective than pulsing with chlorine (100 ppm) in respect of enhancing the vase life of cut gerbera cv. Palmbeach. Among the two growth regulators used as vase preservatives, the performance of GA_3 was much better than BA in the maintenance of the postharvest quality of cut gerbera flowers which were pulsed with silver nitrate (100 ppm) prior to keeping in vase preservatives. The performance of BA treatment as vase preservative was comparatively better with flowers which were pulsed with chlorine (100 ppm).

The increased vase life of 9 days, with delayed flower drooping, petal discolouration, and petal fall was observed with flowers which were pulsed with chlorine (100 ppm) followed by keeping in vase preservative solution containing BA (10 ppm) as well as the maximum vase life of 10.8 days was noted with flowers which were pulsed with silver nitrate with delayed petal discolouration, petal fall and flower drooping was observed with GA_3 (10 ppm) among the different vase preservatives containing $GA_{3.}$

Inclusion of various antimicrobial compounds such as chlorine in vase water can reduce the number of bacteria and extend flower longevity. In addition, the efficacy of biocides utilizing free chlorine (e.g. sodium hypochlorite) is relatively poor in acidified (e.g. pH 3–4) solutions that are typically recommended for hydrating cut flowers (White

1999). The application of the cytokinins benzyl aminopurine (BA) or thidiazuron (TDZ) as pulsing or dipping treatments delayed flower senescence cut flowers. Supplying cut flowers with exogenous sugar maintain the pool of dry matter and respirable substrates, especially in petals, thus promoting respiration and extending longevity (Coorts 1973).

Table 1. Effect of chlorine pulsing and BA treatment on postharvest quality of gerbera cut flowers

Treatment	Vase life in days	Days taken for drooping of flower heads	Days taken for discolouration of petals	Days taken for petal fall
T1(BA20ppm)	7.400^{b}	7.200^{b}	7.600^{c}	8.330^{bc}
T2(BA10ppm)	9.000^{a}	9.000^{a}	10.400^{a}	11.000^{a}
T3(BA 5 ppm)	7.600^{b}	8.000^{ab}	8.800^{b}	9.000^{b}
T4(Control)	5.800^{c}	6.000^{c}	7.600^{c}	7.500^{c}
SEm ±	0.339	0.400	0.283	0.406
$CD_{at5\%}$	1.025	1.210	0.855	1.227

N.B. Similar alphabets are not significant. They are statistically at per.

Wilting of gerbera flowers occurred after water uptake declined. It was found that the vase life of cut flower was above all dependent on water balance, which is the relation between the capacity of the flower for water uptake, water transport and transpiration. Vase life termination for many cut flowers is characterized by wilting. Maintenance of optimum water status was the most important factor in cut flower vase life but the underlying mechanisms leading to disturbed water balance was still unresolved. Water uptake declined with the time for all the treatments, but the rate of decline varied between treatments. Accordingly there were significant differences in the initial fresh weight percentage. It can be said the most common symptoms of imbalance in the water status are wilting, folding and scape bending. Vascular blockage is related to the fast reduction of vase life. The bacterial growth in the xylem of untreated gerbera stems indicates that the addition of the floral preservative to the vase water is recommendable to control bacterial growth and to diminish the vascular blockage.

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Value addition and processing of locally available fruit - Yenjuk at Longleng

[1]Thungchano Ezung, [1]P Chowdhury, [1]Manoj Kumar [2]B.C. Deka and [1]KL Meena

[1]KVK, Longleng and [2]ICAR Research Complex for NEH Region, Jharnapani, Nagaland

*Correspondence: thungchano.ezung@gmail.com

Introduction

Longleng is a hilly district of eastern Nagaland bifurcate out from the Tuensang district in 2004. Before the intervention of new technology in the district, Krishi Vigyan Kendra (KVK) Longleng has done Participatory Rural Appraisal (PRA) survey in 6nos of villages of all three blocks. During these PRA survey, it has been found that there is no preservation and value addition methods of fruits and vegetables in the district. Plenty of Yenjuk (*Myrica Esculenta*) is locally available in district. Being a kind of berry they are highly perishable. Due to lack of knowledge on processing and preservation, tonnes of fruits go wasted every year. KVK Longleng took up initiatives for the promotion of its preservation.

Methodology

Hands of training cum demonstrations on preparation of preserved Yenjuk (*Myrica Esculenta*) were conducted by KVK, Longleng to individual farmers and different SHGs to popularize its utilization. Total 40nos of farmers from different villages viz., Hukphang, Lingtak, Pongching, Pongo and Longleng town (Muli ward) were given hands on training on processing and value addition of Yenjuk for additional income of the farmers. Initially, ripe and firm fruit were selected and washed proper with clean water. Fruits (26kg) were dried in shade for few minutes to drain out water from the fruits. Total 13kg of sugar and 2.6kg of jaggery (Gur) was added to dried fruits. Cooking of mixture (fruit and sugar + jaggery) should be continued till all sugar gets evaporated and thick brown consistency developed. The product obtained was cooled and packed with locally available packaging materials (LDPE, HDPE and PET Jars) so that the shelf life of the product may enhance upto 6months.

Result and Discussion

A total of 260 packets of 100 g value added Yenjuk product has been prepared. Total expenditure was Rs. 3750/- and gross income was Rs. 5200/- with net profit Rs. 1620/-. The benefit cost ratio was 1.38. Farmers have taken great interest in the training and started producing their own product for house hold consumption as well for income generation. Post training feedback was taken from the trained SHG farmers after 3months. It was found that average profit generated by the SHG was Rs. 6400/- in 3 months. Per unit contains packet/PET jar were of 100 g of preserved Yenjuk. Average per unit production cost was Rs. 14.8/- per 100gm packet. Average price of the product in the local market was Rs. 20.00 per packet of 100 gm. Average profit generated through the enterprise was Rs. 6400/- (within 3 months). Total nos of packets prepared was 260 packets of 100 g. Gross income generated: Rs. 5200/-Net income generated: Rs. 1620/- benefit cost ratio (BC ratio): 1.38.

Table 1. Economic analysis of value addition

Sl. No.	Materials	Quantity	Rate (Rs.)	Cost of processing
1	Fruit	26kg	20	520.00
2	Sugar	13kg	40	520.00
3	Jaggery	2.6kg	200	520.00
4	Packaging material	260packets	5	1300.00
5	Tagging	260packets	2	520.00
6	Fuel consumption			100.00
		Total expenditure		3750.00

Inadequate infrastructure to preserve raw materials: As Yenjuk (*Myrica Esculenta*) is a seasonal fruit, during off–season processing cannot be done due to unavailability of required infrastructure to preserve the raw materials. *Inadequate infrastructure for large scale processing:* The other important problem with processing of yenjuk as found in the district is unavailability of machineries and equipments for processing in large scale.

Commercialization of field products of fish based farming system in Dhalai district of Tripura

RK Saha[1*] and D Nath[2]
[1]College of Fisheries, CAU, Lembucherra, Tripura
[2]Holy Cross College, Agartala, Tripura
*Correspondence: ratankumarsaha123@rediffmail.com, nathjim@rediffmail.com

Introduction

Fish has a vital role to play in mitigating the protein deficiency in a developing country like India. Though fish is a very popular diet, its cost is often too prohibited for the common man to afford. Chronic shortage of fish can be attributed mainly to inadequate utilization of the nature's endowments. This is however, notwithstanding this impressive performance achieved during the last six decades in increasing the country's fish production. Tripura is a small state of NE part of India where Dhalai district is the most undeveloped and remote district of all the eight districts of this State. But this district has huge natural resources along with a number of water bodies. Agriculture is the main source of income of the farmers of this district (Saha and Nath 2011). But lack of scientific integration of fish culture with other agricultural practices and the proper marketing facility the district is the economic status of the farmers are not able to develop in proper way. Keeping the above statements in view NAIP launched a programme to develop the livelihood of the rural poor of this district. Under this project College of Fisheries (COF) developed Scientific Fish based Farming System Models (Aquaculture+ Agriculture + Animal husbandry) for the achievement of ultimate goal by enhancing productivity, profitability, employment opportunity and sustainability in the district (Saha *et al*. 2014). There was a great problem to implement this project because of the lacking of proper transportation facilities of the seed and raw materials as well as the farm produce. To overcome such problem COF have taken initiatives to give maximum market ink and transportation facilities for the commercialization and up scaling of the produces to improve the livelihood of the farmers in a sustainable manner.

Methodology

The study has been conducted during the year 2007- 1014 by following methods:

1. Introduced the proper scientific Fish based Farming system.
2. Marketing of fish, vegetable fruit and meat to the local market and vendors for profitability.
3. Marketing of planting material by the beneficiaries in project area as well to other farmers of the district.
4. Encouraged the fish seed grower and sold the fingerlings in local area for the availability of quality fish seed and for best economic return.
5. Marketing of value added fish product by the women of fish farmers family for women empowerment.
6. Production of quality fish feed by the SHG for availability and profitability

Results and Discussion

Scientific Fish based Farming System Models (aquaculture + agriculture + animal husbandry= A^3 models) have been introduced in three (3) clusters *viz.*, Balaram, Maracherra and Baghmara for the achievement of ultimate goal by enhancing productivity, profitability, employment opportunity and sustainability. Total 14 different interventions were practiced for proper development of fish based integrated farming system (IFS).

For commercialization and scaling up following steps have been taken up:

(i) Marketing of fish, vegetable fruit and meat: Farmers have been involved in production of fish as well as fruit, vegetable and pig in the project area. There was a great demand of such products. Apart from the marketing in local markets the linkage has been developed with the vendors who use to come directly in their field to purchase such products.

(ii) Planting material: The farmers were encouraged for production and supply of banana sucker and papaya seed lings to the local farmers as well as the NAIP farmers.

(iii) Fish seed grower: The fish spawn has supplied from the College Fish Farm to the stake holders, S.H.Gs and one M.C.S to grow the fingerlings. It also aimed to give the benefit of the poor farmers and the availability of the quality fish seed in local area. After rearing, the farmers sold fingerling to the local as well as NAIP farmers and achieved an extra economic return.

(iv) Fish feed/ pig feed: Formulation was given to the farmers for preparation of fish feed and pig feed with available local ingredients at their own cost which could able to minimize the production cost to give better economic benefit. .

(v) Value added fish product: The women of fish farmers' family were trained on value added fish product. After getting such training they have started to manufacture such products locally and and started to marketing in local market.

(vi) Fish feed mill: To solve the unavailability of fish feed in due time one small scale fish feed mill was established at Balaram in the field of Santirneer SHG. After the establishment of this mill they have started to prepare the fish to fulfill the demand of that locality.

The integration of different plants and animal component adopted by the local farmer has a great impact on their livelihood. The different products of the IFS are now utilized for their day to day need and also for marketing through which they are now going to improve their livelihood. Along with the scientific integration of IFS and its marketing facility the average income level of per house hold was recorded as Rs. 61,666/- to Rs. 78,726/-.

There was a great problem to get the proper fish seed in due time. To mitigate such problem the initiation has taken to transport the fish spawn from COF farm to the small shallow pond of the farmers for rearing. After rearing, the farmers have started to sale in local fish farmers through which the easy accessibility of fish seed is achieved. The participant has increased their income by selling the fingerlings and due to this reasons local farmers got quality fish seed (Saha and Nath 2012). The establishment of feed mill is a great achievement which minimize the transportation cost of fish feed for the local fish farmers. Now it is capable to prepare @ 150,000 kg fish feed per year to cover the pond of 910 farmers an average of 125 ha area. The marketing facility established by linking the line departments, farmers' contractor, wholesaler, retailer and consumers. It is observed that the impact is not only limited to sale the products or to purchase the required raw materials in due time and need. In different local social or family functions the women or youth people of NAIP are involving as cook or caterer through which they are getting extra economic benefit.

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Future scenario in mechanized production of oilseed crops in India

Manish Kanwat[1], PC Jat[2], AK Tripathi[2] and D Jini[3]

[1]*KVK Anjaw, ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar*

[2]*ICAR-ATARI, Zone-III ICAR RCNEHR*

[3]*ICAR Research Complex for NEH Region, AP Centre, Basar*

*Correspondence: kvkanjaw.icar@gmail.com

Introduction

The domestic production of edible oil is critically insufficient to meet the demand of growing population. It only meets 27% of the total edible oil consumption in the country. The deficit is met through import of edible oils from other countries on which government is spending billions of rupees in foreign exchange. Major Oilseed crops are classified into two groups namely traditional and non-traditional. Rapeseed/ Mustard/Groundnut and Sesame includes in traditional oilseed while sunflower and canola are includes in Non-traditional oilseed. Rapeseed/mustard/Sunflower and canola are important oilseed crops after cottonseed, which contributes approximately 7%, 32% and 10 % in the total domestic edible oil production, respectively. Cotton is the primarily a fiber crop and oil is its bye product while rapeseed/mustard/canola and sunflower are the main oilseed crops. They were grown over 0.576,

Mechanization in natural perspective

Indian food security and surpluses for expert at competition prices requires efficient development and utilization of agricultural resources. Intensive use of agriculture machinery needs to be popularized among farmers to improve the average yield. It may be noted that population density is increasing. Land-to-man ratio is deteriorating and food requirement is growing more and more. It is well known fact the efficient use of agricultural machinery not only speeds up cultivation processes but also accelerates harvesting and threshing operations.

Rapeseed/Mustard/Canola

Traditionally rapeseed crop is sown with broadcast method as no specific sowing machinery is available. The traditional and mechanical sowing methods are elaborated as follows. Traditionally, harvesting of rapeseed crop is done manually with sickle which is a labour intensive operation. Harvested crop is immediately shifted to the threshing floor and is left there for sun drying for few days. Then threshed with animal or tractor treading as no proper harvesting and threshing machinery was available in the country. But in recent year the Agriculture Engineers and Farm Machinery industries has done remarkable job and developed and modified and performed well at farmers' field. The manufactures machine was evaluated and demonstrated in Rapeseed/Mustard/canola growing areas of Punjab, Rajasthan, Madhya Pradesh etc,. Output capacity of the machine was 460 kgh^{-1} with threshing efficiency of 98%. The operational and total cost for mechanical threshing was Rs.1.250 as compared to Rs. 2.800 t^{-1} of output seed for traditional threshing.

Following machinery be acquired for evaluation-cum-adaptation. Swather for canola harvesting, Pick-up table for available combine harvesters and promotion campaign of wheat-cum-canola thresher is strengthened for its commercial adaptation. A comparative field survey should be conducted to assess mechanization status of sunflower as an oilseed crop for enhancing domestic edible oil production in the country.

Plant and Animal Health Management

- Integrated insect and disease management
- Integrated weed management
- Zoonotic diseases
- Trans-boundary and emerging diseases

Pest population dynamics in relation to climate change and strategies for their management

NS Azad Thakur*, DM Firake and GT Behere
ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya
*Correspondence: nsa_thakur@yahoo.com

Introduction

Climate change is possibly the most significant global change event that has attracted the attention of scientific community all over the globe. With the signs of climate change becoming more and more concrete with every coming year, concerns about its possible implications for various sectors of life on the universe are also escalating. On account of its close association with climatic variables such as temperature, CO_2 and precipitation, agriculture is definitely the most climate-sensitive sector. Being a highly diverse groups, insects and pathogens are perhaps the most sensitive to the changing climate. The possible effects of changing climate on insect pests could result in the form of their outbreaks, migration or dispersal, change in bio-diversity, species extinction, host shift, and emergence of new pests or biotypes or races etc. Therefore, insect pest management under changing climate is foremost and important challenge in agriculture sector and consensus should be made to prioritize the research activities in the area. Components of climate change which have potential to influence insect pest scenario includes rise in global temperature, increased CO_2 concentration, iincrease in Ozone concentration, increased UV radiation, extreme weather events like - floods, droughts, high intensity rainfall and hurricanes etc.

Effect of rising temperature and CO_2 on Insects

Changing climate can restrict the distribution of insects directly by influencing their survival and fecundity or indirectly through effects on interacting species that act as food sources, natural enemies or competitors. Closely related insects can differ markedly in their survival of climatic stresses as well as in their ability to reproduce and expand under different thermal conditions, which greatly influences the species distribution and abundance (Hoffmann, 2010). It has been reported that some short-lived species of insects have capacity to respond to climate change within a time frame of tens of years. Some observed impacts of increasing temperature on insects are mentioned in Table 1.

Table 1. Impact of elevated temperatures on insects

Increasing	Decreasing
Northward migration	
Migration up elevation gradient	Effectiveness of insect bio-control by fungi
Insect development rate and oviposition	Reliability of economic threshold levels
Potential for insect outbreaks	Insect diversity in ecosystems
Invasive species introductions	Parasitism
Insect extinctions	

Table 2. Effect of elevated CO_2 on insects

Increasing	Decreasing
Food consumption by caterpillars	Insect development rates
Reproduction of aphids	Development and pupal weight in *Chrysanthemum* leaf miner
Predation by lady bird beetles	Response to alarm pheromones by aphids
Carbon based plant defences	Lipid concentration in small heath
Effect of foliar application of *Bacillus thuringiensis*	Parasitism
Consumption and N utilization efficiency in pine saw fly and Gypsy moth	Effect of transgenics to *Bacillus thuringiensis*
Larval growth in pine saw fly	Nitrogen based plant defence
Growth rate and consumption in Willow beetle	Control of grain aphids with sticky traps

As stated earlier, temperature has been thought to be the most important abiotic factor which can significantly affect the development of insects. The combined effect of higher temperatures and CO_2 concentration could have high subtle effects on overall growth and development of insects. Research conducted in past has shown that effect of elevated CO_2 on insect pests could occur through changes in host biochemical composition. Some observed effects of elevated CO_2 on insects are shown in Table 2.

Effect of changing precipitation on insects

Small body-sized insects may be physically dislodged from the host plant by heavy rainfall, and are often more of a problem during dry seasons when the mortality factor is missing. Climate change resulting in more frequent and/or heavy rainfall would tend to suppress populations of small insects. Increase in the frequency of flooding of fields could tend to suppress some soil dwelling insect populations. However, in contrast, drier conditions would have the opposite effect. Due to global warming, more droughts are expected to be observed due to shift in rainfall pattern and increment in evaporation. Most fungi which are known to cause various diseases in insects (entomopathogens) depend on high relative humidity for successful epidemics, thereby reducing insect pest populations. Higher percentage of relative humidity resulting from rainfall or larger crop canopies may tend to favor fungal epidemics (Petzoldt and Seamann 2012).

Observed impact of climate change on insects with special reference to north east India

Few reports stating possibilities of involvement of climate change either directly or indirectly on insect pest outbreaks, invasion, changes in host shift and emergence of new pests etc as follows

Pest outbreaks: Pine lappet moth, *Kunugia latipennis* in 2011 at Umiam; Litchi bug during 2012-2013 near Indo-Bangladesh border; Sporadic outbreaks of rice hispa in Indo-Bangladesh border; Sporadic outbreaks of swarming caterpillars in different parts of NEH region; Sporadic outbreaks of grasshopper, *Aularches miliaris* in Manipur and Nagaland

Insect invasion: Recent invasion of papaya mealy bug, *Paracoccus marginatus* in Assam, 2010; Recent Invasion of looper caterpillar, *Hypoxidra infixaria* on tea in Assam

Shifting of host by insects: Litchi trunk borer on guava; guava trunk borer on pigeon pea; Banana Fruit caterpillar on dolichous bean; elephant beetles on guava

Emergence of new pests: Saw fly attack on roses; root aphid and white grubs in upland paddy; mealybug on ginger rhizomes

Insect pest management practices under changing climate scenario

1. Insects are poikilothermic organisms and thus are highly sensitive to their surrounding temperature. Increased climatic temperatures are likely to result in the need for more insecticide applications because of the likelihood of the presence of additional pest species, more generations of pests per growing season, and the earlier arrival of migratory pests. Under such situations, need based pest management practices should be followed; i.e. ETL based chemical management practices, identification of pesticides with novel mode of action and delivery, identification of emerging pests or race in new habitat etc.
2. Similarly, biology and life cycles of several arthropods will keep altering under changing climate that ultimately could affect many successful pest management practices including cultural control, biological control and chemical control (Petzoldt and Seamann 2012). Therefore, these practices need be modified according to the biology and behavior of pests e.g. changes in sowing time, altered doses of bio-agents and pesticides; timing of applications and proper IPM programmes against target pests
3. Strategies based on combined use of available management options available may prove to be more effective than reliance on the fungicides alone under climate change situation.

Therefore, a major future challenge for us is to achieve a better understanding of which systems or species are most or least susceptible to projected climate change

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Prevalence of gastrointestinal protozoan infections in pigs of Dimapur District (Nagaland) and its treatment

R Laha[1*], A Goswami[1], M Das[1], MK Patra[2], RK Das[2], N Ebibeni[3], A Sen[1] and BC Deka[2]
[1]*ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya*
[2]*ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland*
[3]*KVK, ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland*
*Correspondence: lahar31@rediffmail.com

Introduction

Rearing of pigs is one of the ways of livelihood of tribal population of north eastern region of India. But one of the major constraints of rearing of pigs is the gastro intestinal (GI) parasitic infections and pigs have been found to be infected with high percentage of various GI parasites. GI parasitism in pigs affects its performance in terms of poor growth rate, reduced weight gain, reduced feed conversion and condemnation of affected organs. Among GI parasites, GI protozoan infections has been reported to cause reduced body weight gain and decreased haemoglobin conc. in infected pigs (Bauri *et al.* 2012) that have generally received little attention. Some of the GI protozoan parasites of pigs like *Balantidium coli* and *Cryptosporidium* spp. have zoonotic significance also. Although some research work on prevalence of GI parasitism in pigs of NE region of India are available (Rajkhowa *et al.* 2003), but most of them restricted their studies on GI helminthes infections and few studies included GI protozoan infections in pigs of this region (Ebibeni *et al.* 2013, Borkotoky *et al.* 2014). But nobody gave emphasis on treatment on GI protozoan infections. So, the present study was undertaken to know the prevalence of GI protozoan infections in pigs of Dimapur District and to treat this infections.

Methodology

To know the prevalence of GI protozoan infections in pigs, a total of 142 numbers of faecal samples of the pigs maintained in organized way in pig farm of ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani (84 nos.) and pigs maintained in unorganized way in a village of Dimapur Distt. of Nagaland named as Molvom (58 nos.) Village were taken into consideration for collection of faecal samples. These faecal samples were examined microscopically to observe the presence of protozoan infections by direct and indirect methods (Soulsby 1986). For the treatment of these animals, two experimental trials to see the comparative efficacy of two treatments against *B. coli* infections and one treatment against *Eimeria* spp. infections were undertaken in pig farm of ICAR Research Complex for NEH Region, Nagaland Centre. For treatment of *B. coli* infections first groups of six pigs were treated orally with a combination of Metronidazole (@20 mg/kg. b.wt.) and Furazolidone (10 mg/kg b.wt.), for consecutive four days. The second groups of six pigs were treated with Oxytetracycline @10 mg/kg. b.wt. orally, for consecutive four days. For treatment of *Eimeria* spp. infections, six pigs of one group were treated with Amprolium @ 45 mg/kg b.wt. orally, for four consecutive days. For comparison, infected control group comprising 4 pigs for each infections were also studied. Faecal samples of pigs of all groups were collected on 3, 5,7,15 and 30 days post treatment and examined to see the efficacy of these treatments by observing cysts or oocysts.

Results and Discussion

Over all 58.45% pigs were found as positive for *B. coli* infection with a distribution of 70.23% in pigs of organized farm and 41.37% in pigs maintained in village condition. Overall prevalence of *Eimeria* spp. was recorded as 42.95% with a distribution of 32.14% in pigs of organized farm and 58.62% in pigs maintained in village condition were recorded. Results of experimental treatments against *B. coli* and *Eimeria* spp. have been presented in Table 1 and Table 2, respectively. It could be observed from these tables that after 15 days of treatment by Metronidazole and Furazolidone combination and 7 days of treatment by Oxytetracycline, all treated pigs showed negative for *B. coli* infections. Faecal samples collected after 3 days onwards post treatment were found negative for *Eimeria* spp. infections. Infected control group of first and second experiments found positive for *B. coli* and *Eimeria* spp. infections, respectively, throughout the experiments.

Balantidium coli are ciliate protozoan parasite responsible for causing Balantidiosis in animals and human. Balantidiosis is a zoonotic disease and is acquired by humans via the fecal-oral route from the normal host, the pig. It is generally harmless for pigs, but sometimes it may produce clinical symptoms and fatal disease. The infected pigs may show moderate to severe diarrhea or may not show any clinical sign. Most human infections are asymptomatic or limited to mild diarrhea and abdominal discomfort. However, in rare instances, the protozoa may lead to hemorrhagic lesions in the intestine, perforation, secondary bacterial infection, and generalized peritonitis. Coccidiosis in pigs causes diarrhea (may be bloody), dehydration, loss of appetite, poor growth and occasional mortality in piglets and has been reported to have negative impact on growth rate of pigs. The parasite damages the walls of the pig’s intestines and usually secondary bacterial/viral infections also develop that often kill the pig. Earlier from this region, Rajkhowa *et al.* (2012) recorded 16.16% *B.coli* infections in an organized pig farm of Assam and Laha *et al.* (2013) reported that 41.3% pigs of this region are infected with *B. coli.* So, the findings of 58.45% pigs as positive for *B. coli* infection in the present study is important for pigs and a caution for human being, as the infection has zoonotic signification. As high as 93% *B. coli* infections in pigs maintained in farm condition at Ranchi, Jharkhand with successful treatments has been reported by Bauri *et al.* (2012) but they observed a quick response of treatment as compare to our study. Ebibeni *et al.* (2013) reported 34.7% *Eimeria* sp. infections in pigs maintained in village condition in Dimapur district of Nagaland. Borkotoky *et al.* (2014) reported 16.25% *Eimeria* spp. infections among indigenous local pigs in Phek District of Nagaland. To our knowledge report of efficacy of amprolium against *Eimeria* spp. infections in pigs are not available and hence we cannot compare our study however, Laha *et al.* (2015) successfully used amprolium for the control of *Eimeria* spp. infections in rabbits in subtrocipal hill region of Meghalaya.

Acknowledgements

We are thankful to Indian Council of Agricultural Research, New Delhi to carry out this research work under “All India Network Programme on Gastrointestinal Parasitism”. The facilities provided by Director, ICAR Research Complex for NEH Region, Umiam, Meghalaya, India, are thankfully acknowledged.

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Zoonotic diseases with special reference to North Eastern India

I Shakuntala*, Samir Das, Sandeep Ghatak, RK Sanjukta, K Puro and Arnab Sen
ICAR Research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: ishakuntala92@gmail.com

Introduction

World health organization defines zoonoses as those infectious diseases or their agents naturally transmissible between animals and human beings. Out of a total of 1405 infectious diseases that affect human beings, approximately 58% (817) are zoonotic in nature; and out of 177 infections that are emerging or re-emerging, about 73% (130) are zoonoses (Woolhouse and Gowtage-Sequeria 2005). North Eastern Region of endowed with one of the most diverse bio reserves in the world and is one of the few remaining areas in the country with large forest covering. It shares international border with Bhutan, Nepal, Bangladesh, Burma, China and Tibet. There is exchange of man, livestock and materials through the porous borders. Hence, there is fair chance of exchanging pathogens and zoonotic diseases along these borders. Some of the Important zoonoses prevalent in the region are Japanese encephalitis, Rabies, Brucellosis, Salmonellosis, Anthrax, Taeniasis, Echinococcosis,Toxoplasmosis and other meat & fish-borne and milk-borne infections causing gastro-enteritis, diarrhoeal diseases, acute food poisoning are widespread.

Important zoonoses of north eastern region of India

Japanese encephalitis: Japanese encephalitis (JE) is caused by the Japanese encephalitis virus, an emerging disease in many other states of India including the north-eastern states. Human disease incidence has been reported in Assam, Tripura, Arunachal Pradesh, Manipur and Meghalaya (Das *et al*. 2015). Children bear the major threat from the disease. However, people of all age groups may be affected by JE as recently seen during the adult JE cases of Assam. In general, epidemics of JE coincide with the rainy season and the period of high mosquito prevalence, the same rule with NE states. *Culex tritaeniorhynchus* is the most important vector in N. E. India.

Rabies: The infection is transmitted to animals or man by contact with the infected saliva, which may penetrate the skin through scratch or a bite. Rabies is primarily a zoonotic disease and can infect a wide range of animals, is the only communicable disease of man, which can be regarded as 100% fatal. In India alone about 20,000 deaths are estimated annually and people are infected following a deep scratch or bite by an infected animal (Sudarshan *et al*. 2004). Most animal bites in India (91.5%) are by dogs of which 60% are strays and 40% pets. Rabies is endemic in the states of NE, recently, out of 270 dog bite cases in Churachandpur district of Manipur, 11 deaths were reported (The Telegraph, January 17 , 2015).

Influenza: An acute infectious viral zoonosis caused by Influenza virus (family Orthomoyxoviridae) may affect human, livestock and birds. Nonetheless, because all influenza viruses have the ability to change, scientists are concerned that H5N1 virus, the strain presently in circulation, one day could be able to spread easily from human to human. Among NE states, Assam, Tripura, Manipur, Meghalaya have reported bird flu in recent years which was limited to birds only (Dhingra *et al.* 2014). During the year 2009, the world had experienced pandemic H1N1 2009 global outbreak and currently India is experiencing many human cases and death due to H1N1 influenza virus and is restricted to human population only.

Nipah virus encephalitis: Nipah virus is a new member of genus Henipavirus (Family Paramyxoviridae). The virus was identified in 1999 when it caused an outbreak of neurological and respiratory disease on pig farms in Malaysia. It is usually spread by fruit bats or pigs. The virus is naturally harboured by Pteropid fruit bats (flying foxes). The disease was also reported in Singapore (Paton *et al.* 1999), Bangla Desh and India (Siliguri and Nadia districts of West Bengal). North East states bordering to West Bengal and Bangladesh should keep a vigil on this virus.

Brucellosis: Brucellosis in animal is caused by several species of *Brucella*, *viz*., *B. abortus*, *B. melitensis, B. suis, B. canis* and *B. ovis.* Man can be infected with *B. abortus*, *B. melitensis*, *B. suis, and B. canis* through ingestion, contact, inhalation and accidental inoculation. Goats, sheep, cattle, water buffaloes and swine are the principal group of animals, with abortion as a symptom. In India, brucellosis in livestock is responsible for a median loss of US $ 3.4 billion. The disease is responsible for a loss of US $ 6.8 per cattle, US$18.2 per buffalo, US $ 0.7 per sheep, US $ 0.5 per goat and US $ 0.6 per pig. (Singh *et al.* 2015). Bovine brucellosis is present in North East states including Manipur, Mizoram, Arunachal Pradesh, Meghalaya, Assam (Shakuntala *et al.* 2013).

Tuberculosis: With 30% of total cases, India has the most TB patients in the world. It is the leading cause of death in India with a total of 3,75,000 deaths annually (RNTCP 2014). *M. tuberculosis* is the major pathogen responsible for 95% of the cases of tuberculosis in human, yet 5% of all deaths from this disease were due to infection with bovine strains which is zoonotic in nature having cattle as a principal reservoir (Gallangle and Jenkins 1998). The prevalence of animal tuberculosis is as follows, Cattle-1.93%, buffaloes-6.39% (Shah, 2002). There had been documented isolation of *M.bovis* from bovine milk samples from India (Srivastava *et al.* 2008). Bovine tuberculosis is one of the priority zoonotic disease in India as discussed in the Roadmap for combating Zoonoses in India by Public Health Foundation of India. The cases from non-tuberculosis Mycobacterium are also in rise with outbreaks being reported from human. There is documentation of animal, fish and environmental NTM isolates also from all over the country.

Leptospirosis: Leptospirosis is caused by a spirochaete- *Leptospira interogans*. The disease is contracted from infected rat's urine/ contaminated watercourses. Populations at high risk are rural farm workers, rice field workers, sugarcane cutters, cattle farmers, fishermen, slaughterhouse and sewer workers. Most of the leptospirosis cases occur in southern part of India. The cases of leptospirosis have been regularly reported from TN, Kerala, and Andaman over the last 2 decades due to farming and inadequate rodent control. Economic impact is due to cost for medical treatment, decreased productivity, impact on trade animals, reproductive failures and reduced milk yield. Seropositivity in bovine in the region has been reported (Shakuntala *et al.* 2013).

Listeriosis: The disease is caused by pathogenic strains belonging to the genus *Listeria*, which includes six species namely *Listeria monocytogenes*, *L. ivanovii*, *L. innocua*, *L. welshimeri*, *L. seeligeri* and *L. grayi*. Out of various listeriae, only *L. monocytogenes* is an opportunistic pathogen in human beings and various animal species, whereas, *L. ivanovii* affects only the animals (mainly the ruminants) as a cause of abortion, and occasionally man also. In India, cases of human listeriosis (2), spontaneous abortion in women (4) has been reported with seroprevalence of the disease varies from 2.77 to 7.0% (Kaur *et al*. 2007). The pathogen has also been recovered from repeat breeding, infertility and mastitis cases in animals (Rawool *et al.* 2006). The disease is prevalent all over the world with more reports pouring in developed countries. *L. monocytogenes* had been isolated from North East India from food of animal origin viz., fish, meat, milk and from integrated farming systems.

Salmonellosis: Salmonellosis is an infection caused by bacterial species belonging to the genus *Salmonella* and usually associated with the ingestion of food containing salmonellae or their products. Salmonellae are widely distributed in nature infecting man and animals alike and are major public health problems all over the world. Most of the *Salmonella* serotypes incriminated in gastroenteritis in man have been isolated from animals and birds. A large number of serovars of s*almonella* found to be occurred in diarrhoeic and enteritis in man and animals. In India, *Salmonella* infections are endemic and one of the most widespread zoonosis. Salmonellosis caused by non-typhoidal species is not only more prevalent but has also shown an increasing trend world over with majority of cases being caused by *S. Enteritidis* and S. Typhimurium. S. Enteritidis, in particular, has emerged as an important cause of gastroenteritis, food-borne infection and a significant health problem in many countries. In northeastern India, *Salmonella* in enteric infections has been reported in piglets, poultry, pigeons and other animals.

Colibacillosis: *Escherichia coli* is the major coliform organism of concern which is responsible for many food borne episodes of infection in infant causing infantile gastroenteritis. Among *E.coli* strains, four strain types are pathogenic and cause gastroenteritis. These are: enteropathogenic *E. coli* (EPEC), enterotoxigenic *E.coli* (ETEC), enteroinvasive E.coli (EIEC), and enterohaemorrhagic *E. coli* (EHEC). *E.coli* O157:H7 responsible for hemolytic and uremic syndrome (HUS) in man can also get access to the milk through contaminated faeces of cattle, udder, handler and utensil and is emerging zoonoses. **Staphylococcal enterotoxic gastroenteritis:***Staphylococcus aureus* is the main bacterium responsible for foodborne poisoning in man through its preformed exotoxins in food of animal origin products mainly from milk and milk products. Most of the milk borne outbreaks in the country in temples, in mid-day meal are related to this organism. Zoonotic diseases which are prevalent and are of serious concern in India are brucellosis, anthrax, plague, leptospirosis, rickettsial infections, arboviral diseases, leismaniasis, taeniasis, cysticercosis and toxoplasmosis. All these diseases are transmitted by either contact, inhalation or by ingestion of the pathogens. Most of them are associated with significant morbidity and mortality. Health education, animal vaccination, and case contact management with appropriate treatment and vector control can prevent these diseases. In northeastern region, there could be unreported zoonotic diseases, needs a wider exploration to produce a comprehensive account of these diseases.

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Impact of Environmental Contamination on Livestock Health With Special Emphasis on Arsenic and Fluoride

AK Bera*, T Rana, S Das, J Bam, S Maity, V Paul, D Bhattacharya and SM Deb.
ICAR- National Research Centre on Yak, Dirang, West Kameng, Arunachal Pradesh
*Correspondences: asitmed2000@yahoo.com

Environmental contamination has considerable adverse consequences on health and physiology of man and livestock. Epidemiological evidence suggested that exposure to higher concentration of heavy metals, pesticides, fluorine and other agrochemicals are the major causes of environmental toxicity that may result in poor immune system leading to reduced resistance in host system. Pollution has direct role on systemic disorder like cardio-pulmonary diseases, viz. chronic obstructive pulmonary disease, hypersensitive pneumonia and chronic heart disease in human beings and allergic diseases such as rhinitis, alveolitis and asthma in animals. On the other hand global pollution due to various metal, non-metal and organic pollutants are increasing by enhanced anthropogenic activities leading to contamination of terrestrial and aquatic ecosystem. Arsenic and fluoride are two major ground water contaminants affecting both aquatic and terrestrial animal and agricultural production system as a whole. Therefore, greater importance needs to be emphasized in solving this multidisciplinary problem. Thus the animal scientist can contribute greatly to issues spanning animal production and the environment. In this review we have discussed the global and Indian scenario on both toxicants, cause, interaction and health effect on animal and public health consequences.

Evaluation of native *Trichoderma* spp. against soil borne diseases of North East Region

Bireswar Sinha*, Someshwar Bhagat, Pramesh Kh, RK Padamini and K Khedarani
College of Agriculture, CAU, Imphal, Manipur
NCIPM, ICAR Complex, New Delhi
*Correspondence: bireswarsinha@gmail.com

Introduction

North East region is characterized by diverse agro climatic and geophysical features which make the region unique in many ways (Sarkar 1994). The altitudinal differences coupled with varied physiography contributes to great climatic variations in NE India. Therefore, the climate of NE region varies from near tropical in the plains of Assam Tripura and south Mizoram to near alpine in the northern Sikkim and Arunachal Pradesh. The greater part of the region has, however, subtropical climate. The present world scenario in agriculture is changing towards the organic cultivation because of the residue and health hazards due to excessive application of the different chemicals. The present research is focused on the management of soil borne diseases by native *Trichoderma* spp.

Methodology

An extensive survey for isolation of native *Trichoderma* spp. was done in all North East states excluding Assam wherever vegetable crops are growing. The representative soil samples were analyzed for presence of *Trichoderma* spp. by soil dilution technique and morphological identification were done as per standard taxonomic keys. Physiological characterization was done by dual culture test, production of volatile and non-volatile inhibitors, extracellular enzyme activity, rhizosphere colonization, biopriming and plant growth promoting activities.

Table 1. Per cent colonization of Trichoderma isolates to sclerotia of S. rolfsii

Sl. no.	*Trichoderma* isolates	Unsterilized soil	Sundried soil	Sterilized soil
1	CAUNCIPM-6	80	65	95
2	CAUNCIPM-36	80	64	93
3	CAUNCIPM-32	80	62	95
4	CAUNCIPM-50	25	20	33.33
5	CAUNCIPM-45	82.67	75	80
6	CAUNCIPM-48	45.67	43	46.67
7	CAUNCIPM-51	53.33	41	45.80
8	CAUNCIPM-11	73.33	55	73.33
9	CAUNCIPM-123	40	25	46.67
10	Control	0.00	0.00	0.00

Total genomic DNA of the fungal cultures was isolated using the HiPurA DNA isolation Kit. For PCR amplification of ITS1 and ITS2 of nuclear ribosomal gene, ITS region was amplified using specific ITS1 and ITS2 primers. ITS1 5'- TCC GTA GGT GAA CCT GCG G - 3'

ITS2 5'- GCT GCG TTC TTC ATC GAT GC – 3'

DNA amplification was carried out in Thermo electron corporation PCR with an initial denaturation step of 95°C for 1 min, followed by 35 cycles consisting of denaturation at 95°C for 1 min, annealing at 55°C for 30 sec and extension at 72°C for 1.5 min and then a final extension step of 72°C for 10 min. Sequencing of the amplified products were done and accession number were obtained. *In-vitro* antagonistic potential of nine potential Trichoderma isolates were used to test the efficacy in controlling soil borne diseases under *in-vitro* condition against *Rhizoctonia solani*, *Fusarium* sp. *Sclerotium rolfsii* for production of non-volatile antibiotics (Dennis and Webster, 1971a) and volatile (Dennis and Webster, 1971 b) at 7.5 and 15% concentrations.

The experiment was conducted in unsterilized and sterilized soils to assess the ecological adaptability of *Trichoderma* spp. Two hundred gram of soil were mixed thoroughly with sclerotia of test isolates of *Trichoderma* separately and fitted into the earthen cups (100ml). Twenty five sclerotia of *Rhizoctonia solani*, *Sclerotium rolfsii* were buried at 0.5- 2.0 cm dept, covered with perforated aluminum foil and incubated at 28±1°C for 7 days. The sclerotia were harvested separately by floatation and sieving method (Rodriguez-Kabana *et al*., 1974) and percent of sclerotia colonization were recorded.

Various locally available substrates (agricultural byproducts) were screened and suitable substrates were subjected for revaluation under different physical factors alone or in the suitable mixtures for growth and multiplication of *Trichoderma* spp. The promising isolates of *Trichoderma* were evaluated against soil borne diseases by different delivery methods under artificial inoculation of respective pathogen in pot and field condition.

Results and discussion

An extensive survey for isolation of native *Trichoderma* spp. was done and a total of 200 numbers of *Trichoderma* spp were isolated from North east Region. For the competitive parasitic ability of the nine potential isolates obtained by laboratory study of *Trichoderma* against *S. rolfsii*, three types of soils, *viz.,* unsterilized, sun dried and sterilized soils were studied and presented in table 1. The colonization percentage of sclerotia of *S. rolfsii* by CAUNCIPM-45 , CAUNCIPM-6, CAUNCIPM-36, CAUNCIPM-32, CAUNCIPM- 11, CAUNCIPM-51, CAUNCIPM-48, CAUNCIPM-123 and CAUNCIPM-50 in unsterilized were 82.67, 80, 80, 80,73.33, 53.33 ,45.67, 40 and 25% , respectively while in sundried soil the colonization percentage were 75 ,65, 64, 62, 55, 41, 43, 25 and 20%, respectively. The degrees of colonization in sterilized soil by CAUNCIPM-6, CAUNCIPM-32 CAUNCIPM-36, CAUNCIPM-45 CAUNCIPM-11, CAUNCIPM-48, CAUNCIPM-123, CAUNCIPM-51and CAUNCIPM-50 were 95, 95, 93%, 80, 73, 46.67, 46.67, 45.80 and 33.33%, respectively.

Bio-priming of pea seed with potent *Trichoderma* isolates from Tripura

The bio-priming of seeds of pea was done for potent isolates of *Trichoderma* spp. *viz*., CAUNCIPM-123, CAUNCIPM-45, CAUNCIPM-32, CAUNCIPM-6, CAUNCIPM- 48, CAUNCIPM-51, CAUNCIPM-36, CAUNCIPM-11 and CAUNCIPM- 50. The highest root length was observed in CAUNCIPM-123 (16cm) However in untreated control the root length was only 6.51cm. The highest shoot length was observed in CAUNCIPM-45(7.99cm). The highest germination percentage was observed in CAUNCIPM-32(94.44%). However in untreated control the germination percentage was only 51.66 per cent. The vigour index was highest in CAUNCIPM-123 where the vigour index was 20.69 and only 5.20 in untreated control.

Mass production of *Trichoderma* spp

Among the different substrates tested, rice bran + mustard cake (1:1) + sugarcane juice (10%) showed the highest growth of Th- CAUNCIPM-51(13.33 x 10^8cfug$^{-1)}$ at 30 days of incubation which was followed by rice bran + mustard cake (1:1) + jaggery (3%) (12.20 x 10^8 cfu g^{-1}).

Molecular characterization of potent Trichoderma isolates

Molecular identification of the isolated Trichoderma isolates was done. The total fungal DNA was isolated by using fungal DNA isolation kit (Hi-Media, India). The isolated fungal DNA was amplified using ITS1and ITS2 primer.

The amplified products were observed by running on DNA gel electrophoresis and found that irrespective of isolates all the sample amplified around 262 bp. PCR products were sent for further sequencing at Xcelris Lab, Ahmedabad and accordingly two of the *Trichoderma* spp identified as *Trichoderma asperellum* of accession number (KT601340) and KT601341(CAUNCIPM 25B). Pot and field evaluation of the potent Trichoderma isolates showed considerable decrease in disease as compared to untreated.

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Economic injury due to the Bactrocera tau (Walker) (Diptera: Tephritidae) on capsicum

T Boopathi*, SB Singh, T Manju, SK Dutta, Y Ramakrishna, AK R Singh, Samik Chowdhury, S Saha, Lungmuana and SV Ngachan

ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram,
ICAR Research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: boopathiars@gmail.com

Introduction

Capsicum, also known as bell pepper or sweet pepper (*Capsicum annuum* L.) is a popular vegetable in India and the country produced 153350 MT of capsicum from an area of 29,140 ha. Since, it has adapted to variable climatic conditions, the production and productivity are limited by insect pests, non-insect pests and diseases and it's attacked by many insect pests and yield loss can approach 30-40%. Among various insect pests of capsicum, fruit flies (Diptera: Tephritidae) is considered to be a major pest causing extensive damage to capsicum growing areas of Mizoram and the yield loss can approach 70-80 % in chilli (Boopathi *et al*. 2013b) and tomato (Boopathi 2013) by fruit flies infestation. The pest not only deteriorates its quality also due to premature droppage of infested fruits (Gupta *et al*. 1990).

The fruit flies has a wide host range and it was capable of significantly reducing capsicum crop yields in open field in north eastern hill region of India. This region represents the endemic habitat of fruit fly belonging to subfamily Dacinae. Flies lay their eggs under the skin of ripening fruit, maggots hatch and feed, spoiling the fruit, causing it to rot and drop. The taxon *Bactrocera* (*Zeugodacus*) *tau* (Walker) (formerly *Dacus tau*) includes flies that are major pests of cucurbit crops in Southeast Asia and is widespread throughout the Oriental region. Although these flies commonly attack fruits of plant species within the family Cucurbitaceae, they have also been found infesting fruits from very different families, e.g., Leguminoseae, Moraceae, Myrtaceae, Oleaceae, and Sapotaceae. The aim of the present study was to clarify the species composition, seasonal fluctuation of male *B. tau* and reaction of several capsicum cultivars against *B. tau*. Understanding the seasonal fluctuation of the *B. tau* population, the damage to the fruits and reaction of several capsicum cultivars against *B. tau* may contribute to the improved management for the pest.

Methodology

An extensive survey was conducted during 2013 to 2015 in Mizoram, India to study the fruit flies infestation in tomato crops. The mature and ripe fruits were sampled at random from each tomato cultivars at the rate of 20 per cultivar at weekly intervals. The collected fruits were placed in separate buckets each containing slightly moist finely sieved sand layer, to facilitate the emerging larvae to pupate. The recovered puparia were placed in Petri dishes inside insect cages (15 × 15 × 15 cm). The pupal morality, adult emergence, fruit flies abundance and sex ratio were also studied from the recovered puparia in each tomato cultivar. The emerging flies were collected and sorted out into an individual species based on the taxonomic description (Drew and Hancock 1994).

Results and Discussion

The fruit flies has a wide host range and it was capable of significantly reducing capsicum crop yields in open field in north eastern hill region of India. A pest survey and subsequent identification confirmed the presence of the tephritid fruit flies, *Bactrocera tau* (Walker) (Diptera: Tephritidae) in capsicum. This is the first report of the insect in the province and population outbreaks resulting in serious damage to capsicum in India. Population fluctuation and seasonal incidence of fruit flies, *B. tau* on capsicum crop using cue traps revealed that the highest fruit flies adults were attracted during April and May. The catches continued to increase from early March and reached a major peak in mid May (426.00) was followed by a sharp decline in end June. Later a minor peak was seen in late June and the catches sharply declined to reach very low numbers in mid/late July. These fruit flies catches coincided with capsicum fruiting period. Studies by Boopathi *et al*. (2013b) reported that fruit fly was more abundant during April and May on tomato, guava and chilli ecosystems.

Population of fruit flies attracted in cue lure traps were positively significantly correlated with maximum temperature (r = 0.457*) (Table 1). Similarly, Boopathi (2013) reported that maximum temperature had positive correlation with fruit flies catches in tomato ecosystem. Gajalakshmi *et al*. (2011) have also reported positive correlation between trap catches and maximum temperatures and hence support our findings. However, maximum relative humidity (r = 0.074ns) had a positive correlation with fruit flies catches in cue lure traps. But, the influence of minimum temperature (r = -0.398ns), morning relative humidity (r = -0.257ns), rainfall (r = -0.290ns) and rainy days (r = -0.173ns) showed a negative correlation with trap catches of fruit flies. Rainfall found negatively correlated with population of fruit flies in present study had been reported by Gupta *et al*. (1990), Gajalakshmi *et al*. (2011) and Boopathi *et al*. (2013b). Given its wide host range and dispersal capability, the insect poses a serious threat to capsicum in Mizoram. Capsicum growers urgently need information on effective measures to control this new pest in capsicum. Therefore, a study on field and laboratory evaluations of selected insecticides and para-pheromone traps for mass trapping against the *B. tau* has been completed recently. Surveys for potential biological control agents, such as parasitoid wasps and entomopathogenic fungi, are also underway.

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Immune responses of stunted fingerlings of rohu following EUS-infection

Chandan Debnath*, Lopamudra Sahoo, Rekha Das, Abhijit Singha, Jayashree Bhattacharjee, Mrinmoy Datta and SV Ngachan

ICAR Research Complex for NEH Region, Tripura Centre, West Tripura, Tripura

*Correspondence: chandannath23@gmail.com

Introduction

Epizootic ulcerative syndrome (EUS), caused by *Aphanomyces invadans*, is a major concern in the fishes of Tripura and other neighbouring states during winter months. North Eastern (NE) states of India were the first to report problems of EUS during May 1988. During the winter season of 2010-11, several large-scale mortalities (20-50%) particularly in small farms due to EUS have been reported and farmers complained of incurring huge losses (NBFGR News, 2011). Due to these serious impacts, even though more than two decades have been passed after its first occurrence, till today farmers particularly of NE and North India consider EUS as the most damaging disease they encounter in fish culture. Very little information is available about the fundamental mechanisms underlying development and pathogenicity in *A. invadans* infection. A thorough understanding of the basic molecular processes, the nature of interactions with its hosts, the identification of genes involved in these processes and survival strategy of *A. invadans* when there is no disease, could lead to novel control strategies that can reduce disease losses (Phillips *et al*, 2007).

Methodology

To address the issue, an experiment was conducted by infecting the fish artificially with the spores of EUS-pathogen to see the sequential changes of biochemical, enzymatic, immunological and haematological parameters in infected fish. **S**tunted fingerlings of rohu (12.35 cm, 22.10 g) were used for this study. The fish were procured from our ICAR farm and acclimatized in the laboratory. They were fed with a floating type pellet feed (20% CP) @ 3% of their body weight in two divided doses daily. For challenging study, 180 fish from the stock tanks were divided into two groups (control and experimental) with 90 fish each and randomly distributed in 6 FRP tanks (30 fish/tank). They were acclimatized over a period of 1-week in those tanks prior to challenge. Each experimental fish was injected intramuscularly into the flank just below the anterior part of the dorsal fin with 0.1 ml of spore suspension (10^4 spores' ml^{-1}) of *A. invadans*, isolated from *Channa striatus*. The suspension of motile secondary zoospores was prepared as described by Lilley *et al*. (1998). The control fish group received 0.1 ml autoclaved pond water (APW) at the same time as the test fish. Thirty fish, each from control and experimental groups (five fish from each tank) were sampled on 1^{st}, 3^{rd}, 6^{th}, 9^{th}, 12^{th}, 18^{th} and 24^{th} day post infection (dpi) and bled through caudal vein after anesthetizing. An aliquot of the blood was heparinized (50 IU mL^{-1}) and the remaining part was used for collecting serum. Furthermore, at each sampling day, muscle tissue from the injected site of fish each from control and experimental group were preserved in 10% NBF for histopathological analysis. Blood and serum samples, collected from the fish were analyzed for biochemical parameters (blood glucose, serum protein, albumin, globulin, albumin: globulin), enzymatic parameters (GOT, GPT, ALP), immunological parameters (NBT, lysozyme and bactericidal activity) and haematological parameters (RBC, WBC and Hb) following standard protocols.

Results and Discussion

The results showed significant decrease of blood glucose, serum protein, albumin, globulin, GOT, GPT, ALP, lysozyme activity, NBT index, bactericidal activity, RBC and haemoglobin levels and significant increase of WBC count in the infected fish. The levels of changes in these parameters are drastic with the progress of time (Yadav *et al.* 2014). The fungus was re-isolated from the damaged issues of the infected fish to confirm the infection.

From this study, it is clear that, stunted fingerlings of fish which are believed to be hardy and resistance enough against the diseases are also highly prone to EUS infection, hence necessary precautions need to taken while stocking stunted fingerlings for grow-out production of fish.

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Bio-efficacy of bio-agents against pre-emergence and post-emergence mortality of off-season cabbage in Tripura

DP Awasthi*, N Majumder, T Bhattacharjee and N Paul

College of Agriculture, Lembucherra, Tripura West, Tripura.

*Corresponding authors: pathodurga@gmail.com

Introduction

Cabbage (*Brassica oleracea* var *capitata* L.) is one of the most important vegetable crop of Tripura. It is a rich source of sulphur containing amino acids, minerals, carotenes, ascorbic acid and antioxidants and is reported to have anti-carcinogenic property (Singh *et al.* 2009). A variety of fungi like *Pythium, Phytophthora Rhizoctonia, Sclerotium,* are found to be associated with the cause of pre-emergence and post emergence mortality in cabbage due to different diseases like seed rot, root rot, collar rot, stem rot *etc.* Among various management practices biological control of plant pathogens is considered as a potential control strategy in recent years, because chemical control results in accumulation of harmful chemical residues and may lead to serious ecological problems thus, the present case of study was undertaken.

Methodology

Two multi location field trials were designed to test germination and seedling mortality *in vivo* condition. The experiment was designed in Randomized Block Design with 5 treatments replicated to 4 times. The treatments include seed treatment along with soil application of *Trichoderma viridae*, *Pseudomonas fluorescence*, *Bacillus subtilis*, *Carbendazim* and untreated or control plots. The final count for germination was taken at 8 days after sowing. The seedlings were allowed to grow for two weeks. The seeds failed to emerge were taken out of soil to ascertain the percent incidence of seed rot and pre emergence seedling mortality. The seedlings showing symptom of collar rot and rotting and black discoloration of roots and foliage were also noted.

Results and Discussion

Fungi belonging to the genus *Trichoderma* and bacteria such as *Pseudomonas*, *Bacillus subtilis* are the most promising bio-control agent against a range of plant pathogens under a variety of environmental conditions. The results of the present trial also revealed that treatments where bio-control agents were used namely T_2, seed treatment of *Pseudomonas fluorescens* (4g kg^{-1} of seeds) along with soil application of *Pseudomonas fluorescence* (@ 2.5 kg of sand ha^{-1}) and $T_{1,}$ seed treatment of *Bacillus subtilis* (5g kg^{-1} of seeds) along with soil application of *Bacillus subtilis* (@ 2.5 kg of sand ha^{-1}) and were found to be significantly effective against pre and post emergence mortality of cabbage. However other treatments namely T_3, seed treatment with *Trichoderma viridae* (10g kg^{-1} of seeds) along with soil (@ 2.5 kg of dry well rotten farm yard manure ha^{-1}) and T_4, seed treatment with *Carbendazim 50%* (2g kg^{-1} of seeds) were also found to be significantly superior against untreated or control plots.

Mechanism by which antagonistic micro-organisms affect pathogen populations are not always clear but they are generally attributed to direct parasitism, competition with the pathogen for food, direct toxic effects on pathogen, indirect toxic effects on pathogen etc. Bio-agent like *Trichoderma harzianum* parasitizes many pathogens like *Rhizoctonia, Sclerotium, Pythium, Phytophthora* and other fungi like *Fusarium* and *Fomes*. Bacteria of the genera

Bacillus also parasitizes and inhibit pathogens like *Pythium, Phytophthora, Sclerotium, Gaeumannomyces etc.* (Agrios, 2005).

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Molecular characterization of fruit flies of mid hills of Meghalaya

A Manger[1], GT Behere[2]*, DM Firake[2], B Sharma[2], PD Firake[2], D Thubru[2], NA Deshmukh[3] and NS Azad Thakur[2]

[1]*College of Post Graduate Studies (CAU), Umiam-793103, Meghalaya*
[2] *Division of Crop Protection, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya*
[3] *Division of Horticulture, ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya*
*Correspondence: ganeshbehere@gmail.com

Tephritidae is one of the largest families of insect order Diptera having more than 4000 fruit fly species. Among the fruit fly species reported worldwide, 325 species are known to occur in Indian subcontinent, of which 243 belonging to 79 different genera are reported from India alone. Fruit flies of the genus *Bactrocera* (Diptera: Tephritidae) are economically important insect pests of fruits and vegetable crops worldwide including north east India. Fruit fly infested fruits are unfit for human consumption and subsequently unmarketable. Little information is available on existence of fruit fly species in north east India. Moreover, due to the significant morphological similarities in between different species of fruit flies, the reliable identification of these species is very difficult task. To address this issue we monitored and collected over one thousand fruit fly specimens through the year using ME and Cue lure fruit fly traps from fruits (Guava and Peach) and vegetable fields. Collected specimens were separated and identified first on the basis of diagnostic keys and subsequently the molecular characterization was undertaken by using mitochondrial (COI) and nuclear (ITS1, ITS2 and microsatellite) gene/s.

A total of ten species of fruit flies of the genus *Bactrocera* were successfully identified and characterized at molecular level. *Bactrocera* spp.1 which resembles similarities with *B. aethriobasis* and *B. ruiliensis* has been reported first time from India. *B. scutellaris* has been reported first time from North East India. Molecular characterization using mitochondrial COI gene detected four non-synonymous amino acid substitutions in between ten species of fruits flies. ITS I region was found to be highly polymorphic in between species of *Bactrocera*. Little polymorphism were also detected at ITS II region of the genome. Microsatellite locus boms3a was also found to be highly polymorphic in ten *Bactrocera* species. The evolutionary divergence in between ten *Bactrocera* species ranged from 0.7% to 21.9%. Phylogenetic analysis revealed that all the species which infest fruit formed a separate clade while species which infest vegetables formed a separate clade. The information generated from this study would be useful for better designing of management strategies for management of fruit flies as every species has differential response to management practices.

Effect of different dates of planting time on prevalence on tomato yellow leaf curl virus on tomato genotypes

Hemavati Ranebennur*, Subrata Biswas, Lopamudra Sahoo, Gangaranidevi and Pinki Pal

ICAR Research Complex for NEH Region, Tripura Centre, Tripura
*Correspondence: hemaiari@gmail.com

Introduction

Tomato (*Lycopersicon esculentun* Mill.) is one of the good and most widely grown vegetable crops, used mainly in Indian cooking, as well as processed products like sauce, pickle, ketchup, puree, dehydrated and of whole tomatoes. The total production of tomato in Tripura 38,060 MT/ha from an area of 1555 Ha, which shows the potential to increase the productivity. With a invention to save the crop from the disease. Among the factors responsible for low yield of tomato, viral diseases are considered as the most serious. Tomato is susceptible to more than 200 diseases out of which 40 are caused by viruses. During last two decades the virus has emerged as devastating one, causing economic loss of up to 100% in many tropical and sub tropical regions. In many cases TYLCV epidemics lead to abandonment of the crop particularly in seasons/ periods favouring whitefly population build up (Pico *et al*. 1996). A recent socio economic survey ranked Tomato leaf curl virus (TLCV), transmitted by *Bemisia tobaci*, as the most important disease causing virus of tomato (chowda *et al*, 2004). Epidemics of tomato leaf curl virus associated with upsurge of whiteflies (*Bemisia tobaci*) on tomato crops has to 100% yield losses. There are 21 different types of Tomato leaf curl viruses prevalent in India and the disease is manifested by yellowing of leaves, upward leaf curling, bushy growth, excessive branching, abnormal growth of plants and flower and fruit abscission. Considering the above facts the present study was undertaken to know the effect of sowing dates on different varieties grown in Tripura.

Methodology

A total of twelve varieties of tomato namely H-24, Tura- Local, All-rounder, BT-10, BT-1, Type-1, Trishul, Arka Abha, Sikkim local, Hisar Arun, Selection-1 and H-608 collected and maintained at ICAR Research Complex for NEH Region, Tripura centre, Plant Pathology Division were evaluated for the tomato leaf curl virus. The experiment was conducted during winter season (2014-15). The tomato seedlings were raised in a seed bed (3.0m × 1.0m) at every 15 days interval starting from October 15 to January 15. Thirty days old seedlings of each variety were transplanted in 3 replications arranged in randomized block design. The plot size was kept (3.2m × 2.65m) and 24 seedlings were transplanted in each plot with a spacing of 60 × 45cm. TYLCV symptoms were diagnosed according to the description of leaf curl and yellowing viruses of pepper and tomato: an overview by Green and Kalloo (1994). TYLCV incidence (%) and gradation were done where HR (Highly Resistant) = no leaf curl symptom, R (Resistant) = 1-25% plants infected, MR (Moderately Resistant) = 26-50% plants infected, MS (Moderately Susceptible) = 76-100% plants infected (Begun and Khan, 1996). The yield of each tomato plot was also recorded. The field experimentation and the sample selection were carried out according to the standards of the randomized Block designs. The data was analysed with the SPSS software using one way ANOVA.

Results and Discussion

The overall results showed that TYLCV incidence was significantly ($P \leq 0.05$) higher in October and December planting than that of November planting. Among the twelve varieties in the experiment the highest TYLCV incidence 83.32 was observed in the Variety BT-1 of December 2014 planting followed by 79.16 in the October planting .The lowest TYLCV observed variety Tura-Local (12.2) in November planting followed by 14.43 in October 2014 planting Tura-Local, Trishul and All rounder performed better among the varieties.

Table 1. Mean TYLCV incidence (%) values observed during different dates of planting

Tomato variety	Early planting (Oct15-Nov15)	Mid planting (Nov 15 – Dec 15)	Late planting (Dec 15-Jan 15)
H-24	33.00^{b}	18.10^{abc}	27.73^{abc}
Tura- Local	14.43^{a}	12.20^{a}	19.13^{ab}
All- rounder	29.30^{b}	14.58^{ab}	13.32^{a}
BT-10	54.16^{c}	34.72^{de}	44.44^{bcd}
BT-1	79.16^{e}	40.86^{e}	83.32^{e}
Type-1	70.83^{e}	52.92^{f}	77.77^{e}
Trishul	24.96^{ab}	12.48^{a}	20.16^{abc}
Arka Abha	58.21^{c}	29.16^{cde}	58.33^{de}
Sikkim local	34.60^{b}	$24.99b^{cd}$	45.83^{cd}
Hisar Arun	62.49^{cd}	$25.00b^{cd}$	66.66^{de}
Selection-1	36.11^{b}	29.16^{cde}	41.66^{bcd}
H-608	29.16^{b}	16.63^{ab}	29.16^{abc}

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Metarhizium anisoplaie can artificially established as a potential fungal endophyte in tea for eco-friendly pests management

Himadri Kaushik* and Pranab Dutta

Assam Agricultural University, Jorhat, Assam

*Correspondence: himadrikaushik18@gmail.com

Introduction

Pioneering work on entomopathogenic endophytes was conducted using maize (*Zea mays* L.), *B. bassiana*, and the European corn borer, *Ostrinianubilalis* (Hu¨bner). Since then fungal endophytes are known to mediate plant defense as a novel biological control mechanism. But little is known about the interaction between the endophyte, host plant and pathogen and understanding the interaction is essential for the development of proper biocontrol strategy. The ecological function of endophytic fungal entomopathogens remains largely known but some worker implicated them on plant growth, herbivore resistance and disease resistance. Endophytes are gaining attention as asubject for research and applications in Plant Pathologybecause in some cases plants associated to endophytes have shown increased resistance to plant pathogens, particularlyfungi and nematodes. Entomopathogens like *Metarhizium anisopliae*, has been reported to colonize the plant rhizosphere and plant roots. But no work has been done in establishing the entomopathogen in tea ecosystem more particularly in an organic ecosystem. Therefore, in the present study we have aimed in establishing fungal entomopathogen *M. anisopliae* as an endophyte in the organic tea ecosystem of Assam.

Methodology

To study the endophytic activity of *M. anisopliae* in the tea ecosystem of Assam, three plots of 400 m^2 area were selected under organic tea garden (Banaspaty Tea Estate of Tea Promoters Group of India, Kolkata, India which is situated in Karbi-anglong district of Assam, India). One for foliar spray, second one was for soil drenching and a control plot was also maintained where only water was sprayed. Distance between the plots was maintained as 500 m. Four months after the first spray samples (leaf, stem and roots) were collected and washed thoroughly with double distilled water. Samples were then surface sterilized by immersing them for two minutes each in 5% sodium hypochlorite (NaOCl) and two minutes in 70% ethanol followed by rinsing for three times in sterile distilled water and were allowed to dry in sterile paper towel. Outer edge of the samples was dissected and discarded. Six sections were made from the trimmed sample and were being placed on PDA medium supplemented with antibiotics. Inoculated plates were finally kept in BOD incubator, at 28±1°C. Observations on fungal colonies were taken and those considered as positive results were randomly selected and transferred to PDA slants. Plant tissue samples, which showed growth of the entomopathogenic fungi on PDA plates, or uninoculated controls, were used for microscopic observations. For light microscopy samples were thin sectioned with a sterilized razor blade and then stained with 0.17% (w/v) cotton blue in lactic acid on a clean glass slide. Alternatively, for SEM study samples sections were fixed overnight at 4^0C in 4% glutaraldehyde in 0.05 M phosphate buffer (pH 7.3) and rinsed three times (10 min each) in phosphate buffer. Samples were then dehydrated in an ethanol series to 100% ethanol. Samples were critical point dried (Balzar).

Result and Discussion

In the present study we have found that *M. anisopliae* was able to colonize endophytically *Camellia sinensis* as could recovered from the samples collected from inoculated treatments which may be due to penetration of inoculum through abaxial sides of leaves. Foliar spray resulted in endophytic colonization of *M. anisopliae* in over 27.8% in leaves, 22.2% in roots and 16.7% in stems while soil drenches resulted 50.0% in roots and 33.33% in stems of the treated plants (Table 1). Low recovery of *M. anisopliae* from spray inoculation could be due to specific cuticular components on the leaf and lack of stomata on the adaxial side as observed by Posada *et al*. (2007) in coffee.

The present work also confirmed the presence of fungal colonization in the xylem of apparently healthy plant parts providing evidence that supports "latent infection hypothesis" proposed by Boddy and Rayner (1983). From the histological studies though *M. anisopliae* was found to present physically in inter and intracellular spaces but did not show any disease symptoms and plants were healthy and these were less infested by pests.We have also found conidia and conidiophores of *M. anisopliae* in the vascular bundles. This fact could explain fungal colonization by means of vascular bundle connections (Paniagua *et al.* 1996). But in the present investigation extensive mycelial ramification and conidial production was observed on the leaf surface and in both intra and intercellular space.

Table 1. Post inoculation colonization (%) of *M. anisopliae* in tea plants after four months of inoculation via foliar spray and soil drench

Treatments	n*	Leaves				Stems				Roots			
		Control		Treated		Control		Treated		Control		Treated	
		+	%	+	%	+	%	+	%	+	%	+	%
Foliar spray	6.0	0.0	0.0	10.0	27.8	0.0	0.0	6.0	16.7	0.0	0.0	8.0	22.2
Soil drench	6.0	0.0	0.0	5.0	13.9	0.0	0.0	12.0	33.3	0.0	0.0	18.0	50.0

*each plate contains 6 sections i.e. 6 plates =36 sections

$$\% \text{ colonization} = \frac{\text{No. of colonized plant sections}}{\text{No. of cultured sections}}$$

s. Similar observation was also reported by Lopez-Llorca *et al.* (1999) in date palm when they did the experiment on histopathological study on infection with *Penicillium vermoesenii*. According to Kuldau and Bacon (2008), intracellular spaces actually have many organic and inorganic nutrients that are able to support the concentration of endophytic fungi.

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Efficacy of some bio- pesticides against tobacco caterpillar in cabbage

Otto S Awomi, Imtinaro L* & Pankaj Neog

SASRD, Nagaland University, Medziphema, Nagaland
*Correspondence: imtinaro2012@yahoo.com

Introduction

Cabbage is an important Cole crop all over the world. It is attacked by number of insect pests. *Spodoptera litura* Fab.is one among them which is also a serious pest in cabbage growing areas in Nagaland resulting in poor yield of the crop. Several insecticides have been recommended through ages to avert pest damage (Ghosh *et al*. 2001). But, almost all of them are obsolete due to development of insect resistance to insecticides (Mehrotra 1993) and there is possibility of presence of residues in the edible parts. The present investigation was undertaken with eco-friendly bio pesticides at various doses and compared with the local check insecticide.

Methodology

A field experiment was laid out in Randomised Block Design during October 2013 to January 2014 at the instructional farm, SASRD, N.U., Medziphema Campus, Nagaland to evaluate the efficacy of some bio- pesticides against tobacco caterpillar, *Spodoptera litura*. Cabbage variety 'Golden Acre' was sown in plots of size 1.8m x 1.8m at spacing of 45 x 45 cm with 10 treatments (table 1) replicated thrice. First spray was initiated after the appearance of the pest population and the second and third application were carried out after 15 days intervals using hand compression sprayer. Observations were recorded on the populations of *Spodoptera litura*on 5 randomly selected plants treatment-wise at one day before spraying (DBS) as pre- treatment count and at 5 and 10 days after each spraying (DAS). Data obtained were subjected to statistical analysis after appropriate transformations.

Results and Discussion

At 5 DAS of the first spray the percent reduction in the larval population of *Spodoptera litura* Fab. varied from 13.06 to 65.66%. The highest reduction of the larval population was recorded in the plots treated with Chloropyrifos with 65.66% followed by Max Neem oil (4 ml/l) with 39.72% , Neem oil (2 ml/l) with 37.20%, Max neem oil (3 ml/l) with 35.00%, B-1 (3 ml/l) with 34.62%, cassava leaf extract with 25.56%, B-1 (2 ml/l) with 24.43%, Ash with 20.69% and tobacco was recorded with the lowest per cent reduction with 13.06%.

The data on per cent reduction in the mean larval population 5 DAS of the second spray as influenced by different treatments ranged between 13.43 to 68.61%. The highest per cent reduction again recorded in plots treated with Chlorpyrifos with 68.61% followed by Max neem oil (4 ml/l) with 42.37%, cassava leaf extract with 40.58%, Max neem oil (3 ml/l) with 39.44%, Neem oil (2 ml/l) with 37.05%, B-1 (3 ml/l) with 33.33%, B-1 (2 ml/l) with 30.63%, Ash with 27.30% and tobacco showed the lowest per cent reduction of the mean larval population with 13.43%.

The data recorded on the effect of the treatments over the mean larval population after 5 DAS of the third spray explains that the per cent reduction varied from 14.76 to 65.28%. The highest reduction of mean larval population was recorded in the plots treated with the standard chemical insecticide Chlorpyrifos with 65.28% while Max neem oil (4 ml/L) recorded highest reduction in the larval population among all bio-chemical treatments with 38.57% followed by cassava leaf extract, B-1(3 ml/l), Max neem oil (3 ml/l), Neem oil (2 ml/l), B-1 (2 ml/l), Ash and tobacco with 36.94, 36.57, 35.56, 31.35, 30.83, 24.44 and 14.76% respectively. Tobacco recorded the lowest per cent reduction of 14.76 %.

At 10 DAS of the first spray the percent reduction in the larval population of *Spodoptera litura* Fab. varied from 9.55 to 73.63%. The highest reduction of the mean larval population was recorded in the plots treated with Chlorpyrifos with 73.63% followed by cassava leaf extract with 38.61%, Max neem oil (4 ml/l) with 33.53% , Max neem oil (3 ml/l) with 30.00%, B-1 (3 ml/l) with 28.96%, neem oil (2 ml/l) with 27.34%, Ash with 26.11%, B-1 (2 ml/l) with 25.77%, and tobacco was recorded with the lowest per cent reduction with 9.55%.

The data on per cent reduction in the mean larval population 10 DAS of the second spray as influenced by different treatments ranged between 7.87 to 76.11%. The highest per cent reduction again recorded in plots treated with Chlorpyrifos with 76.11% followed by Max neem oil (4 ml/l) with 39.34%, Max neem oil (3ml/l) with 38.39%, Neem oil (2 ml/l) with 33.54%, B-1 (3 ml/l) with 33.33%, cassava leaf extract with 28.97%, B-1 (2ml/l) with 27.86%, Ash with 22.70% and tobacco showed the lowest per cent reduction of the mean larval population with 7.87%.

The data recorded on the effect of the treatments over the mean larval population after 10 DAS of the third spray explains that the per cent reduction varied from 10.00 to 78.33%. The highest reduction of mean larval population was recorded in the plots treated with the standard chemical insecticide Chlorpyrifos with 78.33% while Max neem oil (4 ml/l) recorded highest reduction in the larval population among all bio-chemical treatments with 34.14% followed by Max neem oil (3 ml/l), B-1(3 ml/l), Neem oil (2 ml/l), cassava leaf extract, B-1 (2 ml/l), Ash and tobacco with 33.33, 33.23, 30.63, 23.33, 22.41,18.76 and 10.00% respectively. Tobacco recorded the lowest per cent reduction of 10.00%.

In all the sprays both the chemical as well as the bio-chemical treatments were found to be effective in reducing the larval population of *Spodoptera litura* Fab.in cabbage. The conventional insecticide treatment of Chlorpyrifos was found to give the highest reduction with mean per cent reduction of 71.27%, while among the bio-chemicals Max Neem oil treated @ 4 ml/l gave the best result in reducing the larval population with the mean per cent reduction of 37.94%. All treatments with Azadirachtin as a chief constituent *viz.,* Max neem oil at 4 and 3 ml/l, neem oil at 2 ml/l and B-1 at 3 and 2 ml/l, gave a considerable result with the mean per cent reduction ranging between 26.98 to 37.94% while tobacco was found to be least effective even with its reduction percent.

The present findings got support from the observation of Khan *et al*. (2011) who found Chlorpyrifos to be highly toxic against *Spodoptera litura.* the present results are also in line of the work carried out by Deota and Upadhyay (2005) who reported that both *Azadirachta indica* showed both toxicity and antifeedent effect against *Spodoptera litura* thus reducing the population. Misra (2009) also reported that significant reduction in percent head damage due to *S. litura*was recorded in Neem@5 and 6ml/lit at 10 DAS as compared to reduction over control. However, with other doses of neem, the reduction in head damage due to *S. litura*was significant. The Hindu (2013) has also reported that at Pallichal in Thiruvananthapuram, where the cassava bio-pesticide was applied get rid of pseudo stem weevil pests, this substance has proved to be effective in controlling the insect pests. Similarly, the present findings also showed that, it could control the *S. litura* to some extent.

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Biodiversity of mushrooms of western part of Tripura

Jayashree Bhattacharjee*, Debashre Bhattacharjee, Tapas Paul and Arvind Kumar

ICAR Research Complex for NEH Region, Tripura Centre, Lambucherra

*Corresponding author: jayashreebhatt89@gmail.com

Introduction

Mushrooms are in fact the 'fruit' of the underground fungal mycelium. They are macromycetes forming macroscopic fruiting bodies such as agarics, boletes, jelly fungi, coral fungi, stinkhorns, bracket fungi, puffballs and bird's nest fungi. Among fungi, Basidiomycotina in particular have attracted considerable attention as a source of new and novel metabolites with antibiotic, antiviral, phytotoxic and cytistatic activity. Mushrooms alone are represented by about 41,000 species, of which approximately 850 species are recorded from India (Deshmukh *et al.* 2004) mostly belonging to Agaricales, also known as gilled mushrooms (for their distinctive gills), or euagarics. The order has 33 extant families, 413 genera and over 13000 described species (Kirk *et al.* 2008). Mushrooms have been extensively studied in the western countries, while tropical countries like India especially in North-East India these were are less explored the variety and diversity of basidiomycetes fungi were found more in North-east region. Our main objectives was to benchmark diversity of macro fungi, characterize, collect preserve and evaluate edibility of these different species in semi evergreen and deciduous forest of North-east region in India.

Methodology

Our study area was mainly western parts of Tripura like Arundhutinagar, ICAR complex and Nandan Nagar. The fungal surveys depend on timing and location of observations. The survey methods were adopted according to techniques adopted by Natrajan *et al.* (2005). Systematic and periodical survey of different forest and other habitats rich with organic matters of North-East forest were undertaken during July 2013 to September 2013. Necessary materials and equipments such as isolation kit, slants, petridishes containing medium, isolation chamber, typed data sheet, digital camera for photography, digging equipment, heat convector card board, chemical reagents for biochemical analysis were arranged and collection of samples were usually made during day time and field characteristics of mushrooms were recorded in the data sheet which prepared as per (Natarajan *et al.* 1978). Simultaneously a spore print was prepared by placing the pileus downwards where a black and white paper (half white and half black) was covered with bell jar, further biochemical spot test and other necessary processing were carried out. The standardization of specific media (solid and liquid) and various conditions for cultivation of specific fungi are major steps as done by other workers (Rahi 2001).

Result and Discussion

During the systematic surveys at different parts of North East region forest, total 5 mushroom samples were collected. Species were Shiitake (*Lentinula edode*), Maitake (*Grifola frondosa*), Reishi (*Ganoderma lucidum*), Oyster mushroom (*Pleurotus ostreatus*), White button mushroom (*Agaricus bisporus).*

Table 1. List of identified wild mushrooms at western part Tripura

Order	Family	Genus	Species	Edibility
Agaricales	Marasmiaceae	*Lentinula*	*Lentinula edode*	Edible mushroom
Polyporales	Meripilaceae	*Grifola*	*Grifola frondosa*	Edible mushroom
Polyporales	Ganodermataceae	*Ganoderma*	*Ganoderma lucidum*	Medicinal mushroom
Agaricales	Pleurotaceae	*Pleurotus*	*Pleurotus ostreatus*	Edible mushroom
Agaricales	Agaricaceae	*Agaricus*	*Agaricus bisporus*	Edible mushroom

The most dominant species is *Lentinula edode* which is most dominant in rainy season (11.09%) followed by *Grifola frondosa* (9.07%). The most dominant species of over data *Lentinula edode* (7.83%) followed by *Pleurotus ostreatus* (7.01%).

Table 2. Abundance of wild mushroom at western part Tripura

Name of the species	Species no in rainy season	Species no in winter season	Abundance in rainy season	Abundance in winter season
Lentinula edode	55	48	11.09	7.32
Grifola frondosa	45	16	9.07	2.44
Ganoderma lucidum	18	18	3.63	2.74
Pleurotus ostreatus	3	43	0.60	6.55
Agaricus bisporus	14	13	2.82	1.98

The most species of over data Shiitake (*Lentinula edode*), Maitake (*Grifola frondosa*), Reishi (*Ganoderma lucidum*), White button mushroom (*Agaricus bisporus*), in low altitude forest in Tripura. While in other hand Oyster mushroom (*Pleurotus ostreatus*), mostly available in high altitude forest in western. The mushroom diversity and Species richness was found to be maximum in ICAR complex followed by Arundhutinagar then Nandan nagar. Shiitake (*Lentinula edode*) (11.09%) was most dominant in rainy season (Table no 1) Shiitake (*Lentinula edode*), Maitake (*Grifola frondosa*) mushroom found almost all areas of North East region. Oyster mushroom (*Pleurotus ostreatus*), was found mainly cool and more abundance in winter season compare with rainy season.

Lentinula edode was most dominant in rainy season followed by *Grifola frondosa*. while *Lentinula edode*, *Pleurotus ostreatus* was dominant in winter. Shiitake (*Lentinula edode*) was the most abundant species during the rainy and winter seasons. The mushroom diversity and Species richness was found to be maximum in ICAR Complex followed by Arundhuti Nagar.

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Integrated weed management in dry sown direct seeded rice in Tripura

M Chakraborti[1]*, B Duary[1], M Datta[2]

Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal

ICAR Research Complex for for NEH Region, Tripura Centre, Lembucherra

*Correspondence: cmandira1@rediffmail.com

Introduction

Rice (*Oryza sativa* L.) is the major food crop of Tripura. It is predominantly grown by transplanting in the State. But due to water and labor scarcity, farmers are shifting to direct seeded method of rice establishment. However, weeds are one of the limiting factors in direct- seeded rice, which reduce the yield to the tune of 50-100% (Mishra and Singh 2007). Herbicides are promising tools for weed management in modern agriculture, but sole application of herbicides many a times fails to tackle wide spectrum of weeds throughout the critical period of crop weed competition in direct seeded rice. Therefore, development of effective and integrated weed management practices is essential for sustainable rice cultivation. Keeping these points in view, present investigation was carried out to find the suitable integrated weed management practices for the direct seeded rice in Tripura.

Methodology

A field experiment was conducted at Krishi Vigyan Kendra, South Tripura during the *kharif* (wet) season of 2013 using rice variety *'NDR-97'*to evaluate the efficacy of different weed management practices on weed growth and productivity of upland direct seeded rice. Twelve treatments *viz.* pendimethalin at 1.0 kg/ha at 2 DAS (T1), pendimethalin at 1.0 kg/ha + one manual weeding at 30 DAS (T2), pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac sodium at 25 g /ha at 20 DAS (T3), fenoxaprop at 60 g /ha + metsulfuron-methyl and chlorimuron-ethyl (Almix) at 4 g /ha at 15 DAS(T4), bispyribac sodium at 25 g /ha at 20 DAS (T5), metsulfuron-methyl and chlorimuron (Almix) at 4 g /ha at 10 DAS followed by bispyribac sodium at 20 g /ha at 20 DAS (T6), pyrazosulfuron ethyl at 25 g /ha at 3 DAS followed by bispyribac sodium at 20 g /ha at 20 DAS (T7), stale seed bed + smother crop (cowpea) (T8), stale seed bed + one hand weeding at 30 DAS (T9), Sesbania (broadcast) + 2,4-D at 500 g /ha at 25 DAS (T10), three hand weedings at 20, 30 and 45 DAS (T11) and unweeded control (T12) were assigned in a randomized block design replicated thrice. Recommended package of practices were followed in raising the crop.

Results and Discussion

Weed flora present in the experimental field were *Amaranthus viridis, Oldenlandia corymbosa, Spilanthes acmella, Ludwigia parviflora, Cleome rutidosperma, Malvestrum coromondalianeum* among the broad leaf weed, *Digitaria sanguinalis* among grasses and *Cyperus iria* among sedges.

Table 1. Effect of treatments on density and dry weight of weeds, weed control efficiency, yield components and yield of direct seeded rice

Treatments	Weed density (no./m^2) at 60 DAS	Weed dry wt. (g/m^2) at 60 DAS	Weed control efficiency (%) at 60 DAS	No. of panicles /plant	No. of grains / panicle	Test weight (g)	Grain yield (t/ha)
Pendimethalin at 1.0 kg/ha at 2 DAS	78.33	148	41.17	9	72	23.26	2.24
Pendimethalin at 1.0 kg/ha + one manual weeding at 30 DAS	25.33	41.33	83.57	16	116	23.45	3.74
Pendimethalin at 1.0 kg/ha at 2 DAS + bispyribac sodium at 25 g/ ha at 20 DAS	22.67	35.83	85.76	16	120	23.19	3.80
Fenoxaprop at 60 g /ha + metsulfuron-methyl and chlorimuron-ethyl (Almix) at 4 g /ha at 15 DAS	55.67	108.96	56.69	9	89	23.20	2.79
Bispyribac sodium at 25 g /ha at 20 DAS	55.00	118.84	52.76	10	84	23.28	2.66
Metsulfuron-methyl and chlorimuron (Almix) at 4 g /ha at 10 DAS followed by bispyribac sodium at 20 g /ha at 20 DAS	55.33	111.03	55.87	9	85	23.59	2.72
Pyrazosulfuron ethyl at 25 g /ha at 3 DAS followed by bispyribac sodium at 20 g /ha at 20 DAS	49.00	102.87	59.11	12	97	22.87	2.84
Stale seed bed + smother crop (cowpea)	60.00	115.57	54.06	12	90	23.34	2.65
Stale seed bed + one hand weeding at 30 DAS	66.00	128.6	48.88	10	87	23.51	2.51
Sesbania (broadcast) + 2,4-D at 500 g /ha at 25 DAS	77.00	140.08	44.32	11	83	23.42	2.29
Three hand weedings at 20, 30 and 45 DAS	19.33	29.02	88.46	17	120	23.28	3.95
unweeded control	112.33	251.57	0	6	63	23.07	1.08
CD (0.05%)	6.46	13.47	-	2.33	4.93	NS	0.16

The lowest weed density and dry weight at 60 DAS were registered with hand weeding thrice at 20, 30 and 45 DAS which was statistically at par with pendimethalin + bispyribac sodium (T3) and pendimethalin + one manual weeding (T2). Similar result was also reported by Bhurer*et al.*, (2013) in direct seeded rice. Hand weeding at 20, 30 and 40 DAS (T11) registered the highest weed control efficiency closely followed by pendimethalin + bispyribac sodium (T3) and pendimethalin + one manual weeding (T2). The highest no. of panicles/plant, no. of grains per panicle and grain yield were recorded with hand weeding thrice at 20, 30 and 45 DAS which was statistically at par with pendimethalin + bispyribac sodium (T3) and pendimethalin + one manual weeding (T2). The test weight of rice did not vary significantly. Effective and timely weed management under these treatments reduced the density as well as dry weight of weeds which facilitated the crop to have sufficient space, light, nutrient and moisture and thus the number of panicles per plant, number of grains per panicle and finally the yield was increased. Thus it may be concluded that pre-emergence application of pendimethalin at 1.0 kg /ha + bispyribac sodium at 25 g/ha at 20 DAS appeared to be most effective for higher weed control efficiency and obtaining higher yield in direct seeded rice in Tripura.

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Seasonal prevalence of gastrointestinal parasites in goats of Meghalaya

M Das*, R Laha, A Goswami and A Sen

ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya
*Correspondence: meenad3@gmail.com

Introduction

Domestic goat is among the earliest animals domesticated by man and is distributed worldwide with higher concentrations in tropical areas and in dry zones (Di Cerbo *et al.* 2010). Goats are excellent meat producers for human consumption in view of its short generation intervals and the absence of religious taboos associated with their meat as they are rich sources of protein (Ozung *et al.* 2011). Gastrointestinal parasitic infections are common in goats causing considerable economic losses. For controlling gastrointestinal parasitism, information about the epidemiology of gastrointestinal parasites on a regional basis is important. Hence, in the present study the seasonal prevalence of gastrointestinal parasites in goats of hilly region of Meghalaya is reported.

Methodology

To know the diversity of gastrointestinal parasitic infections in goats of hilly region of Meghalaya, a total of 834 fecal samples of goats were collected per rectum from April 2014 to March 2015 from organized farms. Rectal fecal samples were collected manually in suitable containers and labeled carefully. To find out the eggs/ova/cyst of helminths and protozoa, samples were examined by flotation techniques (Soulsby 1986 and Annon. 1977). Samples were preserved and stored at refrigerated temperature (4ºC) for next day examination.

The egg per gram (EPG) and oocyst per gram (OPG) of feces were estimated by modified McMaster technique. Fecal samples found positive for strongyle group of parasites was subjected to coproculture for obtaining third stage infective larvae (L_3). The pooled faecal samples was finely broken and mixed with sufficient quantity of activated charcoal. The mixture was then packed loosely in glass culture dishes and incubated at 27ºC for 7 days as per the described procedure (Annon. 1977). The L_3 was subsequently harvested and identified according to Soulsby (1986). Sporulated oocysts of *Eimeria* sp. was obtained by mixing feces containing oocyst of *Eimeria* sp. with 2.5% potassium dichromate solution as per the procedure described by Bhatia (2000).

Results and Discussion

The overall prevalence of G.I. parasitic infections was 28.65%. Season-wise highest infections was recorded during rainy season (34.92%) followed by cool (26.86%), hot (26.61%) and cold (20.38%) seasons (Table 1). Helminths and protozoa infections were recorded in 63.60% and 23.02% animals, respectively. Among the helminths, Strongyle sp. (32.63%) was recorded highest followed by *Strongyloides* sp. (12.55%), *Moniezia* sp. (10.04%) and *Trichuris* sp. (8.36%). Among protozoa, only *Eimeria* sp. (23.02%) was detected. Mean egg per gram (EPG) and oocyst per gram (OPG) of feces were 592.23 and 345.28, respectively. Mixed infections with various G.I. parasites were also recorded in 3.38% samples. Coproculture of goat fecal samples revealed presence of *Haemonchus contortus* (66.33%), *Oesophagostomum* sp. (26.83%), *Strongyloides* sp. (4.12%) and *Trichostrongylus* sp. (2.70%) larvae. Monthly fecal examination revealed prevalence of helminths and *Eimeria* sp. in goat throughout the year (Table 1). Minimum and maximum prevalence of helminths was recorded in the month of January (7.47%) and August (33.83%), respectively. *Eimeria* sp. was recorded highest in the month of January (41.66%) and lowest in August (7.14%). Seven different species of *Eimeria* sp. were identified after examining sporulated oocysts *viz. E. christenseni, E. hirci, E. caprina, E. jolchijevi, E. ninakohlyakimovae, E. arloingi* and *E. kocharii* for the first time from Meghalaya.

In the present study, the prevalence of G.I. parasitic infections in goats was observed throughout the year. The present finding was in accordance with Olanike *et al*. (2015) who reported prevalence of helminths and protozoan parasites (*Strongyle* sp., *Strongyloides* sp. and Coccidia) in the intestinal tract of goats. Prevalence of *Eimeria* sp. (23.02%) in the present findings is in agreement with the findings of Iqbal *et al*. (2012) from Jammu who reported 54.42 % *Eimeria* sp. infection in goats. Iqbal *et al.* (2012) observed highest infection rate in kids (74.48%) than adult goats (33.33%). The prevalence of *Eimeria* throughout the year might be due to non administration of coccidiostat or coccidicidal drugs by the farmers. This shows that the climate in this region is exclusively conducive for the development and propagation of parasites. Other factors which might be responsible are constant exposure to infections, continuous deposit of infections on the pastures by adult animals as well as poor animal husbandry practices.

Table 1. Seasonal prevalence of G.I. parasites in goats of Meghalaya

Season	Goat	
	Sample examined	No. positive
Rainy season (May - Sept.)	355	124 (34.92%)
Cool season (Oct. – Nov.)	134	36 (26.86%)
Cold season (Dec. – Feb.)	206	42 (20.38%)
Hot season (Mar – Apr.)	139	37 (26.61%)

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Applications of stem cells in veterinary medicine: Overview

N Masharing, Suresh Kumar, N Mahanta, RK Dewry and Ashok Kumar*

ICAR Research complex for NEH Region, Umiam, Meghalaya
*Correspondence: drashokkumar39@gmail.com

The stem cell field in veterinary medicine continues to evolve rapidly both experimentally and clinically. Stem cells are most commonly used in clinical veterinary medicine in therapeutic applications for the treatment of musculoskeletal injuries. New technologies of assisted reproduction are being developed to apply the properties of spermatogonial stem cells to preserve endangered animal species which can also be used to generate transgenic animals for production of pharmaceuticals or for use as biomedical models. Small and large animals serve as valuable models for preclinical evaluation of stem cell applications in human beings and in veterinary, in areas such as spinal cord injury and myocardial infarction. Reviews on the use of animal models for stem cell research have been published recently. Therefore, in this overview, animal model research will be reviewed only in the context of supporting the current clinical application of stem cells especially in veterinary medicine.

Insect and mite pest complex of pigeon pea in agro ecosystem of Tripura, a North Eastern state of India.

N Nair[1*], B C Thangjam[1], M R Debnath[2]
[1] *College of Agriculture, Tripura*
[2] *Horticulture Research Staion, Nagicherra, Tripura.*
Correspondence: navendunair@gmail.com*

Introduction

Pigeon pea (*Cajanus cajan* (Linn.) Millsp.) is one of the most important pulse crop grown in India for its high protein content (24%). Growing of pulses including Pigeon pea in Tripura is gaining momentum in recent years. Pigeon pea harbours a good number of Pests which may assume serious proportions particularly during the reproductive stage of the crop. The major constraint in the production of pigeon pea is the damage caused by insect pests with avoidable losses extending up to 78% in India (Lateef and Reed 1983). Information pertaining to occurrence of pests on any crop grown in a particular locality or region is of prime importance in order to formulate suitable integrated pest management strategy. Such information on pigeon pea is lacking from Tripura, a North Eastern state of India. Therefore, the present work is envisaged to study the diversity of pests of pigeon pea in this state.

Methodology

Pigeon pea crop (variety: UPAS-120) was grown under AICRP on pigeon pea in the campus and experimental farm of the College of Agriculture, Lembucherra, Tripura. Insect pests occurring on pigeon pea plants were observed at weekly intervals from 50 randomly selected plants/site during the period from August 2014 to October, 2015. Different species of bugs *viz.*,coreid bugs, pentatomid bugs, scutellarid bugs, plataspidid bugs, mired bugs and membracid bugs were counted on whole plant basis by visual search method and recorded separately. For jassid average number of adults and nymphs, and for white fly average number of adults per leaf were counted from randomly selected 5 leaves/ plant. For external pod borers, number of larvae was counted by visual search method on whole plant basis. For *Maruca* number of webs of flower buds due to *Maruca* on whole plant basis were counted and recorded. For pod fly, apion and *Etiella zinckenella* per cent of pods infested by each species was counted from randomly collected 100 pods. Blister beetles, chaffer beetles, weevils, hairy caterpillars and defoliators were counted as number of damaging stage (adult or larva) on whole plant basis. For leaf folder, number of larvae was counted by opening the webbed leaves on the plant on whole plant basis. Number of flower thrips was recorded from randomly selected 5 flowers/ plant.

Results and Discussion

A total of 42 insect pests belonging to 7 orders and 28 families and one acarine pest were recorded during the present study, of which maximum number of species were belonging to Order Hemiptera (19 nos.) followed by Lepidoptera (11 nos.) and Coleoptera (6 nos.).

Out of total 42 species of pests recorded during the present study, ten species *viz.*, *Maruca vitrata* (=*testulalis*), *Melanagromyza obtusa*, *Apion clavipes*, *Empoasca kerri*, *Bemisia tabaci*, *Aphis craccivora*, *Odontotermes* sp., *Microtermes* sp., *Myzus persicae*, and *Aceria cajani* have been recorded as the major pests in the field. Eight species *viz.*, *Helicoverpa armigera*, *Exelastis atomosa*, *Etiella zinckenella*, *Lampides boeticus* and *Catochrysops strabo*, *Riptortus pedestris*, *R. linearis* and *Megalurothrips usitatus* were recorded to cause moderate damage and thus can be categorized as moderate pests. Five species *viz.*, *Clavigralla gibbosa*, *Coccidohystrix insolita*, *Oxyrhachis tarandus*, *Coptosoma cribreria* and *Grapholita critica*, were recorded as the pests of minor status and 16 species *viz.*, *Porthesia scintillans*, *Dasichira mendosa*, *Neostauropus alternus*, *Mylocerus dorsatus*, *Mylabris pustulata*, *Oxycetonia versicolor*, *Dolicoris Indicus*, *Piezodorus hybneri*, *Menida Formosa*, *Plautia crossota*, *Nezara viridula*, *Poppiocapsidea biseratense*, *Cletus punctiger*, *Chrysocoris stolli*, *Ceroplastodes cajani* and *Megachile* sp. were recorded as negligible pests as these species were represented by very less number of individuals in the field. Two species of pulse beetle *viz.*, *Callosobruchus chinensis* and *C. maculatus* and the Grain moth, *Sitotroga cerealella* were observed severely infesting the seeds in the storage and assume the status of major pests of pigeon pea seeds in storage.

All parts of the pigeon pea plant have been found to be infested by different insects, of which the pod borer complex was found to be responsible for direct crop loss. A total of 8 species of insect pests constituting the pod borer complex have been recorded, out of which three species *viz.*, *M. vitrata* (=*testulalis*), *M. obtusa* and *A. clavipes* were the predominant pests and are considered as limiting factors in the successful cultivation of pigeon pea in this region. *A. clavipes* is the only coleopteran that has been recorded as the most important pest and was active all throughout the year. The adults fed by nibbling on leaflets, buds and flowers and laid eggs inside of the pod surface. The grubs fed on the seed and pupate inside the pod. Infested pods could be recognized easily by their deformed shapes. Rao *et al.* (2002) recorded it as a serious pest of pigeonpea in Meghalaya. Like the Apion, the pod fly (*M. obtusa*) also oviposits in the tender pods and on hatching the maggot mines in the pods and feed on the soft seeds and both the larval and pupal stages pass inside the pods. Subharani and Singh 2009 considered pod fly, *M. obtusa* as the most obnoxious pest of pigeonpea causing the grain damage ranging from 20 to 80 per cent. The spotted pod borer, *M. vitrata* is serious pest of grain legume crops including mungbean, urdbean, pigeonpea and common beans (Chandrayudu 2008). During the present study also this borer was found to cause extensive damage to floral buds, flowers and pods. During the vegetative stage of the crop whitefly (*B. tabaci*), cow bug (*O. tarandus*), apion (*A. clavipes*), aphids (*A. craccivora* and *M. persicae*), leaf hopper (*E. kerri*), weevil (*M. dorsatus*), mealybug (*C. insolita*), termites (*Odontotermes* sp. and *Microtermes* sp.), leaf folder (*G. critica*) and the leaf cutter bee (*Megachile* sp.) started infesting the crop and continued up to maturity stage of the pods. The termite problem was very serious during very early stage of crop growth and was responsible for gappy stand in the field. Only one acarine pest, *A. cajani* which transmit pigeon pea sterility mosaic virus has been recorded as an important and major pest in this region. Four species of coreid bugs that infest the crop during pod development stage have been recorded, out of which *Riptortus* spp. were the most predominant bugs. Among the five species of pentatomid bugs all were noticed to infest the tender apical plant parts during the reproductive stage of the crop and were of negligible significance. The Plataspidid, *C. cribreria* (lablab bug) and the membracid, *O. tarandus* (cow bud) were found congregating on the tender branches and stems but these are not responsible for any significant yield loss of the crop. Blister beetle (*M. pustulata*), chaffer beetle (*O. versicolor*), Hairy caterpillars (*P. scintillans* and *D. mendosa*) were observed to infest the flowers but in a negligible proportion. The curculionid weevil, *M. dorsatus* were observed to feed on the leaflets only and the leaf cutter bee, *Megachile* sp. was found to cut the leaflets in a semicircular fashion from margins. Very low population of a long legged, greyish black, notodontid insect, *N. alternus* has been recorded as a minor defoliator.

The distribution, abundance and pest status of any insect or mite species vary from region to region because of the variation on geographical and microclimatic conditions. It is, evident from the present study that a considerable number (42) of pests are associated with pigeon pea crop in the agro ecosystem of Tripura, of which ten species are major pests that need primary focus for formulating effective management strategies for profitable cultivation of this important pulse crop in this state.

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Evaluation of some insecticides and bio-pesticides against Shoot and Fruit borer in brinjal

Lalrinzuala, Pankaj Neog* and Imtinaro l

School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland

*Correspondence: pankajneog2@gmail.com

Introduction

Among the major insect pests of brinjal, shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) is regarded as the most damaging insect pest of the crop. It is a cosmopolitan field pest of brinjal causing more than 80% damage from nursery to harvest (Chakraborti and Sarkar 2011). Farmers in most cases solely depend on insecticides for the management of the pests as it produces quick results. Such reliance on insecticides has created many problems such as very frequent application of insecticides, excessive residues on marketed vegetables that concern general consumer health and the environment, pesticide resistance, resurgence, secondary pest outbreak, trade implications, poisoning, hazards to non-target organisms, increased production costs etc. Among the several avenues to overcome the insecticidal resistance problem, replacement with new molecules of insecticide is one of the important considerations. Evaluation of newer molecules for their efficacy against *L. orbonalis*is also a continuous process as newer molecules having novel mode of action are being introduced in the market from time to time. Keeping in view of the above considerations, the present investigation was undertaken to evaluate the efficacy of some synthetic and bio-pesticides against shoot and fruit borer, *L. orbonalis*in brinjal.

Methodology

Field experiments were carried out at Entomological farm, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during *kharif* 2014 to evaluate the efficacy of some synthetic insecticides and bio-pesticides against the pest. A susceptible hybrid Arjani F_1 was grown as per recommended package of practices except insect pest management practices. The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments including untreated control, each replicated thrice. The insecticide treatments were Emamectin benzoate 5% SG @ 0.3g/lit, Profenofos 40% EC + Cypermethrin 4% EC @ 1ml/lit, Flubendiamide 39.35% SC @ 0.4 ml/lit, Chlorantraniliprole 18.5% SC @ 0.3 ml/lit, Lambda cyhalothrin 2.5% EC @ 1.6 ml/lit, Imidacloprid17.8% SL @ 0.3 ml/lit, Chlorpyriphos 20% EC @ 2.5 ml/lit and K Super, a commercial formulation of plant alkaloids (19%) extracted from plant *Vitexnegundo* @ 8 ml/lit. Two sprays were given at 15 days interval using 625 litres of spray volume per hectare when the infestation exceeded beyond the prescribed economic threshold level i.e. 5% infestation.

The observations on the efficacy of insecticides and bio-pesticides employed for carrying out the experiments were recorded as pre-treatment and post-treatment infestation. Pre-treatment infestation percentage was recorded one day before both first and second sprayings and post-treatment infestation percentage was recorded at 3, 7, 10 and 14 days after the respective sprayings to observe the efficacy of different insecticides. Percent infestation of shoot was recorded from 5 randomly selected plants from each plot. To assess the efficacy of each treatment, the per cent reduction of the shoot infestation was calculated.

The observation of fruit infestation as weight and number basis was also taken into account to evaluate the efficacy of different insecticides against the pest. For this purpose matured fruits were harvested at weekly interval. The total number and weight of infested as well as healthy fruits were recorded from five randomly selected plants per plot at each picking. All the pickings were finally pooled together plot wise and the per cent fruit infestation as weight and number basis was worked out. The records of all the healthy fruit pickings were pooled together to get the final yield data per plot and the healthy fruit yield was converted into qt/ha. Data obtained were subjected to statistical analysis of variance after required transformation. Economics of different insecticide treatments were calculated according to prevailing market price of inputs and outputs and accordingly benefit cost ratio (BCR) was calculated.

Results and Discussion

Eight insecticides including one bio pesticide and one plant product were evaluated for their efficacy against shoot and fruit borer, *L. orbonalis* in brinjal. The cumulative mean data of the different days of observation after both the sprayings revealed that Chlorantraniliprole 18.5% SC recorded the highest (76.37) per cent reduction of shoot infestation. It was followed by Profenofos 40% EC + Cypermethrin 4% EC (72.55), Flubendiamide 39.35% SC (68.50), Imidacloprid 17.8% SL (67.30) and Emamectin benzoate 5% SG (67.16). The treatment Chlorpyriphos 20%EC and Lambdacyhalothrin 2.5% EC recorded lesser per cent reduction with 63.53 and 61.42, respectively; while the lowest per cent reduction of shoot infestation was recorded with the treatment of K-Super (51.73). The efficacy of Chlorantraniliprole 18.5% SC, Flubendiamide 39.35% SC and Emamectin benzoate 5% SG against shoot infestation by *L. orbonalis* was reported by Saha *et al*. (2014). Similarly, the efficacy of Profenofos 40% EC + Cypermethrin 4% EC against *L. orbonalis* was reported by Yadav *et al*. (2015).

The per cent fruit infestation taken on weight basis was the lowest on the plot treated with Profenofos 40% EC + Cypermethrin 4% EC (23.84) followed by Chlorantraniliprole 18.5% SC (26.14) which were at par with Emamectin benzoate 5% SG (26.64). Higher per cent infestation was recorded in Flubendiamide 39.35% SC (28.27), Imidacloprid 17.8% SL (33.42), Chlorpyriphos 20% EC (36.94) and Lambdacyhalothrin 2.5% EC (42.06), while K-Super recorded the highest per cent fruit infestation of 59.14 on weight basis.

The per cent fruit infestation taken on number basis on different treatments showed a similar trend with that taken on weight basis. The lowest fruit infestation on number basis was recorded in Profenofos 40% EC + Cypermethrin 4% EC (26.92%) followed by Chlorantraniliprole 18.5% SC (27.32%), Emamectin benzoate 5% SG (29.13%) and Flubendiamide 39.35% SC (30.60%) which were at par with each other. K-Super recorded the highest fruit infestation of 56.98%. Similar findings were represented by Prasad and Hegde (2006) who observed the lowest percentage of dead hearts and damaged fruits of brinjal in plot treated with Profenophos which were significantly superior over other insecticidal treatments. The highest efficacy of Chlorantraniliprole 18.50% SC against fruit damage by *L. orbonalis* was reported by Saha *et al*. (2014).

Among the different insecticide treatments, the highest yield (86.00q/ha) was registered in the plots treated with Profenofos 40% EC + Cypermethrin 4% EC, while K-Super recorded the lowest yield (64.43q/ha) which still differed significantly over the untreated control (46.15 q/ha). **T**he highest Benefit Cost ratio was obtained in the treatment of imidacloprid 17.8% SL (37.12:1) followed by profenofos 40% EC + cypermethrin 4% EC (32.38:1), while the lowest was recorded in K Super (2.22:1). The present findings are in partial agreement with Prasad *et al*. (2011) who reported thatCypermethrin gave maximum benefit cost ratio (36.7:1) followed by imidacloprid (22.3:1).

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Host plant resistance against rice blast caused by *Pyricularia oryzae*

Baiswar P*, Chandra S and Ngachan SV

ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya

*Correspondence: pbaiswar@yahoo.com

Blast of rice caused by *Pyricularia oryzae* can cause yield losses up to 36%. Experiment was conducted at ICAR Research Complex for NEH Region, Umiam, Meghalaya (25 30'N, 91 51'E, 1010 above mean sea level) during 2014 for screening the genotypes against *P. oryzae* adopting uniform blast nursery (UBN) pattern. The nursery consisted of 1106 genotypes comprising Donor screening nursery (222 lines), National hybrid screening nursery (140 lines), National screening nursery hills (102 lines), National screening nursery-2 (642 lines). Test entries were sown 10 cm apart in rows of 50 cm long, after every ten test entries local susceptible variety HR12 was sown and entire nursery was surrounded by two rows of HR12 to provide sufficient inoculum. Fifty kg nitrogen was applied as basal dose and remaining half was provided after 15 days of sowing, excessive nitrogen dose was provided to increase the susceptibility of plants. Blast reaction was recorded using standard evaluation system (SES) for rice. Weather conditions like rainfall, maximum, minimum temperature, morning and evening relative humidity were also recorded during the period of experiment. Results revealed that in Donor screening nursery 33 lines, National hybrid screening nursery 10 lines, national screening nursery hills 21 lines and in National screening nursery-2 40 lines showed resistance against blast.

Bioformulation of *Bacillus megatorium* for the management of disease and pest complex of Okra in organic environment

Pranab Dutta*, S Borauh, J Pegu, P Bhowmick, A Das, MS Rao[1], KC Puzari

Assam Agricultural University, Jorhat-785013, Assam, India,
[1]Indian Institute of Horticultural Research, Hessarghata, Lake Post, Bangalore

*Correspondence: pranabdutta74@gmail.com

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is grown as a summer crop in northern as well as southern states of India. It belongs to the family Malvaceae, originated in Abyssinia than it was taken to North Africa, the eastern Mediterranean Arabia and India. It is one of the important vegetable, mainly grown for its tender fruits in many countries of the world. Okra seeds are good source of protein, vegetable oil and also rich in vitamin A and B, phosphorus and iodine, which play significant role in human diet. Seventy per cent of total world production of okra produced by India form 0.35 million ha dedicated land (FAOSTAT 2008). The production of this crop greatly affected due to some biological and agrochemical constraints in the recent years. Improper and inadequate supply of nutrients and disease incidence are the major constraints in the way of production of this crop. Among the biological constraints, leaf spot disease caused by *Alternaria alternate* and root-knot nematodes (*Meloidogyne* spp.) are the most important and serious disease and pest. The management of such important pathogens could be achieved with the use of chemicals, broad spectrum pesticides, etc. The leaf spot disease is commonly controlled by different fungicides, *viz.*, Duter, Benlate-T, Dithane M- 45, Topsin-M, Rovral, Mancozeb, Iprodion, Tridemorph, Ziram, Bavistin, Pencozeb, Derosol, Signum 334 WG, Amistar 250 AC, Boscalid, Pyraclostrobin. But there is overwhelming evidence that some of the pesticides do pose a potential risk to humans and other life forms and unwanted side effects to the environment which consequently make it difficult to accomplish to the desired level**.** Keeping these points in view the urgent need of the hour is the alternative management approaches. Biological control is an important, effective, eco-friendly and economical component of Integrated Pest Management (IPM) in almost all important crops for development of sustainable cropping systems. Therefore the present study was conducted to see the *in vivo* effect of bioformulation of *Bacillus megaterium* in disease and pest complex as well as growth of the okra crop.

Methodology

The experiment was conducted with the okra variety, HY.BHENDI BSS-893, under upland condition in horticultural experimental farm of Assam Agricultural University, Jorhat, Assam, India during January to June, 2014. A plot size of 6.25m × 6.25m was maintained. Bioformulation of *Bacillus megatorium* was sprayed singly as well as by mixing with vermicompost according to the treatment combinations (Table 1) at the time of bed preparation. Okra seeds were also treated with *B. megatorium* @ 5ml/lit of water. The experiment was replicated four times. The data on per cent disease incidence and per cent pest incidence were recorded at different stages of the crop. Yield parameters like germination percentage (%) and height of treated and untreated plants was recorded in cm.

Per cent disease incidence was calculated by using following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plant units}}{\text{Total number (healthy and infected) of units assessed}} \times 100$$

Record of nematode galls and egg mass in the roots of okra plants were also recorded.

Results and Discussion

The results presented in Table 1 clearly revealed that highest seed germination of 98.80 per cent was recorded in treatment 3 (treatment of okra seed with *Bacillus megatorium* @ 5 ml/lit of water +application of 2 ton of vermicompost enriched with 5 lit of *Bacillus megatorium*/ha) followed by treatment 4 (treatment of okra seed with *Bacillus megatorium* @ 5 ml/lit of water + application of 1 ton of vermicompost). Okra plants infected with leaf spot and sprayed with water (control) showed highly significant reduction in plant height (69.50 cm) whereas, the tall plants (106.80 cm) were recorded from treatment 3 as shown in Table 1.

Table 1. Effect of *Bacillus megatorium* in the growth parameters of okra (Field condition)

Treatment	Germination %*	Plant height (cm)*	% Disease incidence*	% Pest incidence*	Yield (q/ha)*
T_1: Treatment of okra seed with *Bacillus megatorium* @ 5ml/lit of water	95.7 (78.66)^a	72.5^a	44.0 (41.53)^d	6.4 (13.41)^{cd}	178.7^b
T_2: T1+application of 1 ton of vermicompost enriched with 2.5 lit of *Bacillus megatorium*/ha	95.7 (81.58)^b	103.3^d	30.4 (33.37)^b	4.1 (11.58)^b	239.9^c
T_3: T1+application of 2 ton of vermicompost enriched with 5 lit of *Bacillus megatorium*/ha	98.8 (85.66)^c	106.8^d	27.4 (30.04)^a	2.6 (9.07)^a	299.1^f
T_4: T1+application of 1 ton of vermicompost	96.9 (78.69)^a	87.0^b	43.9 (41.41)^d	5.2 (12.54)^c	192.1^c
T_5: T1+ application of 2 ton of vermicompost	93.4 (81.29)^b	93.8^c	(32.1) 33.78^c	4.9 (12.25)^{bc}	204.7^d
T_6: Control (Water spray)	96.5 (78.31)^a	69.5^a	51.1 (45.49)^e	6.6 (14.21)^d	134.1^a
$CD_{0.05}$	1.3	4.8	1.8	0.8	1.1

*Data are mean of four replications, Figures within parentheses are angular transformed values

Similarly significantly lowest disease (27.40 %) and pest incidence (2.60 %) were recorded in those plots where seeds were treated with bio-formulation of *B. megatorium* along with the application of vermicoompost @ 2 ton of vermicompost enriched with 5 lit of *Bacillus megatorium*/ha. This may be due to the reason that *B. megatorium* is a beneficial microbe which have also been reported to produce antibiotics against several fungal pathogens (Jung *et al*. 2003) there are ten different species of beneficial microbes present in vermiwash such as *Serratia marcescens*, *Azotobacter chroococcum*, *Pseudomonas medocina* and *Flavobacterium* spp. Numbers of root-galls as well as egg masses were found greatly reduced in all the treatments as compared to uninoculated control. In the study of number of nematode galls and egg mass in the roots of okra plant treated with *Bacillus megatorium*, lowest number of root galls of 79.0 was recorded in treatment T_3 **(**T_1+ application of 2 ton of vermicompost enriched with 5 lit of *Bacillus megatorium*/ha) followed by treatment T_2 (T1+application of 1 ton of vermicompost enriched with 2.5 lit of *Bacillus megatorium*/ha) with 79.7 numbers of galls. In this treatment lowest number of egg masses (41.60) was also recoded. The results of this experiment showed that the leaf spot caused by *A. alternate* and root-knot nematode, *M. incognita* can cause significant reduction in growth and yield parameters such as germination percentage, plant height etc.

The bioformulation of *B. megatorium* along with vermicopmpost application can protect okra crop from leaf spot disease and root knot nematode. With suitable bioformulation of *Bacillus megatorium* it is certain that it will continue to perform a major role in integrated pest management (IPM).

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Determination of microbial load in Emu birds

K Puro, S Doley*, S Ghatak, S Das, R Sanjukta, I Shakuntala and A Sen

ICAR Research Complex for NEH Region, Umiam – 793103, Meghalaya

*Correspondence: doleysunil@yahoo.com

Introduction

Emu, the flightless bird belongs to the genus *Dromaius*, species *novaehollandiae* and are members of the ratite family along with ostrich, kiwi etc. From its native habitat in Australia, is leaving its footprint across the plains of India, with an increasing number of farmers commercially rearing the bird leading to the transport of birds across national/international borders has created the potential for the spread of infectious diseases. The objective of the study was to evaluate the bacterial load, identify the dominant species of microorganisms present and to determine the presence of pathogenic microorganisms in the feaces of apparently healthy Emu.

Methodology

Total viable count (TVC) of the feacal swab samples collected was done on three occasions with one week gap from 8 emus out of the total 24 numbers representing 3 sheds. Bacterial identification and antibiotic sensitivity profile using phoenix™ and molecular detection of *E.coli* virulence associated genes by PCR method.

Results and Discussion

The TVC of feacal microbial ranges from 113.3 x 10^5 to 94.6 x 10^6 colony forming unit (CFU)/ml. *Escherichia spp*, *Proteus spp* and *Citrobacter spp* were found to be dominant species. Most of *E.coli* was resistant to cephalosporins, piperacillin, ampicillin and aztreonam while *C. amalmaticus* were resistant to ampicillin and cefazolin. *P. mirabilis* were resistant to colistin, ampicillin, tetracycline and trimethoprim-sulfamethoxazole. Virulence genes detected includes fimH, papC, cvaC and iss. Three *E. coli* isolates were positive for antibiotic resistant factor - Extended Spectrum Beta-lactamase (ESBL) gene bla_{CTX}. The TVC of emu is similar to the ranges of TVC from poultry feces. The detection of virulence genes from *E.coli* isolates indicated the harboring of several putative virulence genes possible for pathogenic role and presence of ESBLs positive strain showed the *E. coli* isolates producing ESBLs are becoming more widespread and poses a concern to human health following possible entry and spread through environment into food chain. The Emu birds though harbors pathogens do not show any apparent clinical symptoms suggest there might exist some inherent innate mechanism that confers resistance to developing disease.

Diversity and foraging activity of Insect pollinators of Cruciferous 'Brassica' crops at mid hills of Meghalaya

Rachna Pande[1*], NS Azad Thakur[2], GT Behere[3], Sandip Patra[4], Romila Akoijam[5], Partha Debnath[6] and Remiio New year Bamon[7]

[1, 4,5] *ICAR Research Complex for NEH Region, Umiam, Meghalaya,*

[5,6]*Research Scholar, School of Crop Protection, CPGS, Umiam*

*Correspondence: rachna.ento@gmail.com

Introduction

In sexually reproducing plants, pollination is an essential process for the propagation of the species by proper fruit and seed set. Throughout the world Cruciferous Brassica crops are widely grown for the edible vegetable oil production however it is also used as vegetables for human consumption, as condiments and spices for improved flavour of human diets, and also used for livestock feeding as fodder crop. The valuable oilseed crop Brassica is highly cross-pollinated and require external carrier such as insects for transfer of the pollen grains to the stigmas for proper pollination. A number of insects visit on this crop during flowering period as reported by various workers from different parts of the country (Chaudhary 2001; Singh *et al.* 2004). Shifting of chemical intensive farming to organic farming has opened a new vista for the insect pollinators to play the significant role in increase in yield. Enhancement of insect pollinator as part of eco-friendly crop management should be considered by farmers. This could be done by a reduced use of pesticides, providing nesting sites for solitary bees, and improving pollen and nectar availability for bees. Thus the present study was done to know the diversity of insect pollinators abundant in cruciferous crop in relation to time. So the farmers can alter the time of spray according to peak foraging time of the pollinators.

Methodology

The studies were conducted at farm site of ICAR Research Complex for NEH Region, Umiam, Meghalaya (India) during 2014. The diversity of insect visitors was recorded and the individuals collected by a hand net. Sweeps were made at peak blooming period of mustard crop every day, at fixed time intervals. The abundance of insect visitors per sq. m. area was recorded at two hourly intervals from 10:00 to 16:00 hrs, during the blooming period of the crop. The averages of these observations (diurnal abundance) were worked out. Statistical Analysis - The data collected from field experiments were subjected to the analysis of variance following randomized block design.

Results and Discussion

Cross pollination causes early proper seed set and higher yields in terms of qualitative and quantitative traits (Mishra 1988). There are many insect species which visit mustard blossoms for reward like nectar and pollen as a food, and are the primary vectors of pollen. A total of 10 insect visitors belonging to order Hymenoptera (6), and Diptera (4), were found to visit the mustard blossoms which are enlisted in (Table 1) Hymenopteran visitors belonged to six families Apidae (6). Besides this some Dipteran visitor belonged to family Syrphidae (2) were observed on mustard flowers. From the family Apidae, honeybees (*Apis dorsata, Apis cerana indica, Apis florea, Bombus sp.* and *Trigona sp*.), two species from family Syrphidae (*Syrphus sp. and Eristalis sp*.) visited the mustard flowers. Abrol (1989) recorded 20 species belonging to 12 families of Hymenoptera and Diptera. Goswami and Khan (2014) observed total 19 insect visitors to order Hymenoptera (15) and Diptera (4).

The relative abundance (percentage of insect/m2/2min.) of Hymenopterans were maximum (80.67 %) followed by the Dipterans (19.33 %). Similarly Goswami and Khan (2014) on mustard also supports that the abundance of hymenopterans are maximum than other insects. The activity of hymenopterans was higher at 10:00 h (92.00%) as compared to Dipterans which were active at 14:00 h (29.50%). In Hymenopterans, the honeybees (*Apis cerana himalaya*) activities were observed maximum (52.53 %) at 16:00 h followed by bumble bee *Bombus sp.* (18.75 %) at 10:00 h, *Apis florea* (8.75%) at 10:00 h, *Trigona sp* (7.50%) at 10:00 h and *Apis dorsata* (3.25%) at 10:00 h. Among dipterans, activity of *Syrphus sp.* was maximum at 14:00 h (15.11%) and *Eristalis sp.* was at 14:00 h (7.91%). In Hymenopterans, the honeybees (*Apis cerana himalaya*) were observed maximum (45.30 %) followed by bumble bee *Bombus sp.* (16.59 %), *Apis florea* (6.59%), *Trigona sp* (6.46%) and *Apis dorsata* (1.77%). Among dipterans, *Syrphus sp.* was 9.84 % and *Eristalis sp.* was 5.17 %. Abrol (1989) found that *Apis cerana, A. mellifera, Halictid bees, Halictus sp. and Lasioglossum sp.*, were the most numerous visitors and important pollinators of Brassica crops.

Table 1. Diurnal insect visitors of Mustard flower

Insect visitors	Common name	Order	Family
Apis cerana himalaya	Indian Honey bee	Hymenoptera	Apidea
Apis florea	Little Honey Bee	Hymenoptera	Apidea
Apis dorsata	Rock Bee	Hymenoptera	Apidea
Bombus sp.	Bumble Bee	Hymenoptera	Apidea
Trigona sp.	Stingless Bee	Hymenoptera	Apidea
Bee (unidentified 1)	-	Hymenoptera	-
Syrphus sp.	Syrphid Fly	Diptera	Syrphidae
Eristalis sp.	Drone fly	Diptera	Syrphidae
Fly (unidentified 1)	-	Diptera	-
Fly (unidentified 2)	-	Diptera	-

The results indicate that amongst the diversity of insect pollinator and hymenopterans, bees as frequent visitors in cruciferous crop. Among bees Indian honey bee showed more than 35% abundance in different time period throughout the day. So, farmers should use the insecticides rationally or could use biological control methods as utilization of managed pollinators especially honey bees is considered as one of the cheapest eco-friendly approach in maximizing, the yield of cross pollinated crops. In that context, this work may be extended further in other way.

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Isolation and screening of bacterial endophytes against the fungal pathogens of Naga King Chilli

Rajesha G[1*], Bendangsenla[1], Bidyut C Deka[1] and SV Ngachan[2].

[1]ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, Medziphema, Nagaland

[2]ICAR Research Complex for NEH Region, Barapani, Meghalaya

*Correspondence: rajeshag337@gmail.com

Introduction

King chilli (*Capsicum chinense* Jacq.) also called *Bhut jolokia* is the world's hottest chilli. It is indigenous cultivar grown in Nagaland, Assam, Manipur, Mizoram and other parts of Northeast India. King chilli is unique among other chilli due to its extra-ordinary pungency level. The capsaicin obtained from king chilli is having good market demand in international trade. The fruits are one of the important components in food ingredients of Northeast dishes for flavour and pungency. The area of king chilli increased substantially in Nagaland. However, the production and productivity of king chilli is very low. Diseases are single important limiting factor that affects the production and productivity. Anthracnose, leaf curl virus, bacterial wilt and powdery mildew possess serious threat to king chilli that drastically reduces the production and productivity of the crop. Since North-eastern states following traditional and organic agriculture, lack of organic disease management practices leads to failure in controlling the diseases that leads to loss in production. The present experiment was carried out to identify the effective strains of bacterial enodphytes of Naga King chilli.

Methodology

Survey for the occurrence of fungal diseases of Naga King Chilli and isolation of endophytic bacterial biocontrol agents. Survey was conducted during 2014 in Naga chilli growing area of Nagaland to assess the severity of diseases. Plants showing the typical symptoms were scored as per the severity grade of 0 - 4 and the per cent disease index were calculated as per the methodology suggested by Sheo Raj, 1988. The endophytic bacterial strains were isolated by excising one cm length of the fruit. Later the excised sections were surface sterilized for one min. with 4 per cent sodium hypochlorite. To remove the disinfectant, sections were rinsed five times with sterile distilled water and dried with sterile paper towels and macerated with a sterile pestle and mortar in laminar flow chamber. Tissue extracts were then serially diluted in 12.5 mM sodium phosphate buffer (pH 7.0) and plated on nutrient agar medium and King's B medium in triplicate to recover endophytic isolates, respectively. After two days of incubation, single colonies were streaked separately in respective medium. To confirm isolates as *Pseudomonas* spp. 16S-23S rRNA intervening sequence specific ITSIF (5' AAGTCGTAACAAGGTAG 3'); ITS2R (5' GACCATATATAACC CCAAG 3') primers were used to get an amplicon size of 560 bp (Rameshkumar *et al.*, 2002).

In vitro screening of antagonistic endophytic bacteria: The antifungal activity of isolates of endophytes were tested by dual culture technique using PDA medium. A mycelial disc of 9 mm of the pathogen was placed at one end of the Petri plate. The bacterial antagonists were streaked one cm away from the periphery of the Petri plate just opposite to the mycelial disc of the pathogen. Three replications were maintained for each treatment and pathogen disc without antagonist was treated as control. The plates were incubated at 28 ± 2 °C. The growth of the pathogen towards the bacterial colony and inhibition zone was measured after ten days of incubation. Percent inhibition (PI) over control was calculated as [(C-T)/C]x100, Where, I – Inhibition %, C – Growth of pathogen in control, T – Growth of pathogen in treatment

Results and Discussion

Survey for the occurrence of fungal diseases of Naga King Chilli and isolation of endophytic bacterial biocontrol agents: The survey was conducted in different growing districts of Nagaland *viz*., Dimapur, Kohima, Peren, Wokha, Phek to know the occurrence of fungal diseases of Naga King Chilli. Among the fungal diseases, anthracnose was noticed in all the places, whereas only *Fusarium* wilt and damping off was noticed only in Zhadima and Moalvam respectively. The anthracnose disease was most prominent disease causing economic yield loss at ripening stage. The bacterial endophytic biocontrol agents were isolated from chilli fruits by following the sterility check method. There are 20 bacterial endophytes were isolated from the samples which were collected from different growing regions of the Nagaland. Molecular identification of bacterial endophytes: Amplification of 16S rDNA of 14 isolates with ITS1 and ITS2 region specific primer yielded 560 bp amplicon suggesting that the isolates belong to *Pseudomonas* genus

In-vitro screening of endophytes against the pathogens of King chilli: The bacterial endophytes were screened under *in vitro* against *Pythium*, *Fusarium* and *Colletotrichum* pathogens of Naga king chilli to measure the bio-efficacy. Among the twenty isolates, KEB15 isolate showed the per cent inhibition of mycelial growth of *Pythium* to an extent of 66.67 per cent over control followed by KEB5 to an extent of 64.07%. The least per cent inhibition of 27.41 was observed in KEB19 isolate. In case of Fusarium, KEB5 showed the maximum mycelial inhibition of 69.26 per cent over control followed by KEB2 with mycelial inhibition of 60.37 per cent. Isolate KEB7 recorded the maximum mycelial inhibition of 66.30% against *Colletotrichum* over control and followed by 60.33% of inhibition was noticed in KEB2 isolate.

Cultivation of Naga King chilli is limited by anthracnose or fruit rot in all growing areas of North east. Survey conducted to assesses the severity of diseases of Naga chilli in Nagaland, revealed that the anthracnose disease severity was more in all growing regions of Nagaland. The disease severity of fruit rot was most severe at ripening stage. The prevailing weather condition and the susceptibility of fruits for the aggressive pathogens made the development of disease in severe form. Marinus Ngullie *et al*. (2010) reported the world hottest chilli cultivated in Nagaland suffers great loss due to fruit rot disease caused by *C. gloeosporioides*.

There is a unique group of bacteria that form endophytic associations with plants, and several of these have been reported to be successful in preventing disease development. The uses of bacterial endophytes in agriculture for general and specific biological control applications are current, widespread (Emmert and Handelsman 1999). In the present investigation, isolates KEB15, KEB5 and KEB7 suppressed the mycelial growth of *Pythium*, *Fusarium and* C*olletotrichum*. The inhibition of pathogen by endophytes might be due to the production of antifungal metabolites. The endophytic *Pseudomonas aeruginosa* isolated from chilli red fruit is a principle integrated isolate for controlling the phytopathogen as it showed positive response to antagonism against chilli anthracnose disease (Allu *et al.* 2014). It was considered that the microbial metabolites may have an active role in resistance to disease by functioning as signals mediating a crosstalk between the endophytes and its host (Cao *et al*. 2005). The majority of antagonistic endophytic bacteria are gram-negative and belong to the group of fluorescent pseudomonads, which are effective biocontrol agents (Whipps, 2001).

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Distribution pattern of soil arthropods in varied habitats

Romila Akoijam* and Badal Bhattacharyya[1]

ICAR Research Complex for NEH Region, Umiam, Meghalaya

[1]Assam Agricultural University, Jorhat, Assam

*Correspondence: romi.ak9@gmail.com

Introduction

Soil ecosystems comprise of various kinds of fauna and flora and occupy specific trophic position. The key communities of the soil biota are soil arthropods in which they influence various key soil processes like nutrient cycling, carbon sequestration, etc. They consume plant debris and mineral matter that help in humification and increasing soil organic matter and also involved in maintaining soil texture and structure. In the process, they stabilize and controlled the micro-environment, creating conditions favourable for later colonizers which eventually results in the establishment of higher plants and invertebrate animals. The influence of the soil arthropods on decomposition processes is greatest in the humid regions where plant litter decomposition occurs most rapidly. They are concentrated in the upper horizons of litter layers of the soil and are considered as useful models because they are both taxonomically and ecologically rich in diversity. They are sensitive to agricultural chemical inputs and have the potential as biological indicators of the environment (Gagnarli *et al*. 2015).

To know the distribution pattern of different soil arthropods in varied habitats, extraction with Tullgren funnel method has been a new area of research. By estimating quantitative distribution of soil arthropods in different habitats, the variation of their abundance, their role as bio-indicators and their relationship with the existing environment can be understood as well as different measures can be undertaken to combat against different soil problems.

Methodology

Three habitats viz. Cultivated land of Instructional Cum Research (ICR) Farm, Assam Agricultural University, Jorhat (agricultural field), grazing field of Bor Guri Chapuri, Jorhat (pasture land) and Gibbon Wildlife Sanctuary, Mariani (forest land) were selected for determining the distribution pattern of various soil arthropods populations by using Tullgren Funnel Method. Soil samples were collected randomly from six different places by using rectangular soil sampler (30×11×8 cm) with a depth of 0-15 cm soil layer from the upper surface without disturbing soil profile. The soil temperature was recorded by using soil thermometer and the moisture was measured by gravimetric method. The soil arthropods were extracted by using Tullgren funnel, using 40 watt electric light bulbs at high light intensity with a period of 72 hours (Akoijam R. and Bhattacharyya B, 2012).

According to Singh *et al*. (1978), the populations of extracted soil arthropods per square metre were determined by using the formula,

$$P = \frac{10,000 \times X}{(B \times L)\, n}$$

where, P= Population of soil srthropods per square metre

X= Number of soil arthropods extracted from the funnel

B= Breadth of the rectangular soil sampler (cm)

L= Length of the rectangular soil sampler (cm)

n= Number of samples per habitat

Results and Discussion

Various groups of soil arthropods i.e. collembolans, soil mites, pseudoscorpions, ants, spiders and many unidentified were observed to be prevalent in the selected habitats. During the course of study, 51 % of collembola, 27 % of soil mites and the remaining 22 % of other soil arthropods were recorded from agricultural field. In pasture land, 42 % of collembola, 30 % of soil mites and 28 % other soil arthropods were observed whereas in forest, 36 % collembola, 33 % soil mites and 31 % other soil arthropods were recorded (Table 1). Among the various soil arthropods extracted, collembolans and soil mites were found in large proportion during the investigation. Collembolans contributed 46 %, 28 % was occupied by soil mites and the remaining 25 % was contributed by other arthropods. During study, nine morphologically dissimilar types of collembolans and eleven morphologically dissimilar types of soil mites were observed.

Table 1. Per cent distribution pattern of the soil arthropods in various habitats

Sl.No.	Habitat	Collembola	Soil mites	Other soil arthropods
1	Agricultural field	51	27	22
2	Pasture land	42	30	28
3	Forest land	36	33	31

The organic carbon content is highest in forest land (0.97 %), followed by pasture land (0.73 %) and agricultural field (0.54 %). The soil temperature and soil moisture were positively significantly correlated with the total populations of soil arthropods from various habitats. The higher organic carbon and organic matter content in the forest soil enhanced the population of collembolans and soil mites compared with that of pasture land and agricultural land. Devi *et al.* (2006) used Tullgren funnel for the extraction of soil arthropods and recorded 69.20 % of collembolans from 0-10 cm soil layer of forest floor in Manipur. The percentage was more as compared to that of deeper forest layers. Collembolans and soil mites were the dominant groups extracted at different successional stages of tropical forest and the development and immunity structure of soil arthropods were closely related to vegetation succession process (Yu Guang Bin and Yang Xiao Dong 2007). In making such attempts to this work, particular attention should paid to the role of soil arthropods and microflora as possible indicators of the polluted and degraded soil, soil biodiversity and land use planning should be investigated. The effects of global climatic change on soil arthropods and the ability of soil arthropods to recover after the cessation of a climatic disturbance should be studied extensively.

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Effect of abiotic factors on population dynamics of leafroller and natural enemies in Malvaceae crop at Mizoram state

Samik Chowdhury*, Saurav Saha, T Boopathi, Y Ramakrishna, Lungmuana, AR Singh, SK Dutta, M Thoithoi Devi, ASB Singh and SV Ngachan

ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram

*Correspondence: samikchowdhury33@gmail.com

Introduction

Abelmoschus esculentus (L.) Moench] is one of the most important vegetable which can be raised throughout the year. An average yield of okra varies from 6.5-7.5 t/ha of green fruits during the dry season and 11.5-12.5 t/ha during the rainy season (Ahmed *et al.* 2015). Due to their tender and supple nature and their cultivation under high moisture and input regimes, okra is more prone to pest attack and at a conservative estimate cause about 35-40% losses (*Indiastat.com*). Okra leaf roller *Sylepta derogata* an important pest of okra which causes 36-90% loss in the fruit yield (Misra *et al*. 2002). Reproduction and survival in insects are influenced by a number of environmental factors including temperature, day length, humidity and precipitation, etc. In Mizoram, okra is one of the most important *kharif* vegetable. But productivity is very low because of diseases and pests. Insects are capable of surviving only within certain environmental limits, so one can predict the occurrence of peak activities of a given pest through better understanding of preferred environmental factors. The present study was therefore undertaken to determine the role of different weather factors in infestation fluctuations of the okra leaf roller *Sylepta derogata* .

Methodology

Two year studies were conducted to determine the role of weather in the fluctuation of Okra leaf roller *Sylepta derogata* on three comparatively more susceptible variety( ) , three moderately susceptible and three comparatively resistant genotypes of okra under field conditions at ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram during 2014 and 2015. Experiments were laid out in a Randomized Complete Block Design (RCBD) with nine treatments and three replications. The plot size was kept at 8.5 × 8.5 m, with 0.60 m row-to-row and 0.30 m plant-to-plant distance. All the recommended agronomic practices were carried out on experimental plot except control measures against *Sylepta derogata*. Percentage plant infestation was calculated by dividing the damaged plant by total number of plant and multiplying it with one hundred. Observations were taken at weekly interval during both the years. Meteorological data relevant to temperature, relative humidity and rainfall were recorded, from the adjoining meteorological observatory of the ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram. The data were subjected to square root transformation and simple correlation and multiple linear regression analyses were carried out using MSTAT-C package for both the years individually, as well as on average basis, to determine the impact of abiotic factors on Okra leaf roller *Sylepta derogata* of different genotypes of okra.

Results and Discussion

The data regarding *Sylepta derogata* damage versus weather factors during 2014 and 2015 are shown in Figures 1 and 2 with an objective to determine the trend in fluctuations of *Sylepta derogata* with respect to the weather conditions during the study period. Maximum *Sylepta derogate* damage was recorded on 14.7.2014 with a maximum temperature of 30.44^{o}C, minimum temperature of 23.40^{o}C, average temperature of 26.92^{o}C and relative humidity of 67.46%. During 2015, 3rd week of July (24.07.2015) was found to be the most favorable and resulted in a maximum *Sylepta derogata* damage 44.74% respectively, with a maximum temperature of 31.7^{o}C, minimum temperature of 23.5^{o}C, average temperature of 31.24^{o}C and a relative humidity of 68.57%. On average basis of both years the 2nd week and 3rd week of June was found to be the most favorable and resulted in a maximum *Sylepta derogata* damage, *i.e.*, 38.94 and 44.74%, respectively, with maximum a temperature of 31.41^{o}C, minimum temperature of 24.21^{o}C, average temperature of 27.81^{o}C and a relative humidity of 52.15%. The 2nd most important factor was observed to be rainfall that exerted 27.5% influence on the fluctuation of *Sylepta derogata* damage. During 2015, minimum temperature, average temperature, relative humidity and rainfall contributed towards per unit change in fluctuation of fruit infestation up to 3.5%, 9.3%, 0.6% and 1.8%, respectively.

Correlation of weather factors with Sylepta derogate: Weather factors showed significant effect on the *Sylepta derogata* except the minimum temperature during 2014 and the rainfall during 2015 which showed a non significant correlation with a negative response. On the cumulative basis for both years, the maximum temperature and average temperatures showed a positive significant effect, whereas the minimum temperature exerted a non significant correlation with the *Sylepta derogata* infestation. Relative humidity and rainfall had a negative and significant correlation with the *Sylepta derogata* infestation (Table 1).

Table 1. Correlation between *Sylepta derogata* and weather factors on Okra

Weather factors	2014	2015	Cumulative 2014-2015
Max. Temp (^{0}C)	0.615	0.708	0.681
Min. Temp (^{0}C)	-0.58	0.384	0.284
Avg. Temp (^{0}C)	0.381	0.587	0.571
R. H. (%)	0.751	-0.438	-0.538
Rainfall (mm)	-0.647	-0.287	-0.468

The impact of weather factors on the damage caused by *Sylepta derogata* on 'okra' during 2014 show that the maximum temperature exerted 52.84% role in *Sylepta derogata* damage fluctuation which was the highest of any factor. The impact of this factor was positive and significant. Minimum temperature, average temperature, relative humidity and rainfall had 9.63, 5.40, 0.50 and 17.80% role, respectively, in the *Sylepta derogata* damage fluctuation. The coefficient of determination values between damage of *Sylepta derogata* and weather factors during 2015 revealed that the maximum temperature contributed the maximum role, i.e., 65.52%, towards the *Sylepta derogata* damage fluctuations. The minimum temperature, average temperature, relative humidity and rainfall had a 0.3, 12.64, 2.80 and 8.70% role of *Sylepta derogata* damage fluctuation in the 'okra' crop. The Multiple Linear Regression Models along with the determination coefficient, regarding the impact of weather on the *Sylepta derogata*. On an average of both years, revealed that the maximum temperature was the most important weather factor, which contributed the maximum role, *i.e.*, 58.94% in the fluctuation of *Sylepta derogata* . The other factors, like minimum temperature, average temperature, relative humidity and rainfall, showed 0.24%, 0.40%, 0.60% and 0.50% role in the infestation fluctuation, respectively. The population of natural enemies of insect pest of okra crop habituating in plant with availability of food sources. The correlation studies revealed a positive correlation between ladybird population and abiotic factor *viz.* maximum temperature, minimum temperature, Average temperature, Relative Humidity and rainfall. Maximum temperature is probably the most important weather factor influencing the behavior, distribution, development, survival and reproduction. The ladybird population also positively correlated with maximum temperature (r- 0.453 and 0.553) during 2014 and 2015.

Maximum temperature in the field can be considered as dominant factor for the increase in fruit and shoot infestation of *Earias* spp. on okra, whereas rainfall and relative humidity exert only slightly negative effect.

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Sero-prevalence of *Erysipelothrix rhusiopathiae* in pig population of Ri-bhoi and Khasi hill districts of Meghalaya

Samir Das*, I Shakuntala, Priyanka Mukherjee, Esther Vise, Sandeep Ghatak, Utaran Bhattacharjee, Amarjeet Karam, Amit Chakarborty, K Puro, RK Sanjukta, Dyuti purkait, Surmani Hoidam, Uttam Rajkhowa and Arnab Sen

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: drsamirvph@yahoo.com

Introduction

Erysipelothrix rhusiopathiae is a bacterial zoonotic disease with principal host as swine and occasionally cause skin infection in human being. The risk groups of people for *E. rhusiopathiae* in humans are butchers, slaughterhouse workers, veterinarians, farmers and fish handlers. Beside swine and human, the organism is seen as commensal or saprophytes or pathogens in a variety of wild, domestic animal, birds and fishes and can survive in environment for a long time. Even good number of healthy pigs harbors the organism (both virulent or/and avirulent forms) in the lymphoid tissue of the alimentary tract, particularly in the tonsils. Infection of *E. rhusiopathiae* are disseminated rapidly from infected pig to other pigs in closed herd, usually within 24 hours septicemia develops and leads to fatal disseminated intravascular coagulation. There has been report *E. rhusiopathiae* from all major pig rearing countries with few isolated outbreak reports from India (Shankar *et al.* 2009,).

The disease was mentioned to be present in North East India but no single laboratory confirmed case was reported from the region until we reported the first sporadic outbreak of *E. rhusiopathiae* infection in an organized farm of Ri-Bhoi district in the year 2012 (Das *et al*. 2014). The outbreak initially looked like Swine fever which is very endemic to the region but later confirmed to be *Erysipelothrix rhusiopathiae* infection. During the next three years we cautiously observed for any other outbreak of *E. rhusiopathiae* infection in Meghalaya alongwith sero-prevalence study for the infection using commercial ELISA in two representative district of Meghalaya i.e., Ri-Bhoi and East Khasi Hills.

Methodology

The selection of the geographical area was based on the fact that the initial outbreak was seen in Ri-Bhoi district and the East Khasi Hills is one of the most populous districts for pig population so as to have a comparison. The sample size was calculated for population survey using 'Statcal' programme of 'Epiinfo' epidemiological tool developed by Centre for disease control, Atlanta, United State of America. The pig population of the district was taken for calculation from the 2007 country Animal Census and with an expected frequency of 05% based on literature survey and with confidence level of 99.9% and 410 random pig sera samples were collected from these two districts (205 each) from 2012 to 2015. Indirect ELISA for detecting *E. rhusiopathiae* antibodies (Ingensa, Spain) in pig sera was used. Simultaneously, other possible outbreaks of similar pattern were also studied using culture and molecular diagnostics. The outbreak reports from Meghalaya state Animal Husbandry Department were also scrutinized for any case(s) of *E. rhusiopathiae* in the state.

Results and Discussion

Altogether, 21 number of sera were positive from 410 pig sera samples with an overall sero-prevalence of 5.12% for the two distinct of Ribhoi and East Khasi Hills with 6.34% (13/205) and 3.90 % (08/205) sero-prevalence for the respective districts. During the period there was no reported outbreak of *E. rhusiopathiae* by Meghalaya by State Veterinary and Animal Husbandry Department. All other suspected outbreak investigated by us through culture and molecular methods were also not of *E. rhusiopathiae* in origin.

E. rhusiopathiae infections are uncommon in Meghalaya, the initial outbreak was detected by PCR of 16S rRNA (Das *et al*. 2014) and the unregulated border market of Assam-Meghalaya border was the probable source of infection. Although, during the initial outbreak we were not much prepared for it and only as a preparatory measures to tackle major outbreaks we have stocked primer of *E.rhusiopathiae* and hence, could use for detection and hence, controlled the outbreak at the right time which otherwise was difficult to diagnose, as with the symptoms of fever and hemorrhage, endemic Classical Swine fever (CSF) and emerging Porcine respiratory and reproductive syndrome are the most common suspect. During these three years, there were not any other scientific publication in public domain attributed to *Erysipelothrix* from the state Meghalaya nor did the State Veterinary and Animal Husbandry Department report any other outbreak. Our other suspected cases were also negative for *Erysipelothrix* but the sero-prevalence study shows that the disease is present in the state and may be the outbreak goes unnoticed or not reported. The overall sero-prevalence of *E. rhusiopathiae* for 5.12% in these two districts came out to be similar as reported from other part of the world (Sebastià *et al*. 2011). The serological positivity in the observed study may be because of asymptomatic carrier or because of the state of infection which need to be investigated in details. In conclusion, the disease seems to be silently present in a low frequency in the state and because of its clinical similarity to other endemic disease like CSF many a time got mis-diagnosed or remains unreported. Besides this, the organism isolation and identification is difficult. There is need to investigate the disease in this swine rearing belt of the country covering all the aspects of epidemiology through serological, isolation and molecular techniques.

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Microbial analysis of fermented foods of Northeast India reveals wide diversity of lactic acid bacteria with concurrent foodborne hazards

TK Dey*, D Purkait, K Rhetso, E Vise, U Bhattacharjee, A Ahuja, R Pegu, A Karam, S Huidrom, A Chakraborty, P Mukherjee, A Dutta, K Kakoty, M Singha, R Sanjukta, S Das, K Puro, I Shakuntala, A Sen, R Laha and S Ghatak*

Division of Animal Health, ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence:ghataksnd@rediffmail.com

Introduction

Northeast India falls under one of the thirty four biodiversity hotspots of the world. Over the ages the indigenous population inhabiting the region have discovered and developed ingenious uses of many wild plants within their environment as food sources perhaps after a good deal of trial and error. A wide variety of food items (substrates) are utilized for the purpose including animal fat, bamboo shoot, beef, black gram, colocasia, cow milk, crab, cucumber, finger millet, fish, leafy vegetable, maize, mutton, pork, radish, rai seed, rice, soybean, tree bean, wheat, yak meat, yak milk, etc. Many of these bacteria possess unique characters including unique fermentation traits that may be beneficial to health. On the other hand many of them may possess untoward properties detrimental to health and well being. For example, harbouring of antimicrobial resistances in them. Since many of the food ingredients used as the starting materials for traditionally fermented foods contain low levels of antimicrobials and fermenting organisms are not deterred by these low level antimicrobials, it seems plausible that they might have acquired some degree of resistance. Moreover, on consumption these bacteria may transfer these resistance traits to the gut flora of the consumers, eventually building a pool of resistance genes in the human digestive tract and seriously compromising therapeutic efficacy of many antimicrobials. However this question has not been addressed till date to the best of our knowledge. Therefore, the aim of the present study was to study the bacterial flora including foodborne pathogens associated with the fermented and / or cultured food products with special attention to antimicrobial resistance among theses bacteria.

Methodology

In our study a total of 127 fermented samples comprising of Tungtap, Turumbai, Ngari, Axone, Soibum, Chuchro, Sakamazay, Akamazay and dry fishes were collected aseptically from retail outlets of various geographical regions of North East India and processed within 48hrs.

Isolation of Lactic Acid Bacteria (LAB): Approximately 25 g of sample was triturated and mixed with 225 ml of sterile normal saline solution (0.85%). Sample thus processed was enriched in De Man, Rogosa, and Sharpe (MRSB) broth and Elliker (EB) broth and was incubated at 37 °C for 24 – 48 h followed by plating on MRS agar. Plates were incubated both aerobically and anaerobically (5% CO_2) at 30 °C and 37 °C for upto 96 h. Presumptive Isolates were studied for their phenotypic properties including CO_2 production from glucose, growth at different temperatures, and ability to grow in varying concentrations of NaCl in MRS broth as described by Dykes et al. (1994). Identification of cultures was done using automated microbial identification system, Phoenix 100 (Becton Dickinson, Singapore).

Estimation of food safety parameters- Aerobic Plate Count (APC) as per the methodology prescribed by Food Safety and Standards Authority of India (FSSAI, 2012) and Coliform count was performed. Detection of foodborne pathogens: Fermented food samples were also processed for detection of *Staphylococcus aureus* and *Escherichia coli*. Isolates were presumptively identified by their growth on Baird Parker Agar medium, Eosin Methylene Blue Agar (HiMedia, Mumbai, India) with typical shiny jet black colony (*Staphylococcus aureus*) and purple colony with greenish metallic sheen (*Escherichia coli*). In addition Gram staining of isolates and biochemical tests (Catalase and Oxidase) were performed on suspected isolates. Following presumptive identification, isolates were characterized by Phoenix 100 automated ID/AST system (Becton and Dickinson, Singapore) for confirmatory identification.

Determination antimicrobial resistance: Antimicrobial resistance of isolates was assessed phenotypically by Bauer-Kirby disc diffusion method. Moreover, minimum inhibitory concentrations (MICs) of various antimicrobials were estimated by Phoenix 100 (BD, Singapore) automated ID/AST system.

Molecular characterization: All lactic acid bacteria were subjected to polymerase chain reaction (PCR) employing generic primer pairs specific for LAB. All isolates (LAB and pathogens) were also screened for various antimicrobial resistance genes (*bla*TEM, *bla*CTX-M, *bla*SHV, *qnr, vanA, vanB, tetA, tetB, tetC*). LAB isolates were functionally characterized for riboflavin production potential by screening *ribA* gene; for bile salt tolerance by screening *Bsh* gene and amylase production by screening *Amy* gene.

Results and Discussion

Out of 127 fermented food samples, 31 isolates of various LAB were obtained. Isolates belonged to following species **-** *Leuconostoc mesenteroides ssp cremoris, L. pseudomesenteroides, Pediococcus acidilactici, P. pentosaceus, P. damnosus, P. parvulus, P. acidominimus, Lactobacillus delbrueckii ssp lactis, Lactococcus lactis ssp lactis, Lactococcus raffinolactis, Lactococcus cremoris*. PCR for confirmation of LAB revealed 1600 bp amplicon as was expected for LABs. The resistance patterns of LAB indicated that a majority of lactic acid bacteria were resistant to teicoplanin and vancomycin and such isolates belonged to *Leuconostoc mesenteroides* ssp *cremoris*, *Pediococcus acidilactici, P. pentosaceus, P. damnosus, P. parvulus, P. acidominimus.* Functional characterization of LAB isolates revealed that *ribA* gene was present in 87% of LAB isolates. Similarly, *amy* gene was harboured by 77% of isolates and *Bsh* gene was possessed by 61% isolates. Therefore these results indicated that there was great diversity of LAB species among the traditional fermented foods of north east region with probiotic potential. In addition to probiotic effect, isolates LABs revealed potential for nutritional enhancements of foods by production of riboflavin. Detection of *Amy* gene among LAB isolates indicated that these isolates are capable of sustaining growth in starchy substrate through production of amylase (Tou et al. 2006). Probiotic potential of the LAB isolates is further strengthened by their tolerance to bile salt which might ensure their survival inside gastrointestinal tract. Assessment of food safety parameters (APC and coliforms) revealed wide variation in APC count among samples. APC counts ranged from 7 X 10^3 cfu/g to 35 X 10^9 cfu/g with a mean count of 1.5 X 10^7 cfu/g. While such variation might be attributable to hygienic standards followed in preparation of foods, other factors such as physic-chemical nature of the food also need to be considered. Coliforms were present in approximately 10.3% of samples upto 10^{-3} dilution indicating poor hygienic standard. Detection of foodborne pathogens by conventional bacteriological method revealed presence of *E. coli* in 3.6% of all samples and presence of *Staphylococci* in approximately 10% of the samples. This indicated possible foodborne hazards from the fermented foods though many are cooked before consumtion reducing the chance of foodborne outbreaks. Nonetheless, episodes of food poisoning due to consumption of traditional fermented food items such as Hawaizaar are occasionally reported. Examination of antimicrobial resistance profiles of *E. coli* and *Staphylococci* isolates indicated resistance against many antimicrobials including beta-lactam group, gentamicin, macroloides and others. Major resistance markers included beta-lactamase (BLS), methicillin resistant Staphylococcus (MRS), high level gentamicin resistance (HLGR), high level mupirocin resistant *Staphylococcus* (HLMuRS), mecA mediated resistant *Staphylococcus* (mecA-RS), macrolide-lincosamide-streptogramin type b *Staphylococcus* (Staph-MLSb). Presence of antimicrobial resistance traits among isolates presented considerable risk to the consumers due to possible treatment failure in case of infection by the pathogens and transfer of antimicrobial resistance to otherwise innocuous organisms residing in the gastrointestinal tract of the consumers. Traditional fermented foods occupy an important niche in the food preferences of north east India.

Our results revealed a mixed picture of opportunity manifested by wide diversity of LAB with probiotic potential; and on the other hand considerable risk emanating from poor hygienic quality, presence of pathogens, and prevalence of drug resistance traits.

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Green synthesis of silver nanoparticles using *Kaempferia galanga*: characterization and antibacterial properties against food borne pathogens and resistant bacteria

RK Sanjukta, JB Dutta[1], ASen, I Shakuntala, S Ghatak, K Puro, Samir Das, Surmani H, RK Mandakini, Tushar K Dey and BC Das*

ICAR Research Complex for NEH Region, Umiam, Meghalaya
[1] CVSc. AAU, Khanapara, Guwahati, Assam

Introduction

Surfacing of multidrug resistant commensal/pathogenic microbes has been a grave concern worldwide with the potential to circulate in food animals. The emerging problem with antibiotic resistance is mainly the acquired antibiotic resistance in human and animal associated pathogenic and commensal bacteria. Under this backdrop, the solution to antibiotic resistance is either discovery of new effective drugs, reverting resistance or restricting its spread and dissemination. Green synthesis of nanoparticles using plants is increasingly gaining impetus lately by virtue of its simplicity, cost effective, less harmful and eco friendly characteristics. The present study encompasses the biosynthesis and characterization of silver nanoparticles using *Kaempferia galangal*, an indigenous medicinal plants of the Northeast India and evaluation of their in-vitro antibacterial property against four food borne bacterial strains and two resistant bacteria.

Materials and Methods

Tuber of *Kaempferia galanga* was collected from local market of Meghalaya. It was selected on the basis of their folklore medicinal uses. The collected tubers were first washed in running tap water and further with double distilled water to remove all the dust and unwanted visible particles. Thereafter after air-drying in shade it was ground and was stored in clean, wide mouthed, airtight bottles until further use. For preparation of the extracts, the ground plant materials were soaked in methanol maintaining 1:10, w/v. The mixtures were left for 72 h in a shaker incubator maintained at 45 °C and 200 rpm. The mixtures were filtered several times and were kept for evaporation in incubator at 45°C. The completely dried or semisolid syrupy extracts were scrapped, weighed and stored in air tight glass vials at 4°C, until further use. The resulting extract was employed for the analysis of their antibacterial activity and to check their efficiency as a biomaterial candidate for synthesis of SNPs.

The antioxidant activity of the plant extracts was also assessed on the basis of the radical scavenging effect of the stable DPPH (2,2-diphenylpicrylhydrazyl, Sigma) free radical (Zhang *et al.* 2007). Silver nitrate solution (1 mM) was used as the source of silver ion for the synthesis of SNPs. The plant extracts was used as both as reducing as well as stabilizing/capping agent for the formation of silver nanoparticles. The silver nanoparticles synthesis were confirmed by measuring the wavelength of reaction mixture using a Multiskan Go ELISA reader at a resolution of 1 nm (from 250 to 700 nm) in flat bottom 96 well microtitre plate. The Morphological characterization of the samples was also done by Scanning electron microscope (SEM) analysis using **JSM-6360 (JEOL)** SEM machine. Antibacterial screening was done by both agar gel diffusion and microbroth dilution assay in 96 well titre plate against *E. coli*, *Salmonella Typhimurium*, *Listeria monocytogenes*, *Staphylococcus aureus*, resistant strain of *Klebsiella pneumoniae* (ATCC 700603) and MRSA. The optical density of the plate was read at 490 nm ((MultiscanGo). Cell based biocompatibility and cytotoxicity assays was carried out using two cell lines viz. Vero cell lines and HeLa cell lines were used for evaluating the biocompatibility of the SNPs on normal cell lines and the cytotoxicity potential on cancerous cell lines.

Results and Discussion

The crude methanolic extracts of *K. galanga* showed antioxidant activity, with IC50 values of 8.21 ± 0.04 DPPH IC50 (mg/ml) higher than the standard (BHT). Synthesis was successfully using 1mM silver nitrate aqueous solution and plants extracts at the ratio of 1:9. The formation was indicated by the change in colour from the transparent colour of the reaction mixture changed to yellow to brownish solution, which gradually increased in intensity. Appearance of the brownish red colour indicated the formation of silver nanoparticles. Several scientists reported green synthesis of SNPs using plant extracts (Gogoi and Gogoi 2013). The formed nanoparticles were found to be stable and were uniformly distributed throughout the solution. The formation of nanoparticles was confirmed and characterized by UV–visible spectroscopy to determine the surface plasmon resonance (SPR). Silver nanoparticles were rapidly formed within 5-15 min incubation period after the addition of plant methanol extract. The characteristic peaks (λ_max) of the plants reduced SNPs was observed at 415 nm, clearly indicating the formation of SNPs.

The morphology and size of phytofabricated SNPs were further determined by Transmission Electron Microscopy analysis confirming the synthesis and the morphology of SNPs to exhibit polydispersed nearly spherical shape, with size ranging from 5 nm - 50 nm. The size and shape of the nanoparticle was determined by the frequency and width of the surface plasmon absorption produced. Although nanospheres dominated the population of the synthesized silver nanoparticles as evident from HRTEM and TEM micrographs, in some cases anisotropy was observed. The selected-area electron diffraction (SAED) pattern of the SNPs was typical for SNPs with electrons ring formation that provided confirmation for silver crystalinity nature. Rapid synthesis of the nanoparticles was accomplished within 5-20 min of the reaction. The surface Plasmon resonance of the synthesized nanoparticles was 402 nm. The shape and size of silver nanoparticles were spherical and 5-45nm.

The SNPs against the reference strains of bacteria were found to be sensitive with variable results among the organisms as well as the SNPs synthesized using different plants. Thus SNPs exhibited a broad size distribution and morphologies with highly reactive facets, *K. galanga* reveals inhibition zone size of 19.1± 0.3, 14.2± 0.8,13.5± 0.2, 12.4± 0.8, 14.4± 0.2 against *E. coli*, *S.* Typhimurium, *L. monocytogenes*, *K. pneumoniae* and *S. aureus*, respectively. Against the MDR bacteria the results were also encouraging. Similar patterns were observed with SNPs synthesized from K. galanga with diameter of inhibition as 18± 0.6, 18.5± 0.2, 18.2± 0.4, 18.2± 0.4, 14.2± 0.2, 13.5± 0.4, 13.6± 0.8 and 14.3 ± 0.1 against AR EC 1, AR EC 2, AR EC 3, AR EC 4 AR, SAL 1AR, SAL 2AR , SAL 3 A, R SAL 4 AR respectively. The exact mechanism behind the activity of nanosilver on bacteria is not yet fully elucidated. The three most common mechanisms of toxicity proposed are: uptake of free silver ions followed by disruption of ATP production and DNA replication (Lok *et al.* 2006), formation of reactive oxygen species (ROS) and direct damage to cell membranes. Using the broth microdilution method, the the MIC values were variable for different species, it was noted that *K. galanga* with the MIC value of 2.7 ± 0.2, 2.7 ± 0.3, 2.7 ± 0.3, 2.7 ± 0.4, 2.7 ± 0.1 against *E. coli*, *S.* Typhimurium, *L monocytogenes, K. pnumoniae* and *S. aureus* respectively. Similarly MIC values against resistant bacteria maintained the similar trend. . Both the normal and cancer cell line showed different patterns of dose-dependent cytotoxicity response of SNPs. Compared to normal cells the cancer cell needed less dosage to undergo death. The SNPs was able to reduce the viability in dose dependent manner.

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Degradation pattern and leaching potential of flubendiamide insecticide in soil

Shaon Kumar Das[1], Irani Mukherjee[2] and RK Avasthe[1]

[1]*ICAR Research Complex for NEH Region, Sikkim Centre, Sikkim*

[2]*Indian Agricultural Research Institute, New Delhi*

Correspondence: shaon.iari@gmail.com

Introduction

Flubendiamide belongs to phthalic acid diamide group of insecticide. It is effective against lepidopteron pests including resistant strain in rice, cotton, corn, other fruits and vegetables. It has larvicidal activity as a stomach poison and has limited plant penetration and systemicity. It is a foliar applied insecticide. There is no report available on the persistence and mobility behavior of flubendiamide under Indian conditions. In view of the above, a study entitled **"**Persistence and mobility behavior of flubendiamide in soil**"** was undertaken with the main objectives: Effect of moisture and light on persistence of flubendiamide in soil; and study the downward movement of flubendiamide in soil column.

Methodology

Analytical methodologies for analysis of residues of flubendiamide from soil and water were standardized. Partitioning with dichloromethane for aqueous samples and dipping and shaking with aqueous acetone followed by column clean up with neutral alumina for soil samples were found suitable. Flubendiamide residues were analyzed by HPLC. The persistence of flubendiamide in soil was studied at two concentrations, *i.e.* 1 and 10 μg g^{-1} and under three different moisture regimes viz air-dry, field capacity and submerged condition. To study the effect of light on degradation of flubendiamide, thin film technique was followed. Leaching studies were carried out in packed soil columns with analytical grade flubendiamide, its formulation and its metabolite.

The recovery percent and residue or the amounts of the compound were calculated as follows:

$$\text{Concentration } (\mu g/g) = \frac{\text{Peak area of sample x Concentration of standard } (\mu g/mL) \text{ x Volume of extract (mL) x Vol. of standard injected (mL)}}{\text{Peak area of standard X Weight of sample processed (g)}}$$

$$\text{Per cent recovery} = \frac{\text{Amount recovered } (\mu g/g)}{\text{Fortification level } (\mu g/g)} \times 100$$

Results and Discussion

Persistence of flubendiamide was studied in soil collected from rice growing areas from north India; at two concentrations, 1.0 and 10 $\mu g\ g^{-1}$ and under three different moisture regimes *viz.* air-dry, field capacity and submerged. It was found that the dissipation of the compound in soil varies with the soil moisture regimes, fortification levels and light conditions. Trend in dissipation was submerged ($T_{1/2}$ 150.5-158.4 days)>field capacity ($T_{1/2}$ 177.0-181.1 days)> dry ($T_{1/2}$ 206.6-215.0 days). Slightly faster dissipation was observed at 1.0 $\mu g\ g^{-1}$ level as compared to 10 $\mu g\ g^{-1}$ level. Flubendiamide residues persisted in water beyond 250 days with a half-life ranging from 250.8-301 days. Dissipation from water was faster at pH 4.0 ($T_{1/2}$ 250.8 days), followed by pH 9.2 ($T_{1/2}$ 273.6 days) and 7.0 ($T_{1/2}$ 301.0 days). Application of 2.5% compost to soil enhanced degradation of flubendiamide under both field capacity ($T_{1/2}$ 155.1 days) and submerged condition ($T_{1/2}$ 130.8 days).

Effect of light on degradation of flubendiamide was studied as thin film on petri plates and soil thin film under field capacity condition at 10 $\mu g\ g^{-1}$ by exposure to sunlight , UV-light and dark light. Residues dissipated faster under UV-light ($T_{1/2}$ 7.0-9.1 days), in comparison to sunlight ($T_{1/2}$ 12.0-19.1 days) and dark light ($T_{1/2}$ 33.4-44.2 days). Leaching experiments were carried out in packed soil columns. Effect of analytical grade and its formulation on leaching behavior of flubendiamide was studied. Reduced leaching was observed in case of formulation treatments as compared to analytical grade material. Effect of water available for leaching was studied by passing varying amount of water, simulating 51.92, 103.85, 207.71 and 415.42 mm rainfall, to the columns. Metabolite desiodo flubendiamide was found to be more mobile than flubendiamide. In case of analytical grade flubendiamide even after leaching with water equivalent to 415.4 mm rainfall, more than 68.08% residues remained in top 5-10 cm soil layer.

Effect of date of sowing and varieties on severity of Alternaria leaf spot, rust and yield in soybean

Sunil Kumar*, Engrala AO and AK Singh
School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema
*Correspondence: drsunilk81@gmail.com

Introduction

Soybean (*Glycine max* L. Merrill) is the most important oilseed crop in India. A number of fungal foliar diseases have been reported on this crop. Among them, Alternaria leaf spot (*Alternaria tenussiama*), Rust caused by *Phakopsora pachyrhizi* Syd. and P. Syd. (Sarbhoy and Pal 1997) is the most destructive and causing 30-100% yield loss. Considering the importance of the crop, destructive nature of the diseases the study was undertaken to find out the effect of date of sowing and varieties for the management of these diseases.

Methodology

The field experiment was conducted with four soybean varieties having varied range of susceptibility to alternaria leaf spot, target leaf spot and rust, namely 'JS 93-05', 'JS 335', 'JS 97-52' and 'RKS 18' at School of Agricultural Sciences and Rural Development, Medziphema during *kharif* 2012 and 2013. The crop was planted on different dates starting from 15 June to 25 July of 2012 and 2013 at 10 days intervals in a split plot design with three replications having 45 cm row to row and 10 cm plant to plant distance. Observations were recorded on disease severity at fortnightly interval. Data were also recorded on pods/plant, test weight (g) and yield (kg/ha). Disease severity data were recorded by following 0-9 point scale (Mayee and Datar, 1986) where, 0 = no lesions; 1 = 1%; 3 = 1.1 - 10%; 5 = 10.1 – 25%; 7 = 25.1 – 50% and 9 = more than 50% leaf area covered by lesions. Per cent disease index (PDI) was calculated as follow:

$$\text{Per cent disease index (PDI)} = \frac{\text{Sum of individual rating}}{\text{No. of leaf examined}} \times \frac{100}{\text{Maximum disease rating}}$$

Results and Discussion

The mean Alternaria leaf spot of 26.73 per cent was indicating higher disease severity for the second year as compared to first year (23.80%). Alternaria leaf spot severity under fifth date of sowing i.e. 25th July during both, first (32.45%) and second (39.25%) years have been significantly maximum over rest of sowing dates. 'JS 97-52' with Alternaria leaf spot severity of 14.48% in the first year and 14.02% in the second year was noted least susceptible. Each variety showed significant differences at the same level of date of sowing. However, JS 335 and JS 97-52 in second date of sowing during first year and JS 93-05 and RKS 18 in first date of sowing during second year were found at par. A mean maximum rust severity of 65.50% for the first year and 67.94% for the second year was noted in last date of sowing while, it was minimum recorded in first date of sowing during both the years. It's clearly indicates that the severity of rust was increased with succeeding sowing dates. Varity 'JS 335' showed significantly highest rust severity at all the date of sowing followed by 'JS 97-52' during both the year. Minimum rust severity was recorded on 'JS 93-05'. Variety 'JS 93-05' with RKS 18 in first date of sowing and 'JS 335' with 'JS 97-52' in second date of sowing during first year and 'JS 93-05' with 'RKS 18' during second year were found at par. Shukla *et al.* (2005) also reported that early sown soybean showed low disease incidence as compared to late sown crop. An average maximum seed yield of 1796.8 and 1648.2 kg/ha, respectively were recorded under second date of sowing during both the years. The highest seed yield of 1976.9 kg/ha in first year and 1740.4 kg/ha in second year were recorded with 'JS 93-05' under second date of sowing. However, minimum seed yield was recorded in fifth i.e. 25th July sowing during both the year. In accordance with present findings, Karmakar and Bhatnagar 1995 also reported the yield and yield attributes as influenced by varieties. Thus, our findings clearly indicate the importance of early sowing and varietal selection of soybean for the farmers of Nagaland for obtaining higher yield.

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Weed diversity in West Tripura

U Giri*, D Saha, A Saha, Md Hedayetullah, D Debbarma and Debashish Sen

College of Agriculture Tripura, Lembucherra, West Tripura, Tripura

*Correspondence: utpalagro84@gmail.com

Introduction

Weeds are dominant, unwanted, undesirable plant that compete with cultivated crop for water, nutrient and sunlight and another several reasons such as, high growth rate, high reproductive rate and produce harmful or beneficial allelopathical effect of cultivated crops. There are approximately 250,000 species of plants worldwide, of those about 3% or 8,000 species, behave as weeds and 200 to 250 weeds found to cause major problems in worldwide cropping systems (Holm *et al.* 1979). Agro-climatic condition of Tripura is favorable for wide range of broad leaf weeds, grasses, sedges and aquatic weeds. In the present study, an effort has been made to identify, collect, classify different weed species and to generate baseline information about these weeds of the study area.

Methodology

In the month of September 2013 and 2014, survey of different villages of West Tripura viz. Bajalghat, East Laxmansinghmura, West Laxmansinghmura, Kamalghat, and Santipara were done by the Rural Agricultural Works Experience (RAWE) students of College of Agriculture, Tripura to collect the weeds those were found there in the fields and on the road side of these villages. The collected weeds were identified on the spot and in the laboratory on the basis of their natural characters with the help of identification keys and other relevant literature. Herbarium from identified weeds were stored in Herbarium Section of College of Agriculture, Tripura. Classification, abundance and dominance study of these weeds were done as given below.

$$1.\,Absolute\ density = \frac{\text{Total no of individual sp. in all quadrate}}{\text{Total Number of quadrate}}$$

$$2.\,Abundance = \frac{\text{Total no of individual sp. in all quadrate}}{\text{Number of quadrate in which it occur}}$$

$$3.\,Dominance = \frac{\text{Absolute density of individual species X 100}}{\text{Number of quadrate in which it occur}}$$

$$3.\,Relative\ Dominance = \frac{\text{Dominance of individual species X 100}}{\text{Sum of the dominance of all species}}$$

Results and Discussion

Among the weeds the grasses like *Echinochloa colonum*, *Eleusine indica* and *Eragrostis unoloides* were identified from the crop field as well as road side during that period. The dominated sedge weeds identified from the villages were Cyperus *difformis, C. compactus, C. iria, C. compressus and Fimbristylis littoralis etc.* Major broad leaf weeds identified from the crop field were *Ageratum conyzoides*, *Eclipta alba* and majority of the broad leaf weeds identified from roadside were *Leucas aspera, Sida cordifolia, Mimosa pudica, Cassia tora, Mucuna pruirens, Amaranthus viridis* and *Eclipta alba* etc. *Ludwigia sp.* recorded the highest absolute density (1.2), abundance (1.5), dominance (30) and relative dominance (24) in rice crop. In brinjal, the highest absolute density (1.2), abundance (2.0), dominance (40) and relative dominance (22.22) was recorded by the weed *Phylanthus niruri*. While, in chilli, the highest value of absolute density (0.6), abundance (1.5), dominance (30) and relative dominance (13.04) was found in *Portulaca oleracea.*

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Biochemical changes in relation to late leaf spot of groundnut

Utpal Dey* and DN Dhutraj

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

*Email: utpaldey86@gmail.com

Introduction

Groundnut (*Arachis hypogaea* L.), is one of the most popular oil seed crop grown throughout the world. It is considered as "King of oilseed crops", because of it contain 40 to 49 per cent oil. Groundnut crop is affected by several biotic factors (fungi, bacteria, viruses, nematodes) and abiotic factors. The major fungal diseases are: Early leaf spot (*Cercospora arachidicola* Hori), Late leaf spot (*Phaeoisariopsis personata* (Berk and Curtis) Arx, Rust (*Puccinia arachidis* Speg.). Late leaf spot caused by *P. personata* (Berk and Curtis) Arx.], is one of the most important and destructive disease causing accountable qualitative and quantitative losses (Naab *et al*. 2005). The causal organism is air borne and soil inhabiting and responsible for late leaf spot disease of groundnut, thereby incurring yield losses to the tune of 50-80 per cent. The disease was reported to be more severe during *Kharif* season, moderate during *Rabi* and to a lesser extent during summer seasons. Therefore, keeping in view, the economic importance of the crop and losses incurred by the disease, the present study was undertaken.

Methodology

In the present study, role of the biochemicals *viz.*, phenols (total and ortho dihydroxy), sugars (total, reducing and non-reducing) and chlorophyll (total, a and b) were estimated from the healthy and diseased groundnut leaves of resistant groundnut Cv. TPG-41 and susceptible Cv. JL-24, applying standard biochemical analysis methods (Plummer 1988).

Results and discussion

Studies on host biochemical features of resistance/ susceptibility indicated that the healthy (pre-existing) foliage of resistant groundnut TPG-41 constituted of significantly higher amounts of phenols (total and OD) and chlorophyll (a, b and total) than that of susceptible Cv. JL-24. However, sugars (reducing, non reducing and total) were found to be maximum in the foliage of susceptible Cv. JL-24 than that of resistant Cv. TPG-41. The *P. personata* infection in both the groundnut cultivars caused drastic alternations in these pre-existing (healthy) bio-chemicals. The accumulation of phenols (total and OD) at significantly higher rate in resistant Cv. TPG-41 indicated the role of phenolics in imparting resistance against late leaf spot disease.

Table 1. Biochemical variations in groundnut variety, susceptible and resistant to *P. personata*

Biochemicals content in mg/g	JL-24		% increase or decrease over healthy	TPG-41		% increase or decrease over healthy
	H*	D**		H	D	
Chlorophyll a	0.42	0.27	35.71(-)	0.88	0.81	7.95(-)
Chlorophyll b	0.36	0.21	41.67(-)	0.67	0.52	22.39(-)
Total Chlorophyll	0.78	0.48	38.46(-)	1.55	1.33	14.19(-)
Reducing sugar	3.56	3.23	9.27(-)	4.61	4.29	6.94(-)
Non reducing sugar	1.45	1.28	11.72(-)	2.33	2.21	5.23(-)
Total sugar	5.01	4.51	9.98(-)	6.94	6.5	6.34(-)
Total phenols	2.6	3.0	15.38(+)	2.9	3.3	13.79(+)
OD-phenols	2.1	2.7	28.57(+)	2.4	2.9	20.83(+)

*H: Healthy, **D: Diseased

Further post infection by the pathogen leads to reductions in the chlorophylls (a, b and total) at higher rates in the foliage of susceptible host plants and comparatively at lower rates in the foliage of resistant host plants.

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Diseases in field crops of Tripura

Debasre Bhattacharjee* and Jayashree Bhattacharjee

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura
*Correspondence: debashreebhatt89@gmail.com

Introduction

Agricultural production sustains an annual loss of about 20 to 30% globally due to diseases. Tripura, a state of NE India is endowed with huge biodiversity. The economy of Tripura is primarily agrarian. Agriculture is the state's dominant sector with a contribution of nearly 30% Net State Domestic Product (NSDP). About 52% of total main workers are engaged in agriculture in Tripura, of which cultivators form about 28% and agricultural labourers form roughly 24%. Small and marginal farmers constitute almost 90% of the total farming community in the state. The net sown area is only about 27% of the state's geographical area. The total cultivable area is about 2.55 lakh hectares of land, out of which, total irrigable area is about 1,17,000 hectares or 45.88% which is under irrigation. The state of enjoys a typical climate with variation ranging from sub–tropical to temperate conditions in hilly areas. The climate of Tripura exhibits a strong seasonal rhythm. The agro-climatic condition of Tripura causes survival of several pest and diseases in its ecosystems. Plant diseases is one of the major bottlenecks in agricultural production particularly in irrigated crops, in monoculture cultivations and in certain widely grown rainfed crops as well. To avoid such losses, it is necessary to provide optimum condition in soil, climate and nutrition for plant growth. The crops are usually affected by two undesired factors i.e. diseases and/or pests.

Methodology

The data for important diseases for field crops is being analysed on the basis of literature survey and field observations and compiled.

Results and discussion

Most of the our farmers even today are not able to identify the difference between these two factors causing considerable losses to a particular crop and the cause is considered as some `disease' even if actually it is some 'insect pest'. Two types of factors mainly cause plant diseases viz. parasitic causes- i.e. different kinds of microorganisms like fungi, bacteria, virus, nematode etc and non-parasitic causes - i.e. unfavorable conditions relating to soil, climate, nutrition, water, sunlight, and harmful chemicals. Changing climate also influences plant diseases, especially fungi and molds that grow and spread rapidly when humidity is high (Rosenzweig et al. 2001). Many plant diseases are causing huge losses in cereals and pulses in Tripura**.** Crops suffered most are rice, lentil, maize, cowpea, mung bean, urd bean, tomato, potato etc. In rice mainly BLB, sheath blight, sheath rot, brown spot etc are accountable whereas, in lentil wilt and scelotium rot causes huge economic damages. Plant disease also reduces the quality of food grains by reducing its nutritional quality. Therefore, this is necessary to focus on research aimed at improving food security by reducing crop losses, particularly for low-income farmers.

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Integrative taxonomy in cerambycid beetles of north eastern India

GT Behere*, DM Firake, D Thubru, B Sharma, NS Azad Thakur, SChandra and SV Ngachan

ICAR Research Complex for NEH Region, Umiam, Meghalaya

* Correspondence: ganeshbehere@gmail.com

Introduction

Members of the family cerambycidae are commonly known as Longicorn or Long-horned beetles. The beetles of the family cerambycidae are distributed worldwide but are pre dominant and extensively radiated in the tropics. This is one of the largest families of the coleopteran order comprising of 35,000 species under 4,000 genera in 11 sub-families of which many species are of agricultural and horticultural importance (Lawrence 1982). So far about 50 species of cerambycids are well known as pests of agricultural, horticultural and forest ecosystems and majority of these are borers of stem, shoot, trunks and roots of plants. Many times their infestation is hidden and gets noticed only upon its final stages. It is estimated that there are about 250 species of cerambycids that occur in the agroecosystems of the North eastern parts of India (Gahan 1906, Kumawat *et al*. 2015). Majority of these are poorly studied for their taxonomy and it is estimated that an equal number of species are to be described and made known. Moreover, stage independent identification using traditional taxonomical keys alone is almost impossible. Integration of traditional and molecular characterization of the groups of beetles which have ambiguities in identification will significantly enhance the overall process of the reliable identification in this group of insects. This study envisages a unique integrated approach as the central point for the taxonomy of the cerambycid beetle of India

Methodology

Concerted efforts were made to collect, identify and document the longhorn beetles from the north eastern states of India. Multiple field surveys were undertaken for the collection of cerambycid beetles from various districts of Meghalaya (Ri-Bhoi, East Khasi Hills, East Garo Hills and West Jaintia Hills), Nagaland (Dimapur and Kohima), Tripura (West Tripura), Assam (Dibrugarh), Arunachal Pradesh (Basar). Beetles were collected either by mechanical means (i.e. based on the damaged symptoms) or by using light trap at night time during the peak period of emergence (i.e. April to September). Preliminary identification was carried out by using established taxonomic keys. Same sample were also characterized and identified by molecular taxonomy by using COI gene of mtDNA. Bioinformatics analysis was carried out and good quality sequences were obtained for all the specimens.

Results and Discussion

A total of 185 multiple specimens belonging to 45 different individual species were collected and documented from different locations of north eastern states. Out of this 21 species were identified up to genus level, 13 species were identified up to species level by traditional taxonomy alone with some ambiguity and 11 species were identified by integrative taxonomy (traditional taxonomy and molecular taxonomy).

Table 1 The list of species of cerambycid beetles identified based on integrative taxonomy

Name of Insect Species	Code	DNA con (ng/µl)	DNA Barcode length (bp)
Apomecyna saltator (Fabricius) (2013-14)	CERDBT27	8.5	670
Arhopalus ferus Mulsant (2014-15)	CERDBT30	46.7	680
Aristobia reticulator (F., 1781)	CERDBT16	24.8	624
Batocera lineolata Chevrolat (2013-14)	CERDBT04	1.2	671
Epepeotes uncinatus Gahan (2013-14)	CERDBT17	19.9	671
Glenea pulchra Aurivillius (2013-14)	CERDBT29	46.1	670
Macrochenus isabellinus Aurivillius (2013-14)	CERDBT31	48.6	675
Pharsalia subgemmata (Thomson) (2013-14)	CERDBT05	36.2	630
Sthenias grisator (Fabricius, 1787)	CERDBT07	48.7	671
Stromatium barbatum Gahan (2014-15)	CERDBT13	2.4	627
Xylorhiza adusta (Wiedemann) (2013-14)	CERDBT15	57.1	634

Due to the unavailability of matching sequences in the international genebank for the insect family cerambycidae, molecular identity of 13 species which were identified by traditional taxonomy was not established. DNA barcodes were developed for all the 11 species which were identified based on integrative taxonomy (Table-1). Given the difficulties in identification of cerambycid beetles with traditional taxonomy and lack of matching DNA data in case of molecular taxonomy, the integrative taxonomy approach should be used for reliable identification of cerambycid beetles.

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Evaluation of plant products and antagonistic microbes against grey blight a devastating pathogen of tea

Harikamal Barman[1*], Aniruddha Roy[2] and Shaon Kumar Das[3]

[1]*University of North Bengal, Siliguri, Darjeeling, West Bengal*
[2]*ICAR Research Complex for NEH Region, Umiam, Meghalaya, India*
[3]*ICAR Research Complex for NEH Region, Sikkim Centre, Sikkim, India*
*Correspondence: harikamalbarman@gmail.com

The present study was carried out to evaluate the effect of different oils (lemongrass oil, neem oil, karanj oil, zinger oil, eucalyptus oil and patchouli oil), different plant product extracts (garlic, zinger, false ashoka and datura) and different antagonistic microorganisms (different species of *Trichoderma spp*., *Bacillus sp.* and *Pseudomonas sp.*) on grey blight of tea, *Pestalotiopsis theae*. It was revealed that eucalyptus oil and neem oil (0.05%) showed 98.1% and 94.3% inhibition of mycelial growth over control, respectively. But both of them at 0.1% showed 100% inhibition for the pathogen. Similarly, plant extract garlic and datura showed 98.2% and 95.4% inhibition of mycelial growth over control. Among the different antagonistic agents *Trichoderma viride* showed 74.3% inhibition of mycellial growth over control.

Performance of fungal plant pathogens in the culture media in presence of host plant parts

Jayashree Bhattacharjee[1*], Debasre Bhattacharjee[1] and SG Borkar[2]

[1]*ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, West Tripura*
[2]*Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra*
*Correspondence: jayashreebhatt89@gmail.com

Introduction

Nutrient media, prepared for the growth of micro-organisms in the laboratory is called culture media and the nutrient composition of a culture medium plays a major role for efficient growth of any micro-organisms. Although most fungi can be cultured in nutrient media with ease, some of them have specific and exacting requirements and will not grow on most commonly used nutrient media. Understanding host dependency of fungal pathogens is essential for their multiplication. Different plant pathogens which grows very efficiently in its host plants, sometime performs non-satisfactorily in the culture media prepared for it artificially. Therefore, the present study was undertaken for seeing the efficacy of selective fungal pathogens in its culture media in the presence of its respective host plant parts.

Methodology

The pathogens evaluated in this study were *Fusarium oxysporum, Alternaria alternata, Helminthosporium sp, Cercospora sp* and *Sclerotinia sp. Fusarium* and *Sclerotinia* were of leaf pathogens whereas, *Alternaria, Helminthosporium* and *Cercospora* were of root pathogens. The pure culture of these pathogens was obtained in Potato-Dextrose-Agar (PDA) and Tapioca-Potato-Sugar-Agar (TPSA) media. Tapioca-potato-Sugar-Agar (TPSA) is a low-cost universal media developed for plant pathogens (Bhattacharjee et al., 2015). *In vitro* experiment was conducted to determine the effect of addition of leaf and root extracts of host plants in the culture media on mycelial growth and sporulation of the isolated pathogens. Extracts were prepared from leaves and roots of selected host plants. Plants were selected on the basis of their leaf and root pathogens. For the host of leaf pathogens, the leaves of tomato, sorghum and soybean were used whereas, and for the host of root pathogens, the roots of chick pea were used. The leaves were thoroughly washed in running tap water followed by sterile distilled water. They were air dried at room temperature and ground to obtained extract of each plants species. The extraction was done by using of pestle and mortar. Water extract was obtained by adding each 2 gm of leaves/ root samples to 100 ml of distilled water. The media was incubated at 27 ± 1^{0}C in a hot air oven after inoculation with the fungus. The growth rate of mycelia and sporulation in the fungus was observed after 72 hrs of incubation (Ananomyous 2008).

Results and discussion

The mycelia growth and spore density (numbers/cm^2) in the fungal pathogens were significantly higher in the media enriched with leaf and root extracts of their host plants (Pandey *et al*. 2006). Hence, the study concluded that, the relative growth rates and sporulation of plant pathogens such as *Fusarium oxysporum, Alternaria alternata, Helminthosporium sp, Cercospora sp, Sclerotinia sp* in its culture media can be enhanced by adding the leaf and root extracts of its respective host plants which is important for the maintenance of their diversity.

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Community analysis of plant parasitic nematodes under protected cultivation

Lotika Kalita, BN Chaudhary, AS Panwar*, Hadienlarisa Syiemlieh, Moutusi Tahashildar, Supriya Bhujel and Jimmy Y Yumnam*

ICAR research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: draspanwar@gmail.com

Introduction

Protected cultivation is a technique of cultivation of crops under controlled environmental conditions and in rotation four to five crops are grown in a year. This helps in enhancing quality production. There are numerous pathogenic diseases (virus, bacteria, fungi and nematodes) affecting greenhouse crops of which nematodes are the most common practice affecting crop production. Nematodes are ubiquitous inhabitants of soil, subsisting on living organism of every type and in turn, contributing their biomass to other soil biota. Plant-parasitic nematodes are nearly microscopic, worm-shaped animals virtually invisible to the naked eye when in the soil. They cause significant damage ranging from minor injury to total destruction of plant material.

Methodology

Investigations were carried out during 2012-2013 to study community analysis of plant parasitic nematodes under protected cultivation. A total of 120 soil samples were collected from rhizosphere of different crop grown in green house, polyhouse, shade net in various parts of Assam and Meghalaya. Composite soil samples were collected at a depth of 10-15 cm in rhizospheric region of 10-15 plants / orchard (plantation). All the samples were collected in polythene bags and sealed tightly. Extraction of nematodes from the soil was done by following Modified Cobb's sieving and decanting technique (Christie and Perry 1951) Nematodes were counted by diluting the nematode suspension to a known volume. An aliquot of 1.00 ml nematode suspension was drawn by a pipette and put in a Hawkshlay nematode counting dish to count the nematodes under stereoscopic binocular microscope. Community analysis of plant parasitic nematodes was done by using the methods suggested by Norton 1978 while prominence value was calculated with the formula given by Beals 1960.

Results and Discussion

In the present investigation ten species of plant parasitic nematodes *viz., Helicotylenchus dihystera, Tylenchorhynchus, Hoplolaimus, Meloidogyne, Rotylenchulus, Pratylenchus, Cephalenchus, Macroposthonia, Hemicriconemoides and Xiphinema* were recorded and presented in table 1. Out of the 120 samples collected *Helicotylenchus dihystera* was found infecting 85 samples with an absolute frequency of 70.8%. The relative density of the species increased with increase in relative frequency. *Tylenchorhynchus leviterminalis* and *Rotylenchulus reniformis* was recorded only in 50% samples with absolute and relative frequency more than absolute and relative density. Whereas *Cephalenchus leptus* was found infecting 50% samples with promimnce value of 110.3. In 15 samples *Macroposthonia onoensis* and *Meloidogyne incognita* was reported.

Table 1. Community analysis of different plant parasitic nematodes under protected cultivation (n = 120)

Nematode	Number of sample containing species	Absolute frequency (%)	Relative frequency (%)	Absolute density	Relative density (%)	Prominence value
1. *Helicotylenchus dihystera*	85	70.8	25.2	69.2	46.2	582.2
2.*Tylenchorhynchus leviterminalis*	50	41.6	14.8	13.9	9.2	89.6
3. *Cephalenchus leptus*	60	50	17.8	15.6	10.4	110.3
4. *Rotylenchulus reniformis*	50	41.6	14.8	14.0	9.3	90.2
5. *Macroposthonia onoensis*	15	12.5	4.4	6.2	4.1	21.9
6. *Xiphinema radicicola*	20	16.6	5.9	5.7	3.8	23.2
7. *Hoplolaimus indicus*	24	20	7.1	14.6	9.7	65.2
8. *Meloidogyne incognita*	15	12.5	4.4	3.8	2.5	13.4
9.*Pratylenchus musii*	10	8.3	2.9	3.8	2.5	10.9
10.*Hemicriconemoides mangiferae*	8	6.6	2.3	2.6	1.7	6.6

Hoplolaimus indicus was recorded could infect the 24 samples with absolute frequency and absolute density of 14.6% and 20.0 respectively. Likewise, *Xiphinema radicicola* was found in 20 samples which recorded very less relative density of 3.8% and prominence value 23.2. *Pratylenhus musii* and *Hemicriconemoides mangifera* was the least found species in the samples collected.

It was concluded that out of ten nematode species, *Helicotylenchus dihystera* was the most frequently encountered nematode species in rhizosphere of crops grown in protected cultivation with absolute frequency of 70.8% and relative frequency of 25.2%, followed by *Cephalenchus leptus. Helicotylenchus dihystera* also ranked first in absolute density and relative density (69.2 and 46.2%) and was followed by *Cephalenchus leptus* (15.6 and 10.4%). Hence, *Helicotylenchus dihystera* found to be the more prominence followed by *Cephalenchus leptus* in North East India.

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Impact of various botanicals on the survival of tobacco caterpillar

Partha Debnath*, Rachna Pande, KM Singh, Monilal Chaterjee, Dipali Majumdar, T Rajesh

CPGS, Central Agricultural University, Umiam, Meghalaya
ICAR Research Complex for NEH Region, Umiam, Meghalaya
*Correspondence: entopar1992@gmail.com

Introduction

The tobacco caterpillar, *Spodoptera litura* (Fabricious) one of the polyphagous pests has emerged as a serious noctuid next to *Helicoverpa armigera* (Hubner), distributed widely throughout the tropical and temperate Asia, Australia and the Pacific islands. It has a huge potential to invade new areas or to adapt to a new climatic or ecological situations. The pest is an important foliage feeder and closely related to agricultural crops causing losses to pulses, oilseeds, vegetables etc. Efforts have been made to control its population. For eco-friendly management of this insect among various options, botanicals have been recognised as a source of environment friendly natural pesticides which is easily approachable to the farmers. Bakain (*Melia azedarach),* Tulsi (*Ocimum tenuiflorum*) against *Spodoptera litura* (Pandy and Summarwar 2015), lemon grass (*Cymbopogon flexuosus*) and citronella (*Cymbopogon nardus*), these are some of the medicinal and aromatic plants known for their insecticidal, repellent, deterrent properties. Solutions of these plant leaf extracts are useful in suppression of this devastating defoliator

Methodology

The experiment was carried out at Division of Entomology, ICAR RC for NEH Region, Barapani. Mass culture of *S. litura* was established on castor leaves. Larvae were reared till pupation in glass jars. Pupae formed were transferred to another jar for adult emergence. Cotton swab dipped in 15 per cent sucrose solution was provided as food to the adult emerged and filter paper and muslin cloth was kept as oviposition substrate. Egg laden substrate was replaced daily with fresh one. The plant extracts were prepared as per the methodology described by Bhat and YubakDhoj, 2005 with slight modification. All the plant leaves were collected from the relevant field and weighed 1kg each, thoroughly washed in water and kept for 1 hour in shed to drain out the excess water. Now the leaves were grind with mechanical grinder with the addition of 1 litre of water in each plant extracts. The extracts were collected and pass through muslin cloth, tied and kept overnight to drain out the crude extracts. After getting the crude extracts, it was filtered through What man No.1 filter paper. The filtered solution was kept in bottles and labelled with name of the respective plant extracts. The extracts were mixed with distilled water in 1:4, 1:3 and 1:2 respectively (Bhat and YubakDhoj 2005). All the solutions were evenly sprayed on the castor leaves and kept for minutes to get dried. The experiment was done with 3 replications for each treatment including control. Now, 10 first instar larvae were released using camel hair brush on the treated leaves and the larvae were allowed to feed on the leaves. After 24 hours, the jars were observed. The mortality counts were taken after every 48 hours interval, the moribund larvae were also counted as dead. The data were subjected to analysis of variance (ANOVA) in a Completely Randomized Design (CRD) after appropriate transformations.

Results and Discussion

The data presented in table1 revealed that, in case of 1:4 ratio solutions, citronella and lemon grass shows no or very less per cent larval mortality (0.00%) , as compared to bakain and tulsi extracts which had more mortality (6.67% and 10.00% respectively). In percent pupation, citronella and lemongrass treated leaves showed more pupation (70.00% and 66.67% respectively) compared to bakain (63.33%) and tulsi (60.00%). Tulsi treated leaves showed the lowest per cent pupation. The per cent adult emergence was the lowest in tulsi treated leaves (26.67%) followed by bakain (33.33%).

In 1:3 ratio solutions, citronella and lemon grass had a 6.67per cent larval mortality whereas, in bakain and tulsi, the larval mortality was nearby similar i.e. 29.62% and 32.59% respectively. The per cent pupation was the lowest in bakain treated leaves (36.67%) followed by tulsi treated leaves (50.00%). The per cent adult emergence was the lowest in bakain (13.33%) followed by tulsi (20.00%).

In case of 1:2 ratio significantly highest per cent larval mortality (72.11%) was recorded in tulsi followed by 1:2 ratio of bakain (53.17%) while control treatment showed the lowest mortality (3.33%). Similar result was reported by Pandy and Summarwar2015, nearly 28.34% larval mortality at 0.5% concentration of tulsi in *Spodoptera litura*, and Sharma, 2010 reported 50.0% larval mortality in *Acridaexalta* at 1.0% concentration of Tulsi .Per cent pupation was significantly lower in bakain (13.33%) followed by tulsi (26.67%). The per cent adult emergence was lowest in bakain (6.67%) followed by tulsi (10.00%).Over all maximum per cent adult emergence was recorded in lemon grass (43.33%) followed by citronella(36.67%).Only 6.67% adults were emerged in bakain. Over all highest larval mortality was seen in case of tulsi (72.11%) followed by bakain (53.17%) but per cent pupation was lowest in bakain (13.33%).Citronella and lemon grass had lesser efficacy in all the growth stages when applied in lower concentration though it cannot be over looked as in higher concentration, they showed somewhat positive result. However, all the treatments were found superior over control. So it can be concluded that higher concentration ratio of tulsi have significant effect on larval mortality of *S. litura* followed by the higher concentration of bakain leaf extract. As much as the concentration decreased i.e. from 1:4 to 1:2, the efficacy of all the respective leaf extracts were increased. On the other hand, the plants used in this experiment are easily available, the preparations of the extracts were easy for all, and hence there is a potentiality to incorporate these extracts into botanical insecticides against *S. litura* insect under field condition.

Table 1. Per cent larval mortality, pupation and adult emergence of *S. litura*

Treatments	Concentration (in ratio)	Per cent larval mortality	Per cent pupation	Per cent adult emergence
T_1 (citronella)		0.00	70.00	36.67
T_2 (lemon grass)		0.00	66.67	43.33
T_3 (bakain)	1:4	6.67	63.33	33.33
T_4 (tulsi)		10.00	60.00	26.67
T_5 (citronella)		6.67	66.67	33.33
T_6 (lemon grass)		6.67	63.33	40.00
T_7 (bakain)	1:3	29.63	36.67	13.33
T_8 (tulsi)		32.59	50.00	20.00
T_9 (citronella)		22.22	43.33	20.00
T_{10} (lemon grass)		13.33	30.00	26.67
T_{11} (bakain)	1:2	53.17	13.33	6.67
T_{12} (tulsi)		72.11	26.67	10.00
Control (T_{13})		3.33	80.00	66.67
CD (5%)		12.50	13.70	18.03

*significant

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Studies on different culture media and different nitrogen sources for the Mycelium growth of two Pleurotus species

Pinki Pal*, Hemavati Ranebennur, Lopamudra Sahoo, Gangaranidevi, M Datta and SV Ngachan

ICAR Research Complex for NEH Region Tripura Centre, Agartala
*Correspondence: pinkipal.biotech@gmail.com

Introduction

The commom name "Oyster mushroom" refers to several species of edible mushroom belonging to the genus *Pleurotus*. Oyster mushroom (*Pleurotus* spp.) belongs to the family of Tricholomataceae and is usually found clustering naturally. Among all the species of mushroom, the Oyster mushroom is the second widely cultivated Mushroom worldwide (Nwokoye *et al.* 2010). *Pleurotus* species are popular and widely cultivated throughout the world mostly in Asia, America and Europe because of their simple low cost production technology and high biological efficiency. *Pleurotus* species can grow on a wide range of temperature. *Pleurotus* species are a rich source of proteins minerals (P, Ca , Fe, K and Na) and vitamin. Mushroom protein is intermediate between that of animals and vegetables and it is of superior quality because of the presence of all the essential amino acids (Hoa and Wang 2015). The process of cultivating mushroom has 3 main steps: isolating mushroom from permitting bodies, spawn preparation, bed preparation, cultivating mushroom from these spawns to harvest fruiting bodies (Munsur *et al.* 2012).

Methodology

The experiments were conducted in Plant Pathology labrotory of ICAR Tripura centre during Summer 2015. Two species of Oyster Mushroom *Pleurotus dzamore* (PDZ) and *Pleurotus flabellatus* (PF) were collected from Plant Pathology Division, ICAR-RC-NEH Region, Tripura Centre. Three Agar media were used namely Potato Dextrose Agar (PDA), Yam Dextrose Agar (YDA) and Malt Extract Agar (MEA).The ingredients for those culture media were as follows: PDA : 200 g Potato, 20g Dextrose , 15g Agar powder in 1000 ml of distilled water; YDA : 200g Yam, 20g Dextrose, 15g Agar powder in 1000 ml of distilled water; MEA : 20g Malt extract , 20g dextrose, 15g Agar powder in 1000 ml of distilled water. Media and petri dishes (around 9 cm dia) were autoclaved at 121°C for 30 min. After autoclaving different media were poured into the petri plates under aseptic condition. The 1 cm mycelium discs of PDZ and PF were inoculated on PDA, YDA, MEA medium in 3 replications. The diameter of the mycelium expansion was measured every 3 days Interval for 8 days. Effect of different Nitrogen sources on the basis of dry weight measurement of Mycelium: To study the effect of different Nitrogen sources, potato dextrose (PD) broth was taken as a base medium in a conical flask (100 ml) and supplemented with different nitrogen sources in 3 replications of each .The mycelium of both the strains were inoculated into the flask under aseptic condition and incubated at room temperature . After 20 days the mycelium mat of each strain (PDZ & PF) were filtered through a pre-weighed filter paper, and dried at 75°C for 3 days, cooled in a desiccators and weighed.The data was analysed with the SPSS-16 software using DMRT (Duncan's Multiple Range Test) in one way ANOVA.

Results and Discussion

Effect of different Culture Medium**:** The overall result showed that the *Pleurotus dzamore* species showed no significant difference in the all the three medium in the experiment. While in case of *Pleurotus flabellatus* showed significant growth in (PDA and YDA medium) (Table 1).

Table 1. Mycelium growth of PDZ on different media (diameter in cm)

Different Culture Media	PDZ	PF
Potato-dextrose agar	7.8^{a}	7.53^{b}
Yam dextrose agar	7.8^{a}	7.93^{b}
Malt extract agar	7.73^{a}	6.73^{a}

Ammonium Chloride supported the greatest mycelium growth as a nitrogen source for *Pleurotus dzamore* and Peptone is considered as most favourable nitrogen source for the *Pleurotus flabellatus* spp. The least utilized nitrogen source was Urea for both the species. Effect of different Nitrogen sources on the basis of dry weight (g/100 ml) measurement of mycelium: The overall result shows that the *Pleurotus dzamore* and *Pleurotus flabellatus* species showed significant difference in all the five nitrogen sources used in the experiment (Table 2).

Table 2. Effect of different Nitrogen sources

Nitrogen sources	PDZ	PF
Peptone	0.23^{b}	0.51^{c}
Yeast extract	0.06^{a}	0.33^{b}
Urea	0.33^{a}	0.09^{a}
Ammonium Chloride	0.35^{c}	0.48^{c}
Ammonium Sulphate	0.28^{b}	0.31^{b}

Thus, it can be concluded that we can cultivate the two *Pleurotus* species PDZ and PF in normal room temperature with neutral P^{H} of 7. Among the culture media, YDA and MEA media can be used as well as PDA to cultivate PDZ and PF. The mycelia mass can also be enriched by growing in a medium containing different nitrogen sources like peptone, yeast extract, ammonium chloride, ammonium sulphate and urea. In this study peptone and ammonium chloride supported the highest dry weight of mycelia mass.

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Eco-friendly approaches for the management of Flacherie disease of muga silkworm under the agro-climatic conditions of Assam

M Marak[1], Pranab Dutta[2] and LC Dutta[3]

Assam Agricultural University, Jorhat, Assam

*Correspondence: pranabdutta74@gmail.com

Introduction

Muga silk, a golden yellow yarn which spells grandeur, glossy fine texture and durability is produced by the Muga silkworm *Antheraea assama* Westwood (Saturniidae: Lepidoptera), is the pride of India. This sericigenous insect is an important bioresource of north eastern region of India. It is mainly confined to the Brahmaputra valley of Assam and foothills of East Garo hills of Meghalaya. It is a semi domestic, multivoltine, polyphagous insect reared mainly on Som (*Persea bombycina* Kost) and Soalu (*Litsaea monopetala* Juss). In general, Muga Silkworm is multivoltine with 5-6 broods per year. Commercially rearing takes place in six different seasons viz., Jarua (December-February), Chotua (March-April), Jethua (May-June), Aherua (June-July), Bhodia (August-September) and Kotia (October-November). It is reared by more than 30,000 families in Assam with a total area of 9,400 ha and production of 109 MT. Muga rearing faces many constraints, one being its outdoor nature which compels the muga silkworm to adjust themselves to the adverse effects of climatic conditions and exposes it to many pests and diseases leading to heavy crop loss (Choudhury, 1981). Among the diseases, Flacherie disease caused by bacteria is a menace and the muga silkworm is most susceptible to this disease. The disease is found to occur throughout the year, more prominently during the hot and humid summer climatic conditions, resulting in decrease in silk producing capacity of the silkworm. During these seasons, the larval mortality is estimated to be around 20-70. Maximum incidence is recorded in the late instars (4^{th} and 5^{th} instars) and in peak season the crop loss can extent up to 100%. Flacherie is a generic name which refers to the flaccid condition of the infected worms. The symptoms of the disease are the larva becomes extremely irritable, shrinks in size, and is sluggish, and less responsive to stimuli. Silkworms are sensitive to chemical treatments and therefore use of bio-formulations of plant and microbial origin along in combination with antibiotics could be considered as best alternative for its control. Both *in vitro* and *in vivo* tests were conducted to check the efficacy of the botanicals, bio-control agents and antibiotic separately as well in combinations.

Methodology

For the preparation of plant extracts, leaves of Aloe-Vera (*Aloe barbadensis* Mill.), *Clerodendrum inerme* L. and Mikania (*Mikania micrantha* Kunth), fruits of Amla (*Phyllanthus emblica* L.) and *Terminalia chebula* were used. Extracts were prepared by taking 30g of respective parts and sterilizing them with 0.1 % Mercuric chloride followed by thoroughly washing twice in distilled water and grinding in mortar and pestle by adding 50 ml of distilled water. The extracts were filtered and centrifuged at 10,000 rpm for 20 minutes to obtain cell free solution. The supernatant of the botanical by making the volume up to 70 ml was considered the botanical at 50% concentration of fresh weight basis.

The selected biocontrol agents *Trichoderma harzianum*, *Trichoderma viride*, *Trichoderma asperallum*, *Trichoderma pseudokoningii* and *Pseudomonas fluorescens* were evaluated *in vitro* against the bacterial pathogens. The bio-control agents were pre-cultured in Potato Dextrose Agar (PDB) broth for 72 hrs. Streptomycin and Tetracycline were investigated against the pathogen. Two concentrations of 50 ppm and 100 ppm of the antibiotics were prepared. Paper Disc Method was employed to screen the efficacy of the botanicals, bio-control agents and antibiotics. Here 10 ml of bacterial suspension cultured from 48 hrs old bacterial cultures was added in 90 ml of sterilized molten Potato Dextrose Agar (PDA) medium in each petriplate of 9cm diameter. After the agar has gelled, sterilized paper disc of 2cm diameter were dipped in different phytoextracts/biocontrol agents/ antibiotics for 1min. and placed in the centre of the PDA plates. The basal medium (PDA) with a paper disc dipped in sterile water was served as control. Each treatment was replicated 5 times and incubated at 25±1°C. The inhibition zones formed were measured in mm. and observation was recorded up to 72 hrs at periodic interval of 24 hrs.

Two Botanicals, a bio-control agent and an antibiotic (evaluated as best through *in vitro* studies) alone and in their compatible combinations were tested further in controlled conditions. The muga worms were reared indoors in Som twigs kept in conical flasks containing sugar solution (Bindroo, 2010). The different treatment combinations were T_1 : Control (no treatment only water spray) + Pathogen, T_2 : Botanical 1 (50%)+ Pathogen, T_3 : Botanical 2 (50%)+ Pathogen, T_4 : Bio-control agent+ Pathogen, T_5 : Antibiotic + Pathogen, T_6 : T_2+T_3 + Pathogen, T_7 : T_2 + T_4 + Pathogen, T_8 : T_2 + T_5 + Pathogen, T_9 : T_3 + T_4+ Pathogen, T_{10} : T_3 + T_5 + Pathogen, T_{11} : T_2 + T_3 + T_4 + Pathogen, T_{12} : T_2 + T_3 + T_5+ Pathogen, T_{13} : T_3 + T_4 + T_5+ Pathogen, T_{14}: T_2 + T_4 + T_5+ Pathogen and T_{15} : T_3 + T_{14} + Pathogen. 3^{rd} instar worms were brushed @ 5 worms/ twig for each treatment already sprayed thoroughly with the aforesaid treatments. The twigs in conical flasks were kept in nylon nets. The worms were then allowed to feed. The twigs were changed every day and spraying was done accordingly. Three replications were maintained for each treatment. Observations on mortality percent were recorded daily and subjected to analysis of variance.

Results and Discussion

The leaf extracts of aloe vera and Mikania showed remarkably higher efficacy against the flacherie causing pathogen *Pseudomonas aeruginosa* and *Bacillus subtilis* respectively (Table 1). In case of bio-control agents *Trichoderma asperallum* was found best against both the pathogens. As for the antibiotics Streptomycin at 100ppm concentration showed the best results.

Table 1. Effect of different concentration of antibiotics against the causal agent of flacherie disease of muga silkworm (% growth inhibition)

Treatment	Concentration	*B. subtilis*	*P. aeruginosa*
Streptomycin	50 ppm	3.1	2.7
	100 ppm	3.16	5.6
Tetracycline	50 ppm	0.0	0.0
	100 ppm	2.3	0.0

Testing the compatible combinations in controlled conditions: When the best management approaches were tested *in-vivo* it showed that all the treatments have some effect in controlling the disease. However, treatment 14 (*Trichoderma asperallum* + Streptomycin 100 ppm + Aloevera 50%) and 15 (T_{14}+ Mikania 50%) showed best results in managing the disease causing pathogen.

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Biogenic synthesis of myconanoparticle (Ag nanoparticle), and management of soil borne plant pathogen

Pranjal Kaman, Pranab Dutta* and Manash Ranjan Das[1]

Assam Agricultural University, Jorhat, Assam
[1]*CSIR-NEIST, Jorhat, Assam*
*Correspondence: pranabdutta74@gmail.com

Introduction

Plant diseases are posing great threat to the agricultural production throughout the world and millions of dollars have been in efforts to control these plant diseases. Recently environmental hazards caused by excessive use of pesticides have been discussed widely and putting concentration on pest emergence and resurgence. Scientists are now putting efforts to find a new, environmentally safe technology. So, nanotechnology may of such kindly, which is still in nascent stage but in the forthcoming days it may lead to sustainable agriculture. The science nanotechnology in plant pathology is very new and not much work has been done for the management of plant disease, antimicrobial mechanisms and ecotoxicity issues of naoparticle.

In green nanotechnology for the synthesis of nanoparticles (NPs) micro-organisms and plants extract are used as many micro-organisms aggregate inorganic material within or outside the cell to form NPs. Microbial synthesis of NPs is a green chemistry approach that interconnects nanotechnology and microbial biotechnology. Biosynthesis of gold, silver, titanium NPs by bacteria, actinomycetes, fungi, yeasts and viruses have been reported. Silver nanoparticles (Ag NPs) have become one of the most commonly used nanomaterial In recent years, the green approach of nanoparticles synthesis by biological entities has been gaining great interest over other physio-chemical methods which have many hidden disadvantage. Fungi have become the best choice for the nanotechnologists due to wide variety of advantages they provide over bacteria, yeast, plants and other physio-chemical properties. Moreover they are easy to handle, required simple nutrient, possess high wall binding capacity, as well as intracellular metal uptake capabilities. Some of the fungus which have been widely used for synthesis of nanoparticles include *Trichoderma reseei, T.viride, Phytophthora infestans, Aspergillus niger, A.flavus, A.clavatus, Fusarium oxysporum, Verticillium* spp. *Penicillium* spp, *Pleurotus sajor caju.* Silver nanoparticles (AgNPs) have attracted intensive research interest because of their important applications as antimicrobial, catalytic, and surface-enhanced Raman scattering effect. Silver has been used as an anti-microbial agent for centuries, the recent resurgence in interest for this element particularly focuses on the increasing threat of antibiotic resistance, caused by the abuse of antibiotics. One of the potential applications in which silver can be utilized is in management of plant diseases. Since silver displays multiple modes of inhibitory action to microorganisms, it may be used for controlling various plant pathogens in a relatively safer way compared to synthetic fungicides. Until now limited research provided some evidence of the applicability of silver for controlling plant diseases. In the present study, an effort was made to synthesized Ag NPs from *Trichoderma asperallum* and its effect against soil borne pathogen.

Methodology

Source of T. asperallum: Pure culture of *T. asperallum* was collected from Mycology Research Section, Assam Agricultural University, Jorhat. The pure culture was maintained by periodic subculture in potato dextrose agar slants.

1. Biomass production of *T. asperallum:* Biomass production of *T. asperallum* was done in a potato dextrose broth supplemented with with peptone @ 1% and carbon source @ 0.05%. *T. asperallum* will be allowed to grow in PDB for 7 days
2. Synthesis of Ag NPs from *T.asperallum*

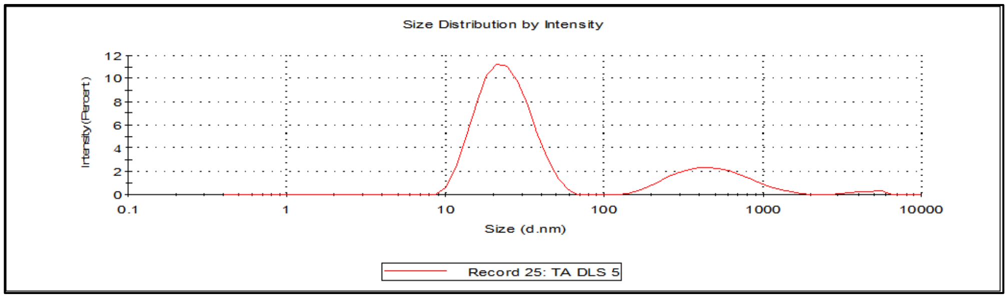
For the synthesis of Ag NPs 50ml of aqueous solution of 1mM silver nitrate was made to react with 50ml of *Trichoderma* supernatant solution in a 250 ml beaker. The pH was adjusted to 10. After that whole mixture was kept in shaker for 5days maintained in a dark condition. Control experiment was conducted with uninoculated set.

It was observed that control retained its original colour but silver nitrate treated with fungal supernatant changes to brown in colour due to the deposition of Ag NPs. The brown colour of the fungal cells can be clearly visble from the photograph as shown

Characterization of biosynthesized Ag NPs: The characterization of Ag NP was done by UV-Visible Spectrophotometer, Dynamic Light Scattering, Zeta potential, XRD, Transmission Electron Microscope and Scanning Electron Microscope.

1. UV-Visible Spectrophotometer : The absorbance peak are observed between 300-500nm **.**UV-Vis spectra illustrated shows, a strong surface Plasmon resonance at 420nm indicated the presence of silver nanoparticles.

2. Dynamic Light Scattering: Dynamic light scattering (DLS) which is based on the laser diffraction method with multiple scattering techniques was employed to study the average particle size of silver nanoparticles. The result found was that the size of the silver nanoparticles was 27.63 nm.



We can conclude that induction of biocontrol agent like *T. asperallum* to form nanoparticle may reduce cost of cultivation as in nanoform it was found significantly highly effective against the pathogen.

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A new record of *Fusarium oxysporum* causing root rot, inflorescence and capsule rotting in large cardamom

R Gopi*, RK Avasthe, H Kalita, Ashish Yadav, Chandan Kapoor and Chanda Poudyal

ICAR Research Complex for NEH Region, Sikkim Centre, Gangtok, Sikkim

*Correspondence: ramaraj.muthu.gopi2@gmail.com

Introduction

Large cardamom (*Amomum subulatum*), a member of Zingiberaceae family is one of the main cash crops cultivated in Sikkim and Darjeeling District of West Bengal covering an area of about 26,060 ha. It is grown in cold humid conditions under the shade of trees at altitude between 800-2000 meters above msl with an average precipitation of 3000-3500 mm spread over about 200 days and with temperature ranging from 6-30 degree ^{o}C (1). Sikkim is the largest producer of large cardamom (3681 MT) and constitutes the major share of Indian and world market. In Sikkim during 2013-14 the total area under large cardamom was 15,711 ha with production of 3,690 tonnes and productivity of 235 kg/ha.

Methodology

In the recent studies during 2014 and 2015 on diseases of large cardamom, new kind of symptoms like stem lodging, inflorescence and capsule rotting was observed in ICAR farm Tadong, Gangtok. Isolation of pathogen was done on PDA after surface sterilisaton of infected portion of the plant using 3% Sodium hypochlorite for 3 min. Cultural and morphological characters were studied. The isolated pathogen was send to IARI, New Delhi for identification.

Results and Discussion

Fusarium oxysporum was frequently isolated from the infected parts of the plant. The symptoms initially appeared as small brownish lesions (Fig. 1) on the stem especially on the leaf sheath attached to the stem. Later the lesion increased in size and turned black. The infected tillers broke at the point of infection before attaining actual maturity and the partially broken tillers bent downwards and hung from the point of breakage. The leaves and leaf sheaths of affected tillers showed dried up appearance giving blighted appearance. The infected flowers (Fig. 2) and capsules appeared black in colour emitted unpleasant smell due to rotting. The causal fungus from the infected portion was isolated on potato dextrose agar (PDA). The pathogenecity was also proved by placing a bit of mycelium in an open flower and covering the spike with polythene bag. The typical disease symptoms appeared after five days. The pathogen produced micro conidia and macro conidia. Micro conidia appeared in the beginning where as macro conidia produced 15 days after inoculation on the culture plate. Micro conidia are one or two celled whereas, macro conidia are multiseptate gradually pointed and curved toward the ends.

On the basis of microscopic and cultural characteristics the causative fungus was identified as *Fusarium oxysporum*. The identity of the fungus *Fusarium oxysporum* was confirmed from IARI at New Delhi. The pure culture of the pathogen has also been deposited in the Indian Type Culture Collection, Indian Agricultural Research Institute, New Delhi (ITCC-Accession No. 9498.14). The present report constitutes a new record of *Fusarium oxysporum* causing stem lodging, inflorscens, and capsule rotting in large cardamom. Association of *F. oxysporum* with rotting of root and panicle has already been reported in small cardamom (*Elettaria cardamomum* Maton) belonging to same family Zingiberaceae (Vijayan *et al*. 2013).

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Morphometric and Molecular characterization of Leafhoppers in certain important crops

Rupashree Das[1],* and Anjumoni Devee[2]

Assam Agricultural University, Jorhat, Assam.

*Correspondence: E-mail: rupashreedas2q@gmail.com

Introduction

Leafhoppers belong to the family Cicadellidae under the order Hemiptera. The members of this family are found in all zoogeographic areas inhabited by vascular plants, and many species are capable of transmitting diseases among economically important crops (Zahniser and Dietrich 2010). Cicadellidae are small wedge shaped insects of various forms, colour and sizes and distinguished by having one or more rows of small spines extending the length of hind tibia. Approximately 22,600 species have been described and making Cicadellidae is one of the 10th largest families of insects (Viraktamath 2007).

Methodology

The present work was conducted in the Department of Entomology, Assam Agricultural University, Jorhat, during 2012-2013; 2013-14 to give a comprehensive information of Leafhoppers found in rice, okra, French bean and potato. Thirteen species of leafhoppers belonging to 8 genera (*Nephotettix, Recilia, Cofana, Exitianus, Hecalus, Amrasca, Cicadulina* and *Empoasca*) under 6 tribe (Athysanini, Deltocephalini, Cicadellini, Macrostelini, Hecalini and Empoascini) were identified. From rice, 9 species *viz*., *Nephotettix virescens, N. nigropictus, N. cincticeps, Recilia dorsalis, Cofana spectra, C. unimaculata, Exitianus nanus, E. indicus* and *Hecalus porrectus* were identified. Among these *E. nanus*, *E. indicus* and *H. porrectus* were previously not reported from Assam. There was one species *viz.*, *A. biguttula biguttula* from okra and each of two species *viz., C. bipunctata, Empoasca* sp. (sp.I) and *A. biguttula biguttula* and another *Empoasca* sp. (sp. II) were identified from French bean and potato, respectively. The molecular characterization was done for *N. virescens, N. nigropictus, N. cincticeps, C. spectra, C. unimaculata, E.nanus, E. indicus, H. porrectus* and *A. biguttula biguttula* using 11 SSR molecular markers.

Results and Discussion

The highest percent polymorphism and polymorphism information content (PIC) were recorded for BEM-14 (100% and 0.969 respectively), indicating the robustness of the marker in differentiating even a small sized population. However, the markers, BEM-6, BEM-12 and BEM-20 showed lowest polymorphism (50%). The dendrogram based on genetic distance separated the samples into two major clusters. *E. nanus, H. porrectus* and *N. nigropictus* were grouped together, and had greater genetic distance from *N. virescens, N. cincticeps, C. spectra, C. unimaculata, E. indicus* and *A. biguttula biguttula*. Similarity matrix for Jaccard's Coefficient based on SSR banding of the 9 leafhoppers species, the similarity value ranged from 0.250 to 0.791. Average similarity was found to be 0.580. This study will help proper identification of leafhopper species in ecosystem of Assam, to know their genetic diversity and phylogenic evolution.

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Molecular characterization of ladybird predators of aphid pests in agriculture and bamboo forests of Tripura

Santa Ghosh[1*], *GT Behere*[2] and *BK Agarwala*[1]
[1] *Tripura University, Suryamaninagar, Tripura*
[2]*ICAR Research Complex for NEH Region, Umiam, Meghalaya*
*Correspondence: shantaghosh08@gmail.com

Introduction

Several species of aphids are important pests of crop and other economic plants in Tripura and elsewhere in northeast India. *Aphis gossypii* Glover, *Myzus persicae* (Sulzer), *Aphis craccivora* Koch and wax producing horned aphids of bamboos are common among them. Natural control agents like predators are considered important in the management of pest populations of these aphids. Ladybird predators are widely recognized as potential and promising natural control agents. Biological fitness of natural populations varies in different habitats. Polyphagous ladybird predators that feed on different aphid prey species on different cultivated plants are likely to show differences in biological fitness and, therefore, in their genotypes. The most potent genotypes of a predator species showing greater predation efficiency will be an important source of biocontrol agents. To address this we used COI gene of mitochondrial DNA for molecular characterization of multiple populations of four species of ladybird species *viz., Coccinella transversalis* (Fab.), *Cheilomenessexmaculata* (Fab.), *Micraspis discolor* (Fab.) and *Anisolemnia dilatata* (Fab.) collected from different cultivated habitats of Tripura. We aim to quantify the extent of genetic variation if any in different populations of ladybird species collected from different habitat and to established evolutionary relationships among them.

Methodology

The multiple specimens of respective species of ladybird beetles were collected from different habitats of Tripura. All the samples were identified taxonomically using established taxonomic keys. Representative specimens were preserved in 100% ethanol for molecular characterization work. DNA was extracted from ethanol preserved specimens by Qiagen's DNeasy® Blood Tissue Kit. Qualitative and quantitative analysis of DNA was performed in Nano Drop. All the samples were subjected to PCR amplification using LepF1 and LeR1 and or LCO/HCO primers which targets partial COI gene of mitochondrial genome. The success of PCR amplification was tested on 1.5% agarose gel. Two specimens from each habitat of all four species were sequenced commercially. Sanger sequencing was carried out from both the end (5' and 3'). Sequence analysis was performed in molecular biology software Staden Package (Staden *et al*., 2000). Molecular identity of sequenced was confirmed through BLASTn search in online NCBI portal (http://www.ncbi.nlm.nih.gov). Multiple sequence alignment was carried out in Clustal W (Thompson *et al.*, 1997). All the analyzed sequences were submitted to NCBI for accession numbers. Phylogenetic analyses were conducted in MEGA6 (Tamura et al., 2013).

Results and Discussion

Good quality sequences were obtained for all the sequences and no insertions or deletions (INDELs) were detected among the different species of ladybird irrespective of their habitats and geographic locations. SNPs (Single Nucleotide Polymorphism) were not detected in different populations of the three ladybird species namely *C. transversalis*, *C. sexmaculata* and *A. dilatata*, they showed 100% nucleotide homology with each other. However, in the case of *Micraspis* species, one of the four representative populations collected from *Leucas aspera* host plant showed 52 nucleotide mutations (SNPs). Of these, 51 mutations appeared to be synonymous and only one mutation was found to result in the alteration of a codon for the amino acid from Valine to Isoleucine within the aliphatic group of amino acid. The other three *Micraspis* populations collected from *Cucurbita maxima*, *Oryza sativa*, and *Melastoma* *melanensis*, respectively, were identical in their nucleotide sequences. As expected, *C. transversalis*, *C. sexmaculata* and *A. dilatata* formed a separated clade in ML tree supported by 100% bootstrap values. *Micraspis* sp. collected from *Leucas aspera* separated from other three species of the same genus with the clade. The evolutionary divergence of *Micraspis* sp. collected from *Leucas aspera* against three species of the same genus was 0.105, which is considered to be the genetic distance between two separate species. These results suggested that, *Micraspis* sp. collected from *Leucas aspera* stand out to be a different species. Results bring out that each of the four species of ladybird predators of aphid pests are fairly homogenous with respect to COI gene that is considered to be functionally very active in cells yet evolutionary conservative. This may also imply that these ladybird predators might be showing homogeneity in their reproductive and feeding efficiency in the environment of Tripura. That means that diverse populations of a ladybird predator species found in Tripura mutually interbreed and consist of randomized individuals with equal genetic and biological potency. The *Micraspis* sp. collected from *Leucas aspera* should be identified at species level.

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Livestock, Poultry and Fisheries in Agriculture

- Small holders livestock farming
- Dairying as avenue for livelihood
- Piggery, poultry and goat farming
- Mithun and yak husbandry
- Backyard fish farming
- Aquaculture diversification

Livelihood Promotion of tribal pastoral communities on NER hills

S M Deb*
ICAR-National Research Centre on Yak, Dirang, Arunachal Pradesh
*Correspondence: sm_deb@yahoo.com

Yak is the most ecologically sustainable genetic resource of the Himalayas which provides livelihood support and nutritional security for highlanders; especially, the poor tribal farmers (*Brokpas*) on remote hills of Arunachal Pradesh. Yaks are reared on pastoral system by the tribal people on high hills where no other livestock husbandry or crop production is possible. They can sustain severe cold (up to -60^{0}C) and can travel comfortably on snow bound steep hills and hypoxic conditions. They are multipurpose animals which provide milk, meat, fibre, dung and are also useful for transportation of household goods. Thus, livelihoods of rearers are solely dependent on yaks. Traditionally, the yaks are reared under free-ranged system in the high hills where the air, water, and pasture are free from any pollution, and their products are organic and just natural.

Yak husbandry, in one hand is highly remunerative with cost-benefit ratio (B:C ratio up to 4:1) when yaks are reared on alpine pasture, on the other hand it is facing the challenges like transhumance system of farming at present. The yak rearers are living with sub-human facilities in harsh geo-climatic conditions with meagre food and no medical facilities and are away from their families during summer when yaks graze on alpine pasture (above 13000 ft MSL) in Arunachal Pradesh across the international border with China. During winter the alpine pasture is covered with heavy snow and rearers have to come down to lower altitude near their villages to feed their yaks. At that point of time the yak herders stay in the village and allow the yaks to graze in the adjoining pasture lands, simultaneously grazed by other livestock. Over grazing causes deterioration of pasture land. This is followed by an increase in the weed population, which are occasionally poisonous to yaks. Due to scarcity of fodder during winter, yaks lose 25-30% of their body weight. Lack of scientific husbandry practices, weak marketing linkage and non-adoption of technologies for value addition of yak products are reducing the profit margins of yak rearers. Due to these difficulties, the youths of yak rearing communities are abandoning the yak husbandry. The human population of Arunachal Pradesh across the international border with China, whose livelihood primarily depends on yak husbandry, are thinning out which may have serious long term security implication of the country. The human population of the high mountainous border area comes to the lower altitude as the major agriculture is virtually non-existing above 3,000 meter MSL. The Sino-Indian international broader of Arunachal Pradesh is in very high altitude of even 6000-7000 meter above MSL and yaks, reared on migratory system, is the only source of livelihood of these highlanders who are poorest of the poor. They are totally dependent on yak husbandry and it is reported that yaks contribute to 62% of their livelihood requirements.

The Government of India has a very keen interest for the betterment of the border people and to protect Indian Territory. This policy decision is a ray hope for the improvement of the livelihood of the poor highlanders and betterment of yak husbandry in the state in coming future, which is complementary in nature. Due to the impending climate change scenario, yak rearers may be forced to migrate in the search of congenial environment to the higher altitude which is near to the international border. However, as stated above, due to lack of infrastructural facilities (roads, housing, basic amenities) at those regions the villagers are not encouraged to settle in those bordering villages.

Only development of infrastructure for settlement of human population in those border villages may not be sufficient unless livelihood support on a sustainable manner is created. As mentioned above, yak rearing can be the only economic activity suitable for those regions. Therefore, yak rearing has to be seriously promoted among the local highlanders so that they can settle in the Indian Territory near international boarder and earn their livelihood under sustainable and organic production system. For generating more income and to improve the livelihood of highlanders though scientific yak husbandry the following issues need attention:

1. The yak husbandry has to be profitable employing available and upcoming technologies emerging out of research activities in dynamic mode. ICAR-NRCY also demonstrates and train farmers for adoption of scientific yak

husbandry for enhancing their income and improvement of their livelihood. Yaks are traditionally reared on organic method, therefore, their products may fetch premium price for the organic produce.

2. Yak is also known for its packability in difficult hilly terrain, even at -50^0 C and in hypoxic condition, where mule can't be used effectively. The military and para-military forces can adopt yak as pack animal because of several advantages over mule at higher altitude and difficult terrain of the Himalayas. Yaks suffer less, comfortably move on difficult terrain, and carry more loads under harsh geo-climatic conditions of higher hills which may give strategic advantages. If that happens, yak rearers (highlanders) of the border villages will be encouraged to train their yaks for packability for use of the military and para-military forces to carry their essential commodities on hire basis with a pre-fixed rate. Yak rearers will, thus, get more remuneration from their yak in addition to the milk, meat, hides and wool and will be tempted to settle at the border villages.
3. High altitude pastures are the lifeline of the yak rearing in mountainous bordering states of India. Quality of these high altitude pastures are degrading day by day due to several reasons like over stocking, infestation of toxic weed species. Without amelioration of the pastures, settlement of local at the border is very difficult. ICAR-NRCY has identified several grasses and legume species to rejuvenate this degraded high altitude pastures. In addition with identification, conservation and value addition techniques of the grasses like ensiling, hay making and preparation of complete feed block has been standardized for the feeding in lean season. Therefore, for settlement of the local in these border villages, high altitude pastures must be nurtured along with the construction of road and other infrastructural facilities.

All the schemes targeted to address creation of basic amenities, welfare and settlement of the people in the states' international border areas has to be converged and yak husbandry, employing modern scientific technologies, will fillip the gap of enhancing their economic return and thereby improving their livelihood in addition to addressing the national issue of Indo-China border security.

Fish based integrated farming system (IFS) models for small and marginal farmers of North East Region: options, opportunities and challenges

Ratan Kumar Saha*

College of Fisheries, Central Agricultural University, Lembucherra, Tripura

*Correspondence:ratankumarsaha123@rediffmail.com

The basic source of income of farmers of northeastern region is mainly from agriculture and allied sector. Natural water bodies for fishery are very few in numbers and as such development of pisciculture is restricted to tanks, ponds and swamps but a variety of icthyofauna is available in this region. The North Eastern region has been ranked 6th among the top 25 biodiversity spots in the world. Despite such a rich resource potential, a substantial part of the resources in this region remain unutilized and unavailable. Fish is one of the major sources of protein in the northeast region of India and plays an important role not only to combat malnutrition but also in livelihood security. Most of the area in this region is covered by rugged and inaccessible terrain, steep hills, high mountain ranges, and undulating topography. However, owing to some unique problems of demographic pattern, age old techniques of production, land tenure system and comparative isolation, there has not been much breakthrough in farming system concept.

Location specific fish based integrated farming system (IFS) models may be boon for enhancing the productivity of animal protein in north eastern states of India. The various fish based IFS technologies were developed by different institutes and some of them have been identified suitable for northeastern states. Such technologies are either A^4 (Aquaculture +Agriculture + Animal Husbandry + Apiculture) or A^3 or A^2 model which includes - (i) Fish-vegetable farming, (ii) Fish-fruit farming, (iii) Fish-veg-fruit farming (iv) Fish-pig farming, (iv) Fish-vegetable-pig farming, (v) Fish-fruit-pig farming, (vi) Fish-fruit-vegetable-pig farming, (vii) Fish spawn rearing–vegetable farming, (viii) Fish-medicinal plant farming (x) Fish-rice-vegetable-fruit farming, (xi) Fish-goat-veg-fruit farming, (xii) Fish-mushroom farming, xiii) Fish-beekeeping-fruit farming, xiv) Fish-beekeeping-veg farming, xv) Fish-beekeeping-mastered farming and so on.

Therefore, aquaculture, if integrated with agriculture, animal husbandry and apiculture has been found to be a productive and economic as compared to the conventional farming practices. It provides efficient means of recycling agriculture and domestic wastes into the ponds while maintaining the energy flow, production/ yield enhancement and the environmental equilibrium. Out of the various integrated fish farming technology developed by different authors and institutions, some of the technologies are discussed below:

1. Fish-vegetable farming (FVF): The fish culture in the village pond is analogous to agricultural practices. Six fish having different feeding habits and habitats are used for composite fish culture. These comprises three indigenous species like Rohu, Mrigal, Catla and three exotic varieties like Grass Carp, Silver Carp and Common Carp. In addition to that vegetable farming was started in the embankment of pond. Usually a land space of about 200m^2 is needed for kitchen gardening and embankments of a fish pond provide more area than this. In a year two crops of vegetables can be grown. Pond embankments can also be used for growing crops of pulses and oil seeds. This integration can add to the income of fish farmers by 25 to 35%, if not more.

2. Fish-fruit farming (FFF): In this system fruit farming is mainly practiced at the adjoining sloppy or upland areas of embankment. Six fish having different feeding habits and habitats are used for fish culture. The produce of fruit farming would not only provide the additional income to the fish farmers but also improves the environment. Generally, to meet the daily needs of fruits for a family of 4 – 5 members a land space of about 200m^2 is needed. Among fruit crops, banana, papaya and coconut are the best. In case of upland or hilly areas, the main cultivable fruits include papaya, pineapple, banana etc. Some tuber crops like ginger, turmeric etc. may be cultivated at the space between the fruit plants.

3. Fish-fruit-veg farming (FFVF): As discussed in Sl. No. 1 & 2.

4. Fish-pig-fruit-veg farming (FPFVF): Rising of pigs can be fruitfully blended with fish culture by setting animal housing units on the pond embankment in such a way that the waste and washings of house are drained into the fish pond. About 60% of the fish production cost generally incurred for feed and fertilizer and by utilization of pig manure which acts as both feed and fertilizer, the cost of fish production has been considerably reduced. A stocking density of 7,500 fish fingerlings per hectare water area comprising of 40% surface feeders, 20% column feeders, 30% bottom feeders and 10% feeding on macro-vegetations are ideal in such farming practice. During a period of one year, two crops of pigs (6 months each) have been raised. The pigs are fed three times a day with balanced pig diet as per their requirements and generally fed @ 1.4 kg/pig/day. Grasses and green cattle fodder can also be provided to the pigs to reduce the feed cost. The green fodder has been incorporated to the extent of 15 to 30% in the feeding ration. Harvesting of fish can be done after 12 months of culture and a fish production of 3000 - 3500 kg ha^{-1} has been achieved along with 4,200 to 4,500 kg of pig meat (live weight). Apart from this a land space of about 200m^2 is needed for kitchen gardening and embankments of a fish pond provide more area than this. In a year two crops of vegetables can be grown. Humus acts as a rich source of fertilizers for crops. This integration can add to the income of fish farmers by 25 to 35%, if not more.

Further, fruits and flowers can also be integrated with these. These horticulture crops would not only provide the additional income to the fish farmers but also improves the environment. In one hectare pond area 0.3 ha land is available as dykes on which any citrus plant or papaya can be cultivated. Among fruit crops, banana, papaya and coconut are the best. Lemon and guava are also good fruits for growing on pond embankment. Flowers and vegetable can be grown also in remaining space. The fish would get benefit by way of shades from plants, free direct heat of sunlight to promote the extensive algal growth. The fruit, vegetable and flowers would get the rich pond bottom soil which can be used as a good fertilizer for the plantation. The singhara/ pani phal (*Trapa* sp.) culture can also be done in 2/3 portion of the pond. The rest portion of pond is left open for aeration and light preparation. It is a very important technology to integrate the fish culture activity along with different plant (fruit and vegetable) and animal (pig).The farmers would get benefit from the programme in different ways by producing fish along with fruits and vegetables according to the specific area and location. There is a good demand of fish, vegetable, fruit and meat in local market. So, it is very important to integrate the fish culture activity along with the different plant and animal according to specific area, location and topography.

5. Fish spawn rearing–vegetable farming (FSVF): It is a profitable practice through which the fallow small ditches can be utilized for scientific system of spawn rearing. The system ensures maximum benefit for the farmers within a short period by the utilization of minimum investment. The practice can be performed in a small ditches/ water bodies of 0.02 to 0.10 ha area with depth of 0.75 to 1.0m. The spawn was stocked @ 5- 10 million of single or combination of two to three species. After harvesting the advance fry or fingerlings, the same fallow land can be used for the low land adapted vegetables like arum (*Arum* sp.), amaranthus (*Amaranthu* sp.), dhane (*Coriandrum sativum*). Through vegetable farming farmers can also earn around Rs.12,000- 15,000/- as additional money from one ha area.

6. Fish-medicinal plant farming (FMF): Another integration with medicinal plants was identified. This provides the additional income to the fish farmers and improves the environment. In these practice different medicinal and ornamental plants like sandal (*Santalum album*), aloes (*Aloe vera*), agar (*Aquilaria crassna*), arjun (*Terminalia arjuna*), Cinchona (*Cinchona Rubra*), haememelis (*Hamamelis virginiana*), turmeric (*Curcuma longa*), pudina (*Mentha asiatica*), amla (*Emblica officinalis* Gaertn) etc. can be incorporated. It is not only for economic benefit but it can also strengthen the local and national medicine company and ethnic groups.

7. Fish-rice-vegetable-fruit farming (FRVFF): Areas where paddy fields retain water for 3-8 months in a year, such type of farming system can be adopted. The plot can be renovated by excavating canals, pools or trenches to retain water which will provide shelter to fish during summer months. The stored water also is used for the irrigating crop of paddy. A production of fish to the tune of 1200 to 1500 kg ha^{-1} can be achieved during the period depending on the climatic conditions and natural productivity status of the soil and water. The dyke of the paddy field and channel can be used for the plantation of fruit crops like papaya, banana etc. Among vegetable crops, brinjal, cucumber, pumpkin, bottle gourd, bean etc. can be cultivated after the harvesting of rice in the same field. The dyke and the field adjoining to the pond can be used for bottle gourd and pumpkin cultivation. The platform for bottle gourd and pumpkin was made above the water body and channels which provide shed for the fishes. Bamboo twig and pole under the water have facilitate the growth of periphyton/ biofilm and minimize the cost of fish feed.

8. Fish-fruit-veg-goat farming Model (New): It is considered as poor man's cow and a goat's excreta are considered as a very good organic fertilizer. The goat excreta contains organic carbon-60%, N-2.7%, P-1.78%, K-2.88% and its urine is also equally rich in both N and P. At least 50-60 goats are essential to fertilize 1 ha pond. The goat breeds are Jamanapari, Beetal, Barbari for milk and Bengal, Sirihi, Deccani are used for meat purpose. Goats are selective feeders and consume Berseem, Napier grass, Cowpea, Soybean, Mulberry, jackfruit leaves etc. This integration can provide 3500-4000 kg fish ha^{-1} $year^{-1}$ without supplementary feeding and fertilizer.

9. Fish-fruit-Mushroom Farming Model: Fish farming can be integrated with mushroom culture. The shed of mushroom culture may be prepared on pond embankments which get required moisture from pond water. Mushroom cultivation fits in very well with sustainable farming and has several advantages. It uses agricultural waste products, a high production per surface area can be obtained, after picking; the spent substrate is still a good soil conditioner as well as pond fertilizer. Three kinds of mushrooms: oyster, shiitake and wood ear may grow for small scale production.

There are lots of opportunities for the development of hill farming system.

The Northeastern Hill Region has rugged terrain and limited land resource; however, the region is blessed with enormous water source in the form of rivers, streams, ponds, beels, mini barrages, wetlands etc. with huge unique biodiversity. There exists a tremendous potential for fish farming in various forms as mentioned in the above. However, an integrated approach of fish farming by associating different components of paddy and livestock including poultry, piggery and duckery are found more meaningful to utilize the available farm space of a farmer so as to boost up the farm income and subsequently fish production of the region as witnessed from the production, productivity and income of the farmers after intervention.

Improvement in smallholder pig farms and augmentation of income for food security

Avijit Haldar [1,] *, Dhrubojayoti Das[2], Biswarup Saha[3], Prasenjit Pal[3], Sandwip Das[1], Saptak Dey[1], Ashok Santra[4], Anup Das[5], Dipjyoti Rajkhowa[5], S Hazarika[5] and M Datta[1]

[1] *ICAR Research Complex for North Eastern Hill Region, Tripura Centre, Lembucherra, Tripura*

2 Krishi Vigyan Kendra, Birchandramanu, Manpather, South Tripura, Tripura

[3] *College of Fisheries, Central Agricultural University, Lembucherra, Tripura*

[4] *Eastern Regional Station, National Dairy Research Institute, Kalyani, West Bengal*

[5] *ICAR Research Complex for NEH Region, Umiam, Meghalaya*

* Correspondence: avijit_vet@rediffmail.com

Introduction

Smallholder pig farming is an important livelihood source in many South East Asian countries including India. The rapid change in increasing market-oriented agricultural production and the ongoing trend towards improved productivity and thus higher earnings from pig farming keep the market attractive even for small producers. Food from local sources is highly preferred by rural as well as urban citizens. Despite its importance, the smallholder pig systems are faced with a number of production related constraints like inferior quality, non-descriptive type of pigs, disease risks, poor nutrition, poor management, limited access to technology, information and services. Thus, the present study aimed to build up the capacity of the smallholder pig farmers through some interventions like training, shelter management, rearing of good quality pigs, adoption of improved husbandry practices, health care and implementation of piglet production system in resource limited areas of Tripura, a State of North Eastern Hill (NEH) region of India. The objectives were (i) to improve knowledge and practice level on pig rearing, (ii) to evaluate the benefits of pig shelter, (iii) to investigate the performance of various crossbreed pigs, (iv) to assess the impact of the demonstrated programme on socio-economic conditions of the farmers.

Methodology

Two-stage stratified random sample survey on 178 smallholder tribal farmers using pre-designed, semi-structured questionnaires was conducted to collect information. A proximate composition of local feed items including an experiment on evaluation of the growth performances of pigs fed diets containing varying proportions of locally made choak (rice bear waste) along with concentrate feed mixture were done. Phenotypic performance data on seven pig varieties maintained by representative 84 farmers was recorded over a period of 14 months. Data on economics of smallholder pig farms was also collected from representative 84 farmers.

Results and Discussion

The majority of the beneficiaries (83.71%) belonged to either low or medium income groups, of which 14.04% of the beneficiaries were probably the poorest group in the present study. Feeding of locally made choak (rice bear waste) upto 25% of total dry matter increased (p<0.05) growth rate and improved (p<0.05) FCE in pigs as compared to the control pigs (without choak feeding) as well as the pigs fed with locally made choak) upto 50% of total dry matter. After shelter management and adoption of improved husbandry practices, a good and very good conditions in and around the pig shelter were recorded among 71.34% and 24.16% of the beneficiaries, respectively in and around the pig shelter. In the past, 86.51% of the farmers reared pigs for fattening purpose, while 92.13% of the farmers practiced breeding of sows for piglet production after joining the programme. The average body weights of female and male pigs among various pig varieties varied significantly (p<0.05) at birth, 2- month, 6- month, 1 year of age and during 1st conception. Litter size and piglet mortality ranged from 7.86±0.69 to 10.67±2.42 and between 4.80±7.28 and 15.47±8.88%, respectively across different pig varieties. The present net income (INR 25070.00 ± 970.0) was 11.13 times more than the previous year net income (INR 2251.00 ± 113.7) from smallholder pig farming. There was highly significant (p<0.05) impact of the present interventions over rearing factors (housing structure, type of pig varieties etc) as well as socio-psychological factors (confidence in pig rearing, feeling of security, satisfaction etc). The implementation of 'piglet production farming system' augmented food security by 148 days and thus brought wealth to the resource- poor tribal farmers.

In the present study, simple and small interventions enhanced the productivity of smallholder pig farms, augmented economic benefits and improved practical knowledge as well as various socio-psychological factors of the smallholder pig farmers. The shifting from the traditional 'fattener pig production system' to 'piglet production farming system' has brought a substantial change in income generation and food security in the tribal families. This model might be a showcase to view the profitability and success of the smallholder pig farmers in search of alternative sources of income for livelihood. Acknowledgement: The financial supports by the National Agricultural Innovation Project (NAIP). National Initiative on Climate Resilient Agriculture (NICRA) and Tribal sub Plan (TSP), Indian Council of Agricultural Research, New Delhi to carry out the present research work are highly acknowledged.

Physical characterization of Indian Mithuns

Sabyasachi Mukherjee, Anupama Mukherjee, I. Sosang Longkumer, Moonmoon Mech, Yanger Jamir, Kobu Khate and Kezhavituo

*Correspondence: Sabayasachi.Mukherjee@icar.gov.in

Introduction

A study was undertaken to generate phenotypic characterization of mithun (*Bos frontalis*), a rare domesticated species of NEH region, which will be important to assist in breed improvement and conservation programme of mithuns under Indian scenario.

Methodology

A total 134 Mithuns belonging to four different breeds (Nagaland, Arunachal Pradesh, Manipur and Mizoram) under three age groups (young stock I up to 1 year of age, young stock II with 1-3 year of age and adult stock with 3 year and above) to study their various morphological traits. These included height at wither (HW), body length (BL), heart girth (HG), face length (FL), tail length (TL), neck circumference (NC), neck length (NL), ear length (EL), horn length (HL), horn circumference (HC), and length between point of shoulder to point of pin bone (PS). The visual observations of physical coat color pattern of mithun consisted of color of the coat, muzzle, hoof, tail switch, fore limbs and hind limbs, respectively.

The morphometric data of mithuns were analyzed for the least square analysis of variance (Harvey, 1990) to find out the influence of various genetic and non-genetic factors like strain, sex and age groups of animals using PROC GLM of SAS statistical program (SAS 2008).

Results and Discussion

Mithun (*Bos frontalis*) is having a heavy and well-proportioned compact muscular body with quite aggressive temperament. The body was well developed and symmetrical with distinct muscles. The color of the head is mostly black with grayish fore head or white fore head and white face. The horn is massive at the base pointed outwards and slightly curved upward and tapering end. Tips of the horn are either blunt or pointed and eyes are prominent, bright and alert. Males have more developed body muscle and horn than females. The hump was massive and bigger in males than female. The neck was strong and well developed with pendulous dewlap which was thick and muscular with folds. The chest was thick and broad. The skin of these animals was thick, smooth and tightly attached to body. The udder was well attached and small in size with squarely placed black teats or white teats. Bulls were having a good size of blackish brown scrotum. The tail was long and reaching up to the hock joint with black or white tail switch.

The physical parameters of mithun such as birth weight (BW), stock weight (St.Wt.), height of wither (HW), body length (BL), heart girth (HG), face length (FL), tail length (TL), neck circumference (NC), neck length (NL), ear length (EL), length between point of shoulder to pin-bone (PS), horn length (HL) and horn circumference (HC) were analyzed and the overall least square means for each parameters were 21.58 ± 0.24 kg, 305.67±5.89 kg, 114.21±1.18 cm, 157.91±1.91 cm, 154.48±1.75 cm, 35.79 ± 0.46 cm, 70.17 ± 1.06 cm, 81.78 ± 1.78 cm, 37.69 ± 0.72 cm, 19.53 ± 0.70 cm, 70.9 ± 0.89 cm, 18.66 ± 0.54 cm, 23.84 ± 0.55 cm, respectively.

The present study was a systematic attempt to characterize mithun phenotypically as the literature on these aspects in this species is quite scanty. The study generated valuable base line data on mithun phenotypes. These information will be utilized to develop mithun specific species descriptor for breed registration of mithun.

Ornamental fish business in backyard fish farming in North-East India – challenges and prospects

AK Tripathi*, Aniruddha Roy, Piyashi Deb Roy and N Uttam Singh

ICAR Research Complex for NEH Region, Umiam, Meghalaya

*Correspondence: aktripathi2020@yahoo.co.in

Introduction

The North-Eastern region of India is one of the hot spots of freshwater fish biodiversity in the world. This region is blessed with great diversity of ornamental fish in its vast aquatic resources (Mandal *et al*. 2007). A total of 250 ornamental fish species have been reported from this region which are diversified over 37 families, 114 genera and 10 orders. The Indian ornamental fishery sector being heavily dependent on the North-East region for the supply of native ornamental fish, the agribusiness opportunities in this sector have been recognized by producers, collectors and traders. Out of the 200 species of ornamental fish exported from India, 85 per cent are from the North Eastern states of India. The major markets of the ornamental fish from the North-East region are Kolkata, Mumbai, Chennai, Trivandrum and Cochin. The supply of Indian ornamental fish is mostly dependent on wild catch (85 per cent) and few artificially bred varieties of exotic fish (15 per cent). Out of 186 species of ornamental fish in the North-East, 28.44 per cent are only ornamental, 5.91 per cent are considered as sports as well as ornamental, 12.9 per cent as food fish as well as ornamental and 9.67 per cent as sport and ornamental (Sarkar and Ponniah 2006). Ornamental fish from India is exported to twenty seven countries at present. The marketing channel most commonly observed in the region is collectors – unregistered small traders – wholesalers – exporters at various ports. The highest share of profit is obtained by exporters (45 per cent), followed by wholesaler (30 per cent), unorganized trader (20 per cent) and collectors (5 per cent).

Poor infrastructure and lack of access to market information are acting as obstacles to the development of organized marketing in the ornamental fisheries sector. Incentives to establish ornamental fish production unit in the region is being provided by the Government. Since many of the native ornamental fishes are under the stress of over-exploitation, new species are emerging as ornamental fishes, thus further expanding the horizon of ornamental fish business opportunities in the North-East region. However, increasing fish business opportunities of live ornamental fish globally also poses sustainability concerns since the supply is almost entirely dependent on wild catch.

Methodology

The challenges and prospects of ornamental fish business in backyard fish farming in North-East India have been assessed through Strength-Weakness-Opportunities-Threat (SWOT) analysis.

Results and Discussion

The North-East region of India is endowed with vast aquatic resources of ornamental fishery, which is unique and has great demand in the country as well as in international markets. The returns to investment with the business opportunities in relation to the marketing of ornamental fish in the North-East is that profit can be realized by producers, collectors and traders in the value chain.The pattern of profit sharing in the ornamental fishery sector of the North-East indicates that the benefit sharing in this sector is not equitable, and the fish farmers and the collectors are deprived heavily of their due share in the value chain. There is lack of implementation of proper guidelines in marketing of ornamental fish in the region which acts as a loophole in the sustainability of the ornamental fishery sector in the region.

Owing to lack of steady supply of common ornamental fishes, new species are emerging as candidate ornamental fishes with increasing trade opportunities in this sector (Mandal *et al.* 2007). In this regard, training in breeding of native and exotic ornamental fishes for both ecological and economic sustainability of the sector has to be provided. This can also help in creating employment potential for a large chunk of the labour force in the North-Eastern region. All the stakeholders such as collectors, exporters, importers, dealers and consumers have shared responsibility in upholding the sustainability of the ornamental fishery sector of this region. Corporate sectors can also invest in promoting sustainable ornamental fisheries in the region through Corporate Social Responsibility. Overexploitation of ornamental fishery resources in future is a looming threat in the ornamental fishery sector of the North-East region of India. If the regulations and guidelines regarding collection and marketing of ornamental fish in the region go unchecked, there may be loss in the biodiversity in this sector. An important issue to be addressed is the existence of unorganized marketing and absence of any direct export. Threats looming the sustainability of the ornamental fishery sector are lack of knowledge about the conservation status of native ornamental fishes, their indiscriminate collection, degradation of water bodies such as rivers at an alarming rate, pollution, poisoning, and over-fishing of broods and juveniles. Among the 250 species of ornamental fish found in the North-East, 10 have been reported to be critically endangered, 28 endangered, 50 vulnerable, 45 lower risk – near threatened, 8 lower risk – least concerned and 3 data deficient. Das *et al.* (2013) found that the constraints in ornamental fish marketing in the North-East are inadequate infrastructural facilities, requirement of heavy investment in the initial stage, lack of government incentives, non-availability of good quality brood stock, less demand in local market, lack of transportation and marketing facilities, labour non-availability and its high cost, lack of good quality feed, disease incidence and wide fluctuation in market price of inputs. Dissemination of market information is abysmally low (Mandal *et al.* 2007). Since the supply of ornamental fish in this region is heavily dependent on wild catch, the question of sustainability of the existing market is posing to be a serious question of late. The North-East region being endowed with vast ornamental fishery resources, the market expansion opportunities have remained untapped. The market linkages have been mostly limited to domestic arena within the country with the absence of any direct export to the destination markets. This is causing serious blockages in the way of realizing the huge foreign exchange that could have otherwise been obtained by establishing direct export marketing from the North-East region. Access to market information, market intelligence and creation of necessary market infrastructure are required to overcome the challenges to develop an active market of ornamental fishery in the region. Direct linkages with the top destinations of ornamental fish export in the world have to be established by means of contract marketing and tie-up arrangements. The ornamental fish collectors and fish farmers should be encouraged to play the major role in the marketing channel to increase the producer's share in the consumer's rupee. Corporate sectors should necessarily be tied up in this regard for increasing the investment and sustainability in the ornamental fishery sector of the North-East region of India.

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Environment friendly pig production with supplementation of Indian gooseberry and multienzyme on the performance, nutrient utilization, Nitrogen, Calcium and phosphorus balance in crossbred (T&D) finisher pigs in Assam.

Bidyut Jyoti Das*, Bibeka Nanda Saika, Robin Bhuyan, Abani K Das, Arundhati Bora, Jitendra Saharia, Mukul Bora and Purabi Deka

College of Veterinary Sciences, Assam Agricultural University

*Correspondence: bjdassam@gmail.com

Introduction

Pig occupies an unique place among the meat producing animals of North Eastern part of India. Pig farming is considered to be the most encouraging and appropriate livestock enterprise. Piggery has a tremendous scope and potential to boosts the country's total meat production and to fill the gap between availability of animal protein and its actual requirement in a short duration. India possesses a total pig population of 10.29 million of which NE region is having 3.92 million as per 19th livestock census (Anon 2012). More than 38.11% of the total pig population of the country is in the North Eastern (NE) states. The per capita availability of meat for the country per person is 1.5 kg/year, whereas in Asia the per capita availability of meat per person is 13.3 kg / head / year. There is tremendous scope for the development of pig husbandry in this region because of the growing demand for pork and also have the potentially available resources to produce pork in eco-friendly manner. At present many works have been conducted in Southeast Asia to accelerate pork production in eco-friendly manner with substances having antimicrobial properties such as use of phytogenic feed additives like herbs, residues, extracts, essential oils. Exogenous supplementation of phytase has demonstrated the ability to increase phosphorus bioavailability and thus growth rates in pigs (Adeola 1998) by cleavage of phosphorus molecule from phytate. The addition of multienzyme improved weight gain, feed intake and FCR in pigs. In the present study an attempt was made to explore the performance and nutrient utilization in growing-finisher pigs by supplementing diets with multi enzymes either alone or in combination with amla.

Methodology

Twenty cross bred (T & D) pigs of about 2 months of age and average body weight 11.39±0.17 kg, irrespective of sexes were randomly divided into four groups. The experiment was conducted in a RBD design. The finisher ration was prepared as per BIS 1992.The experimental diets *i.e* control, control ration 0.05%multienzyme, 1.5% amla and 0.05% multienzyme and 2.0 % amla and 0.05% multienzyme were added and the rations were designated as T_1, T_2 and T_3 . Fresh water was made always available at all times. The daily feed offered and leftover were recorded. The pigs were weighed at fortnightly intervals. A five day metabolism trial was carried out after the animals at the end of finisher stage to study the digestibility of nutrients and retention of N, Ca and P. The daily feed intake, urine and faeces voided were recorded. The samples of feed, faeces and urine were analyzed for various nutrients (AOAC 1995**)** and data was analyzed using SAS. The digestibility of all nutrients, Calcium, Phosphorus and Nitrogen balance were determined and average daily gain, feed: gain ratio was calculated.

Results and Discussion

The digestibility of all nutrients (Table1) was significantly different among treatments. The DM, OM,CP,EE,CF and NFE digestibility was highest ($P<0.05$) in T_3 than others. The digestibility of other nutrients was comparable. Lower DM, OM,CP,EE,CF and NFE digestibility in C might be due to older age of the pigs. The digestibility of DM, OM and CP was lower across treatments which might be due to lower response of older pigs to NSP degrading enzyme supplementation than in younger pigs (Olukosi *et al*., 2007)**.** A significant increase ($P<0.01$) of % retention of intake nitrogen, calcium and phosphorus (g/d) was observed in 2% amla and 0.05% multi enzyme supplemented T_3 group. Several earlier reports indicated a favourable effect of phytase in improving the digestibility and increasing the retention of calcium and phosphorus. In respect of initial body weight, in final body weight gain T_2

and T_3 was significantly (P<0.05) different from C and T_1 which might be due to incorporation of amla and multienzyme in the diet. The ADFI (kg) and feed intake per kg gain (kg) was higher (P<0.05) in T_3. The better performance of pigs fed T_3 could be attributed to the increase palatability of feed and multienzyme which has resulted in better digestibility of nutrients.The feed conversion efficiency in T_3 group was significantly (P<0.05) different from the C, T_1 and T_2 group and cost of feeding per kg gain was lowest in T_3 group. The results of this study demonstrated that addition of multi enzymes and amla to the diets show significant effect in terms of nutrient utilization, growth performance and feed gain ratio in T_3 group with 2% amla and 0.05% multi enzyme with excretion of lesser amount of environment pollutant like phosphorus and nitrogen.

Table 1. Effect of dietary treatments on nutrient digestibility (%), % retention of nitrogen, calcium and phosphorus balance, growth performance of crossbred pigs in finisher stage

	Parameter	C	T_1	T_2	T_3
Digestibility (%)	DM	61.00 ^{a}±1.00	63.00 ^{b} ±0.57	65.00 ^{c} ± 0.57	67.00 ^{d} ±0.57
	OM	52.00 ^{a} ± 0.57	54.00 ^{b} ±0.57	58.00 ^{c} ± 0.57	60.00 ^{d} ±1.15
	CP	48.00 ^{a} ± 0.57	50.00 ^{b}±0.57	55.00 ^{c} ± 0.57	60.00 ^{d} ±0.57
	EE	53.00 ^{a} ± 1.00	55.00 ^{ab} ±0.57	57.00 ^{bc} ±0.57	60.00 ^{d} ±0.57
	CF	30.00 ^{a} ±0.57	36.00 ^{b} ±1.00	39.00 ^{c} ±1.52	41.00 ^{d} ±0.57
	NFE	61.00 ^{a} ±0.57	64.00 ^{b} ±1.15	69.00 ^{c} ±1.15	73.00 ^{d} ±0.57
% Retention	Nitrogen	48.00 ^{a}±1.52	53.00 ^{b} ±0.57	57.00 ^{c} ± 0.57	60.00 ^{d} ±1.52
	Calcium	60.00 ^{a} ± 0.57	62.00 ^{b} ±1.15	64.00 ^{c} ± 1.57	68.00 ^{d} ±0.57
	Phosphorus	45.00 ^{a} ± 2.88	52.00 ^{b}±1.52	55.00 ^{c} ± 1.73	60.00 ^{d} ± 1.15
Performance	Initial wt(kg)	39.58 ^{a} ±1.12	40.14^{a} ± 0.42	41.91 ^{b} ± 0.70	42.96 ^{c} ± 0.62
	Final wt(kg)	70.05 ^{a}± 0.03	71.39 ^{a} ±0.86	74.77 ^{b} ± 1.13	80.20 ^{c} ± 0.58
	Weight gain(kg)	30.47 ^{a} ±0.02	31.25 ^{a} ± 0.14	32.86 ^{ab} ± 0.23	37.20 ^{bc} ± 0.44
	ADG(g)	419.00^{a} ±27.20	446.00 ^{a}± 15.06	469.00 ^{ab}± 30.05	532.00 ^{bc} ±28.72
	ADFI(kg)	1.75^{a} ± 0.04	1.77^{ab} ± 0.03	1.80 ^{b}± 0.02	1.85^{c} ± 0.01
	FCR	4.02^{a} ± 0.00	3.97^{a} ± 0.00	3.83^{a} ± 0.00	3.49 ^{b} ±0.00
	Cost of feeding /kg gain(Rs.)	84.57	83.50	80.71	73.36

Mean values in a row not sharing common superscripts differ significantly (P<0.05)

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Study on short duration aquaculture production using IMC and two indigenous fish species, *Banganadero* and *Osteobramabelangeri* in different agro-climatic conditions of Manipur

Ch. Basudha, NG Singh* and N Prakash

ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Manipur

*Correspondence: devibasu@yahoo.com

Introduction

Aquaculture is essentially dependent on the availability of good quality water. In case of freshwater aquaculture, the problem of water scarcity and pollution is very site-specific with wide variations depending on annual rainfall. Water availability for aquaculture is already become a serious constraint in several parts of Asia, including Manipur and north eastern states of India and climatic shifts caused by climate changes are likely to impair the impacts. During summer months, the low availability of water in the culture ponds leads to an increase in the pollution beyond the tolerable limits of the cultured organisms. Since climate change is expected to affect the availability of freshwater and the flow in rivers it is essential to address the water budgeting, lower water availability and quality, and zero water exchange farming system issues. With view scarcity of water and unpredictable climate change, short term fish rearing were conducted in different agro climatic conditions of Manipur.

Short term fish farming is the process of composite fish culture technology with components of indigenous fish species reared in ponds with high densities for 6-7 months duration. Fish species like *Bangana*sps and *Osteobramabelangeri* along with Catla, rohu, mrigal and grass carp that can be farmed for a period of 7 months in ponds and harvested. 5000-6000 kg/ha can be achieved in this culture technology. B*angan*a and *Pengba* both are high price fishes and it has ready demand in local markets. B*angana* can survive wide range of temperature. It is detrivorous and bottom feeder. *Bangana* and *Pengba* can be stocked in place of the mrigal and rohu stocks respectively in this culture method.

Since, growth of fish is adversely affected in Manipur during winter from middle of November to early March, it is a common practice to drain, dry and renovate ponds during winter. As such, most ponds remain unutilized for more than 3-4 months. However, *Banganadero* and *Osteobramabelangeri* stocks can be grow and high survival rate even in winter months with little modified practices.

Methodology

Ponds having 0.25 ha water areas having 1.5- 2.0 m water depth were selected in different locations viz., Yangoi Khongbal, Khabam Bamdiar, Tokpaching, Khabi Imphal and ICAR Manipur Centre and. Ponds were cleaned and dried for few days. Lime was applied @250-350 kg/ha depending on the soil pH condition of the ponds. Water quality of the ponds were collected and analysed. 10,000 fingerlings of mixed carps comprising *Catlacatla, Labeorohita, Cirrhinamrigala, Ctenopharyngodonidella, Banganadero* and *Osteobramabelangeri* in different ratio were stocked. The compositions of the fishes were 30% surface feeder, 30 column feeder, 30% bottom feeder and 10% grass carp respectively. Stocking of mrigal and *Bangana* (50:50) together made the total of 30% of bottom feeder component as both *Mrigal* and *B. dero* being bottom feeder. 10% 0f 30% stocking of column feeder was made by *Osteobramabelangeri*. The fishes were stocked in the month of March-April and harvested in the month of October. Fishes were fed with pellet feeds, mixture of rice bran and oil cake (1:1).

Results and Discussion

Good survival of *Pengba* was observed 80-85% in the valley. *Banganadero* survival was the highest among the culture fishes 87-90% in all the locations. However, different growths were observed in different locations. It perhaps as a result of different water management, feed management and husbandry practices. The fish productions were ranges 1300-1700kg/0.25ha in 7 months. Their C:B ratio were ranges from 1:1.5 to 1:2.5

Fish farming in short duration can be countenance climate change factors that include variability of temperature, air humidity and total rainfall. The study further revealed that perceived low yield from fish culture to be a consequence of the negative impact of climate change. This study concluded that there's a need for the active involvement of stakeholders in developing techniques and use of local fish candidates for farming relating to climate change mitigation and beneficial response strategies to global warming. These packages of practices for fish farming systems have been successfully developed and verified extensively for economic viability and feasibility at the farmer's level in Manipur. Recognizing aquaculture as a commercial entrepreneurship, such system can be adopted by carrying out suitable modifications and developing location specific technologies suitable in different agro-climatic regions, where water resources, healthy stocks of fish and land are available. The sustainable fish farming, being remunerative, can, therefore provide livelihood as well as generate employment.

Tibetan sheep: a unique endangered breed of Eastern Himalaya

Brijesh Kumar*, RK Avasthe, Mahak Singh, Passang Bhutia and Sumi Handique

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Sikkim

*Corresponding author: drbrijeshvet02@gmail.com

Tibetan sheep playing a key role in sustaining the livelihood of highlanders suppose to be remotest of remote tribe of India; along with yak. In fact before the closure ofTibetan border the whole trade of this Tibet- Darjeeling rout is exclusively revolving around the Tibetan sheep. Either it may be dried meat or precious garments made up of Tibetan sheep wool under barter system of trade. Tibetan sheep is very hardy and thriving well in very harsh climatic condition of Tibetan plateau. At higher altitude sheep flocked reared under transhumance system (seasonal cyclic movement) and their movements are clearly defined and mostly governed by weather and pasture availability. Their migratory pattern includes alpine pastures at altitude of 15600 ftamsl in Phalung valley to as high as at altitude of 18500 ftamsl of cold desert region near to border of Tibetan autonomous region, China.

The coat colors of Tibetan sheep are mostly white with black or dark brown neck and face. The face is black or brown spotted with white or complete white with black eyes are observed in the flock. The ewes are polled while the rams are horned with average size 18.40 ± 0.73 cm. Their ears are drooping with average length and width 11.09 ± 0.20 cm and 6.29 ± 0.06 cm for male and 10.33 ± 0.25 cm and 5.65 ± 0.09 cm for female respectively. Tibetan sheep have typical Roman nose with average Roman height 13.49 ± 0.24 cm in male and 12.41 ± 0.15 cm in female. The feet, face and ventral portion of neck and abdomen devoid of fleece. The tail is short and thin type with length and base circumference is 13.47 ± 0.61 cm and 6.93 ± 0.39 cm respectively in male and 13.93 ± 0.30 cm and 7.57 ± 0.41 cm in female respectively.

Since Tibetan sheep inhabitation, where agriculture practices subtle to nil and clear vegetation dynamics exist at higher altitude. During winter season especially in month of January and February area experiencing heavy snow fall and virtually no pasture or very little dried grass present in cold desert forcing sheep to live in partially starved condition apart from copping with severe snow fall. These all leads to a weight loss of approximately 14 percent (12 to 16 percent) in adult sheep. Limping is another problem of higher altitude and recent study revealed that about 11.8 percent of animals suffered with extremities gangrene because of frost bite. Other diseases like ectoparasitic infestation 45 percent, diarrhea 8 percent and parasitological screening of faecal samples revealed 26.53 percent animal suffering with various gastrointestinal parasites. Veterinary care are not reached at higher altitude that compelled *Dokpas* (sheep and yak herders) to rely on indigenous technological knowledge which has been transferred from generation to generations without any documentation.

The Tibetan sheep is medium size breed and average adult male weight 46 kg (39 to 50 kg) and average adult female weight 44 kg (37 to 49 kg). There is clear weight dynamics exist and it is found that during cold winter month adult male losses 16.03 percent and adult female losses 13.49 percent of their weight. Through this phenomenon it could be infer seasonal climatic variation and subsequent manifestation to fodder availability. It is also observed that during winter season especially from December onwards there is heavy snow fall and by the time all available pastures are either been utilized or covered with snow. This leads to partial starvation of sheep leading to weight loss. When latter in month of May, sheep reaches on alpine pasture in Phalung valley there is fresh luxuriant green pasture available and sheep start gaining their weight and by the end of October and November reaches to its maximum weight. The *Dokpas* usually slaughter their sheep in month of October and November in cold desert region, air dried it and stored for round the year consumption.

The ewes have good mothering ability and twinning is very rare. Lambing mostly take place once in year especially in the month of February to 1st week of March in cold desert region with average weight of new born 3 kg. First shearing of the lamb done at age of six month and adult animals sheared once in a year in the month July in Phalung valley when *Dokpa* tribe celebrate their important festival i.e. *Drukpa Tshechi.* The average wool yield 700 gm. per sheep average staple length and fiber diameter are 11.86 cm and 29.08 µm respectively with 3.83 percent medulation. The quality trait of wool is sub white, full of glass, equal and long fiber, high compactness, high elasticity and big pull and it is believed that carpet made from the Tibetan sheep wool is one of the best qualities in the world.

Despite huge contribution in livelihood and ecological sustenance of remotest of remote part of the country and most fragile ecosystem. The Tibetan sheep had not given due attention, either by researchers or policy makers. The present population declined to only 235 heads in North Sikkim which is very alarming for the existence of this valuable sheep germplasm and deserves immediate conservation.

Apparent metabolisable energy values of Guar korma and Decorticated cotton seed meal in cockerel.

Chongtham Sonia[1*], Praveen K Tyagi[2], AB Mandal[3] and M Norjit Singh[4]

[1] *ICAR- Research Complex for NEH Region, Manipur Centre*

[2,3] *ICAR- Central Avian Research Institute, Izatnagar*

[4] *College of Vety. Sc. &A.H, R.K. Nagar, Tripura*

*Correspondence: drsonia.vet@gmail.com

Introduction

Guar (*Gyamopsis tetragonoloba*)- a drought resistant annual legume predominantly grown in India and Pakistan. The plant is primarily grown for its galactomannan polysaccharide gum which has numerous industrial and food processing applications. Due to increasing price of protein sources such as soya, the cost of production of feed for birds has also increased. Roasted guar korma reduces production cost as it provides alternative to costly protein sources such as soya, ground nut (GNE). Cottonseed meal (CSM) is by-product of oil extraction from cotton seeds. Cottonseed meal is an ingredient for poultry diets. The present study was carried out to evaluate the comparative energy utilization of guar korma and decorticated cotton seed meal by cockerel.

Methodology

The experiment was conducted at Central Avian Research Institute, Izatnagar, in accordance with animal welfare norms. The energy bioassay was conducted at two substitution levels, 100 and 200 g/kg of reference diet of guar korma and decorticated cotton seed in cockerels following the method of Sibbald and Slinger (1963). Cockerels (n=45; 15 weeks old) were used. The reference diet (Table 1) and two test diets at two substitution levels (100 and 200 g/kg) both for roasted guar korma (GK) and decorticated cotton seed meal (DCSM) were offered to the birds for a preliminary 8 days feeding period. Each of the 5 diets was offered to nine replicates of each group. The feed intake during this period was recorded to determine the voluntary intake. This was followed by collection period of three days. During this period, a weighed quantity of feed was offered which matched the intake measured during preliminary feeding period. The total excreta collection method was used. The pooled excreta sample from each bird was dried at 70^{0}C in a forced-draft hot air oven to constant weight. The dried feed, residue if any and excreta samples were ground and assayed for gross energy (GE) using a by Ballistic Bomb Calorimeter.

The AME_N values of the diets were calculated as per the method of Hill and Anderson (1958). AME_N values of diets were then multiplied by 1.015 since the mineral and vitamin premix was superimposed at 1.5 kg/98.5 kg diet. The AME_N values of the test ingredient were calculated as AME_N of the test diets after correction for mineral and vitamin supplement= 0.80R + 0.20T or 0.60R + 0.40T (where R is AME_N of reference diet after correction for mineral and vitamin supplement and T is the AME_N of the test ingredient). The data of the AME_N were analysed following completely randomized design (CRD) as per Snedecor and Cochran (1969).

Results and discussion

Roasted guar korma contain 44.67 % protein, 4.02% Ether extract, 4.89% crude fibre, 4.23% total ash and 0.95% acid insoluble ash. The chemical composition of DCSM are 36.92% crude protein, 2.65% ether extract, 5.74% crude fibre, 5.18% total ash and 1.02% acid insoluble ash. In guar korma substituted diets, the feed intake, energy intake and dry matter metabolisability did not differ significantly as compared to reference diet. The test diet 2 of guar korma had significantly ($P<0.001$) higher protein intake and significantly ($P<0.05$) lower energy metabolisability than test diet 1 and reference diet. While in DCSM substituted diet, there was no significant difference in dry matter metabolisability between reference and test diets, but the feed intake was significantly ($P<0.05$) higher for test diet 1 than reference diet. The protein intake was significantly ($P<0.001$) higher in test diet 2 when compare to reference and test diet 1. However, energy intake and energy metabolisability in test diet 2 of DCSM was significantly ($P<0.05$) higher than test diet 1 but no significant difference with the reference diet.

Table 1. Composition and nutrient content of reference and test diets (on dry matter basis).

Ingredient (g/kg)	Reference diet (g/kg)	Guar korma (g/kg)		Dicorticated cotton seed (g/kg)	
		100	200	100	200
Maize	835	751.5	668	751.5	668
Soybean meal	100	90	80	90	80
Fish meal	50	45	40	45	40
Guar korma	-	98.5	197	-	-
Decorticated cotton seed	-	-	-	98.5	197
Mineral-vitamin premix*	15	15	15	15	15
Total	1000	1000	1000	1000	1000
Calculated nutrient composition (Kcal/kg or g/kg)					
AME	3360.55	3338.95	3316.21	3337.30	3278.30
Crude protein	129.600	179.867	237.789	171.745	218.978

* Mineral-vitamin premix to supply (per kg of diet) limestone 6g, dicalcium phosphate 4g, iodised salt 2g, DL-methionine 0.2g, lysine 0.2g, mineral premix 1g, vitamin premix 1g, B complex 0.1g, Toxine binder 0.5g.

The AMEn values of GK and DCSM were 3379.95 ± 63.44 and 3192.39 ± 56.58 Kcal/kg. The AMEn value of reference diet was 3256.61 ± 84.53 Kcal/kg and for test diet 1 and test diet 2 of GK were 2531.43 ± 228.67 and 2478.33 ± 226.18 Kcal/kg, respectively with an overall test diets value of 2504.88 ± 222.32 Kcal/kg. The AMEn values of test diet 1, test diet 2 and overall test diets values of DCSM

In the present study, there was no significant difference in feed intake, energy intake and dry matter metabolisability. Birds fed with test diet 2 of guar korma had protein higher intake and lower energy metabolisability than test diet 1 and reference diet. The AMEn value of reference diet was 3256.61 ± 84.53 Kcal/kg. The AMEn values of test diet 1, 2 and overall test diets values of DCSM substituted diets in cockerel are 2556.86 ± 204.87, 2417.03 ± 165.56 and 2486.94 ± 194.49 Kcal/kg respectively.

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Effect of stocking density on growth and survival of pabda (*Ompok bimaculatus*) in earthen ponds under low-input management

Chandan Debnath*, Lopamudra Sahoo, Rekha Das, Abhijit Singha, Gulab Singh Yadav, Mrinmoy Datta and SV Ngachan

ICAR Research Complex for NEH Region, Tripura Centre, West Tripura, Tripura

*Correspondence: chandannath23@gmail.com

Introduction

Ompok bimaculatus (Bloch, 1794) is an indigenous silurid catfish of South-East Asia. The fish is popularly known as Indian butter catfish or *pabda* (popularly). The maxillary barbels of the fish are longer than head length (HL), pelvic fin rays are 8, anal fin rays are 50-70 and pelvic fin not reaching anal fin origin. The fish is well known for its excellent taste and high market price (Rs. 400-500 kg^{-1}). It has also ornamental value; in global ornamental fish business, it is traded as 'two-spot glassy catfish'. Like other tropical catfishes, it breeds in streams, rivers and floodplains during monsoon months. But due to indiscriminate fishing and ecological changes, its wild population has declined steadily (>50%); this species is now endangered and at high risk of extinction. So, it is essential to save this fish from extinction through development of appropriate culture technique. Being highly demanded and priced, NBFGR, Lucknow prioritized the fish for aquaculture diversification in India and other neighbouring countries. Aquaculture of the fish will provide quality broodstocks for restocking and conservation programs (NBFGR, 2011). However, not much information is available regarding the breeding, larval rearing and grow-out production of the fish (CAMP, 1997). Pabda did not receive much attention in aquaculture till date due to insufficiency of gravid stocks for experimentation. Therefore, a suitable culture method is very important to ensure reliable and regular supply of the fish. Growth and survival of fish in ponds depend on stocking density, quality and quantity of fertilizers, feed applied. Hence, the present experiment was designed to see the effect of stocking density on the fish in earthen ponds under low-input management. Subsequently, the effect of protein supplementation (30 and 35%) on growth and survival of the fish at least performed stocking density was also evaluated.

Methodology

In this study, the growth and survival of pabda fingerlings were examined at 3 stocking densities in 9 earthen ponds (0.03 ha) over a period of 6 months. The standard method of pre-stocking pond preparation included liming at 250 kg ha^{-1} and basal fertilization [3 t cowdung mixed with 30 kg single super phosphate (SSP) ha^{-1}] before stocking of fish. 30-day-old fingerling (3.36±0.08 cm and 0.83±0.02 g), stocked at 4000 ha^{-1} was designated as T_1, 5000 ha^{-1} as T_2 and 6000 ha^{-1} as T_3. Intermittent fertilizations were carried out in alternate weeks with cowdung at 500 kg ha^{-1} and inorganic fertilizers (10 kg urea + 15 kg SSP ha^{-1}) in order to maintain the pond fertility. Intermittent liming was also carried out at 100 kg ha^{-1} a at 3-month intervals except the higher dose (200 kg ha^{-1}) used before winter months. Fingerlings in all the treatments were fed with RB and MOC (1:1) at 2-4% of their body weight. The water quality parameters were analysed following the standard methods and using kits. Plankton analysed by direct census method. SGR and FCR were calculated following standard references. After 6 months, the fish were harvested by repeated netting, followed by dewatering the ponds. The live fish were counted and weighed individually. Survival (%) and production (kg ha^{-1}) of fish were then calculated and compared. The compounded diets having the protein of 30% and 35% were prepared and compared with application of conventional RB and MOC as feed. The data were analysed through one-way ANOVA using SPSS v11.2.

Results and Discussion

The physicochemical parameters of water and plankton were at the optimum level for fish culture (Jena and Das, 2011). Highest weight and length gain was observed in T_3 and lowest in T_1. Final length and weight of fish also followed the same trend as weight gain. Highest specific growth rate was observed in T_3 followed by T_2 and T_1. Feed conversion ratio was significantly lower in T_1 followed by T_2 and T_3. The production of fish obtained from T_3 was highest (294.2 kg) followed by T_2 (247.0 kg) and T_1 (197.5 kg). Similarly, the survival of fish was highest in T_3

(75.2%) followed by T_2 (75.3%) and T_1 (76.2%). Stocking density mostly has negative impacts on growth and survival of fish. However, in this study, the growth and survival of pabda increases with increase of stocking density similar to the findings of Toko *et al.* (2007). This says the density evaluated is very insufficient to affect the production of pabda under pond conditions. The density of 4000 fingerlings ha^{-1} was least productive among the 3 stocking densities evaluated in this study. Hence, the fish of that treatment was supplemented with diet having high protein (30 and 35%). The production of pabda was increased by 10% with 30% protein diet and 13% with 35% protein diet compared to conventional RB+MOC diet containing <20% protein.

Pabda may be cultured in higher stocking densities. Hence, further studies are recommended under increased stocking density for more production of pabda. During inadequate availability of pabda fingerlings, the fish may be suggested for culturing at a density of 4000 to 6000 fingerlings ha^{-1} for higher income being the fish is highly priced. Hence, for commercial pabda production protein content of the feed must be chosen accordingly for additional production of fish.

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Influence of prepartum and postpartum supplementation of copper and vitamin E on mastitis and milk yield in crossbred cows

Dipak Sinha[1*], Neelam Kewalramani[2], Harjit Kaur[3], BT Phondba[4] and AK Tyagi[5]

[1]*College of Agriculture, Tripura, Lembucherra, West Tripura*

[2 3,5]*National Dairy Research Institute, Karnal, Haryana*

[5]*National Dairy Development Board, Anand, Gujarat*

*Correspondence:dipak60abu@gmail.com

Twenty four dry pregnant Karan-Fries cows were selected to study the effect of copper and vitamin E supplementation on incidence of mastitis and milk yield. They were divided into three equal groups of eight animals each and supplemented with Gr I (unsupplemented Control), Gr II (Cu @20 ppm) and Gr III (Cu @ 20 ppm + vitamin E @1000 IU/day) from 60 days before calving to 90 days of lactation. All the cows were kept under similar feeding and management conditions. After parturition, fortnightly milk samples were tested for sub-clinical mastitis (SCM) using modified California mastitis test (MCMT) and somatic cell count. In the first fortnight after parturition, per cent incidence of SCM and score/teat was 46.88, 43.75 and 25.00% and of 0.97, 0.95 and 0.44 in groups Gr I, Gr II and Gr III, respectively. At 90 days of lactation incidence of infection decreased to 15.63 and 0.19 % respectively, in Gr I and Gr II groups whereas, it was nil in Gr III. The number of somatic cell counts was also more in Gr I and Gr II as compared to Gr III. The numbers of clinical mastitis cases were 4, 3 and 1 in three respective groups. The duration of mastitis was also lower in Gr III than Gr I and Gr II. The overall milk production in different groups during experimental period were 14.48, 14.43 and 15.47 kg/day showing significantly higher ($P<0.05$) in Gr III due to lower incidence of sub-clinical and clinical mastitis. No change in the milk composition observed in different groups. The inference can be drawn that supplementation of copper @ 20 ppm and vitamin E @ 1000 IU/d from at least 60 days prepartum to 90 days postpartum to can reduce the incidence of mastitis and improve milk production.

Identification and expression analysis of Aquaporin 3a in *Clarias batrachus* testis during spawning

J Choudhury[1], SJ Monsang[1], L Sahoo[2], BK Behera[3], H Priyadarshi[1], SC Mandal[1] and J Parhi[1]*

[1] *College of Fisheries, CAU, Lembucherra*

[2] *ICAR Research Complex for Tripura Centre, Lembucherra, Tripura*

[3]*CIFRI, Barrckpore, West Bengal*

*Correspondence: jjparhi@gmail.com

Introduction

In teleosts, spermatogenesis is regulated by pituitary gonadotropins via specific receptors in leydig and sertoli cells, through the synthesis and release of sex steroids (androgens and progestins) and growth factors, respectively (Schulz *et al*. 2010). However, the final stage of spermatogenesis or "spermiation" principally involves the production of hydrated seminal fluid that facilitates the acquisition of motility and the passage of spermatozoa through the spermducts (Scott *et al*. 2010). In teleosts, as suggested for mammals, aquaporins may be involved in the hydration of the seminal fluid as well as in sperm physiology. Aquaporins (AQPs) are a family of hydrophobic, integral membrane channel proteins (25-34 KDa) which have been strongly associated with rapid passive movement of water. In vertebrates, teleosts have the highest copy number with up to 18 paralogs reported in zebrafish (Tingaud-Sequeira *et al*. 2010). AQPs have been suggested of playing an important part in follicle development along with involvement in early spermatogenesis, secretion of tubule liquid and in the concentration and storage of spermatozoa. In fish, not much is known about the distribution and functionality of AQPs in relation to reproduction. Artificial seed production of Magur (*Clarias batrachus*) is hampered by the inability of spontaneous spermiation in males even after induction with synthetic hormones. This has led to collection of macerated sperm to fertilize the ova after sacrificing the male. This procedure also causes stress in gametes causing poor survivability of hatchlings. Since, AQP has been suggested for possible involvement in the hydration of the seminal fluid as well as in sperm motility, it is therefore important to identify and study the expression profiles of AQP that might play a role in testis and sperms during spermatogenesis.

Methodology

Identification of AQP 3a gene in *Clarias batrachus* : The testis of the experimental fish, *Clarias batrachus* was collected aseptically and total RNA isolated using trizol method. cDNA was synthesized using the First Strand cDNA synthesis kit (Fermentas, USA) as per the protocol supplied by the manufacturer. Based on the available sequence of other species, degenerate primers were designed to amplify the AQP 3a gene. The amplified gene was cloned and sequenced.

Expression study of AQP 3a under experimental condition : The partially identified sequence for AQP3a gene was utilised to design primer sets for real time PCR to study expression levels using SYBR green chemistry. Acclimatized experimental fishes of around 200-300 gm were injected with Ovaprim at 0.3 ml per kg of body weight. The fishes were then divided into two groups, group 1 was kept in a natural pond condition whereas group 2 was maintained in FRP tanks under controlled condition. After 16 hours of injection, spawning was observed in group 1 where as no spawning was observed in group 2. Testis tissues from both groups were collected and the mRNA expression level was measured using Real time PCR for **AQP 3a** and **prepro-catfish gonadotropin-releasing hormone (pcGRH)**. B actin gene was used as housekeeping gene.

Results and Discussion

PCR amplification with gene-specific primer set led to isolation of AQP 3a (419 bp) from *Clarias batrachus* testis tissue. It was then sequenced and submitted in the NCBI database (Accession No. KT004436). The available sequence of *Clarias batrachus* were used for phylogenetic analysis along with five other species. The phylogenetic analysis was performed using MEGA4, software by neighbour joining method. The result showed the closeness with other Siluriformes species where as distant from Cypriniformes species.

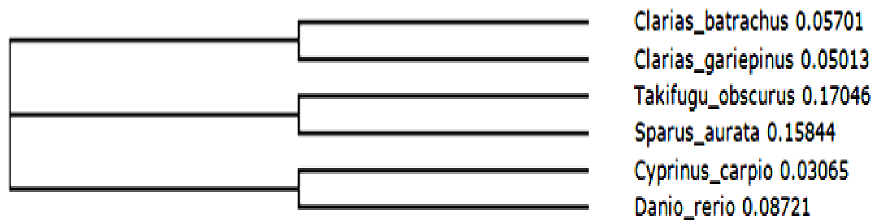

Fig 1. Phylogenetic tree based on the partial ORF sequence of the AQP3a gene.

The expression of **AQP 3a** was found nearly 50 times more in group 1 as compared to group 2 where as **prepro-catfish gonadotropin-releasing hormone (pcGRH)** transcripts were more in group 2 compared to group 1. This result provides evidence of possible role of AQP 3a in spawning of male cat fish through hydration of testis and sperm as well.

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Effects of supplementation of moringa leaves on performance of crossbred grower pig

Keshab Barman*, DK Sarma and Purabi Kaushik

ICAR-National Research Centre on Pig, Rani, Guwahati, Assam

Correspondence: barman74@rediffmail.com

Introduction

In pig farming, feed cost alone represents more than 70-75 % of total cost of production. In intensive pig production, pig directly compete with human being for feeding, since conventional fattening is based on the feeding of cereals like maize, wheat, oats, barley etc along with other protein, mineral and vitamin supplement. Farmers are unable to support costly feeding program because of high cost of cereals and oil cakes. As a result, animal nutritionist used to search for new feed resources especially unconventional feeds in order to produce economic feeding programme for swine and other livestock. Moringa leaves (*Moringa oleifera*) are one of such unconventional feed for pigs. Moringa leaves are a valuable source of protein (23-24 % on DM). It increases the growth rate, milk yield and birth weight of dairy calves. Research on effect of Moringa leaves supplementation in swine feeding is very scanty. In the present studies, moringa leaves was supplemented at different levels to see its effect on growth and nutrient utilization in crossbred grower pig.

Methodology

Eighteen crossbred (HS x GH) grower pig (about 2 months old, body wt. ranged from 12-14 kg) of either sex were divided into three groups of six each in a randomized block design. Three different diets were used for feeding of the animals namely - T_1: standard grower ration without moringa (*Moringa oleifera*) leaves, control diet, T_2: standard grower ration supplemented with 5% moringa (*Moringa oleifera*) leaves, T_3 and standard grower ration supplemented with 10% moringa (*Moringa oleifera*) leaves. The pigs were fed on the experimental grower rations twice daily in the morning and evening. The nutrient requirement of pigs was made as per BIS (1986). The pigs were fed on the experimental grower rations twice daily in the morning and evening. The experiment was conducted for a period of three months. Digestibility trial was conducted at the middle of the experiment. The lysine and methionine are balanced in all the rations as per requirement. Proximate composition was done as per AOAC (1990). Data were analyzed as per method of Snedecor and Cochran (1989).

Results and Discussion

The crude protein content (% DM) of the grower ration was ranged from 18.82±0.08 to 20.36±0.06 while that of moringa leaves was 15.11±0.73. The average dry matter intake were (kg/d) 0.617±0.028, 0.624±0.009 and 0.595±0.016 respectively which was reduced with increased level of moringa leaves in the ration. Digestibility coefficients (%) of all the nutrients increase non significantly in moringa supplemented groups.

Table 1. Effect of moringa leaves on nutrient utilization in grower pigs

Parameters	T1	T2	T3	P Value
DMI, kg/d	0.617±0.028	0.624±0.009	0.595±0.016	0.456
ADG, g/d	207.8±2.2	216.7±3.3	209.2±5.8	0.324
FCR	2.88±0.20	2.65±0.15	3.07±0.19	0.319
Feed cost/kg gain	72.41±5.02	62.09±3.51	67.88±4.19	0.305

T1: 0 % moringa leaves in the diet; T2: 5 % moringa leaves in the diet; T3: 10 % moringa leaves in the diet

Crude protein digestibility was significantly ($P<0.05$) higher in T2 group in comparison to other two groups. The average body weight gain (g/day) was non significantly found higher in moringa leaves supplemented groups. The cost (Rs/kg gain) was reduced non significantly ($P>0.05$) in T2 and T3 groups in comparison to T1 group. The FCR was found non significantly higher in T3 group while lower in T2 group (Table 1).

From this study, it is concluded that moringa leaves can be supplemented @ 5 % level in grower crossbred pigs for improvement in growth and feed conversion efficiency.

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Effect of lipopolysaccharide on immune response and immune gene expression of *Labeo bata*

Lopamudra Sahoo[1*], Janmejay Parhi[3], Chandan Debnath[1], Hemavati R[1], Rekha Das[1], M. Datta[1], JR Dhanze[3], SV Ngachan[1], Kurcheti Pani Prasad[2]

[1] *ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura*

[2] *Central Institute of Fisheries Education (CIFE), Mumbai, India*

3 College of Fisheries, Lembucherra, Tripura (W)

*Correspondence: lucy2311@gmail.com

Introduction

Aquaculture is one of the fastest growing food producing sectors in the world. India is the second largest producer of fish in the world contributing to about 5.43% of global fish production. Disease has become a primary constraint to aquaculture growth and is now responsible for the severe impact on both the economic and socio economic development in many countries of the world. Good management practice is the single approach to overcome disease problems. Using antibiotics and other chemotherapeutics to control fish diseases may lead to development of drug resistant pathogen, environmental pollution and accumulation of residues in fish (Alexander *et al.* 2010). As pathogens are mostly opportunistic, they establish in immunocompromised fish, hence it is essential to enhance fish immunity and fitness by improving the diet of fish (Awad *et al*. 2015). In this context use of dietary immunostimulants to enhance the immune system of fish is considered as an attractive and promising area. One such potential immunostimulant is lipopolysaccharide (LPS) which is the principal cell wall component of gram-negative bacteria. It is known to be among the most potent modulators of mammalian immune functions (Burrell 1990).

Material and methods

Lipopolysaccharide (LPS) from *Escherichia coli* 0111:B4 was used in feed in three different doses: Dose 1 / Low dose (50 mg kg^{-1} feed), Dose 2 / Medium dose (100 mg kg^{-1} feed) and Dose 3 / High dose (150 mg kg^{-1} feed). The fish species employed in all the experiments were fingerlings of L. *bata* with an average body weight of 10 ± 2 g. Three tanks containing 30 numbers of fish for each dose of every treatment were taken for study. Feeding was done to the fishes @ 3% of the body weight. The fishes other than control group were fed with experimental feed containing immunostimulants till 30 days. After challenging with bacterial pathogens, they were fed with control feed. After immunostimulation trial the fish in various experimental groups were challenged with *Edwardsiella tarda*. Fishes in the different experimental groups were sampled at 7days, 15 days, 30 days of feeding and 1 day post challenge (1 DPC). For serum, blood samples were drawn from caudal veins in the remaining anaesthetised fishes into tubes without anticoagulant. For tissue harvesting, the fishes were anaesthetized using 0.1 ppm of MS 222 and tissue was aseptically collected from head kidney of the fresh fish for total RNA isolation.

Total erythrocyte count (TEC)/ Red blood cell (RBC) and Total leukocyte count (TLC)/ White blood cell count (WBC) was determined as per the procedure of Schaperclaus. Total serum protein was estimated according to Biuret method. Albumin was estimated by bromocresol green (BCG) binding method. Globulin was calculated by subtracting albumin values from total plasma proteins. Serum glucose was measured as per the method followed by Trinder using a kit manufactured by Abcam (UK). The Nitroblue tetrazolium (NBT) assay was carried out following the protocol of Anderson-Siwicki. *Myeloperoxidase (MPO) activity:* The total myeloperoxidase activity present in serum was measured according to Quade and Roth with slight modification by Sahoo. *Serum lysozyme activity:* The lysozyme activity level was measured using the turbidimetric assay following Sankaran and Gurnani using hen egg white lysozyme (HiMedia) as standard. *Serum bactericidal activity:* Parts of the sera collected were utilized for studying serum bactericidal activity following Kajita . The bactericidal activity of test serum was expressed as percentage colony forming units in the test group to that in the control group. *Relative* The relative percent survival (RPS) in different treatment groups were calculated by the following formula:

RPS= 1-(no. of mortality in treatment group/no. of mortality in control group) X100

Based on sequences obtained in an earlier experiment customized taqman gene expression assay for immune genes like C3, Lysozyme g, interferon (IFN) α, IFN γ, transferrin, β-2 microglobulin and housekeeping gene β actin, were obtained from Applied Biosystems (USA). Head kidney tissue was collected from three fishes of each replicate of each treatment group at 7 days, 15 days, 30 days and1 day post challenge (DPC) and pooled together. The relative expression level of target gene was obtained using $2^{-\Delta\Delta CT}$ method. Mean values of all parameters were subjected to one-way ANOVA to study the treatment effect and Duncan's multiple range test was used to determine the significant differences between any two means.

Results and discussion

TEC was significantly higher ($p \leq 0.05$) in LPS fed group in comparison to control group during the study. TLC showed increasing trend till 30th day of feeding with significantly higher values for the treatment groups compared to control. Serum protein, albumin and globulin were significantly increased ($p \leq 0.05$) in LPS fed group of fish compared to control group immediately after 7 days of feeding and post challenge with *E. tarda*. Serum glucose was always significantly lower in LPS fed group of fishes compared to the control group. Immune parameters like respiratory burst, lysozyme, myeloperoxidase and serum bactericidal activity was significantly higher ($p \leq 0.05$) in LPS supplemented groups compared to control group. Following experimental challenge with E. *tarda* relative percent survival of LPS fed group of fishes was recorded as 95%, 95% and 92.5% for dose 1, dose 2 and dose 3 groups respectively. Statistically significant differences were observed on the expression of immune genes in the head kidney of *L. bata* after feeding of LPS incorporated diet. It was seen that expression of complement component C3 was significantly up regulated after 7 days of feeding and 1 DPC, down regulated after 30 days of feeding and no significant difference after 15 days of feeding were observed for all the groups compared to control.

All LPS fed groups demonstrated elevated gene expression of β-2 microglobulin. Significantly low expression ($P \leq 0.05$) of lysozyme g after 7 days was observed in LPS-fed groups except group fed with dose 1 LPS supplemented diet. At all other point of sampling significant up regulation was observed in all groups as compared to the control and during that period group fed with dose 2 and dose 3 of LPS supplemented diet showed higher expression, compared to group fed with dose 1 of LPS supplemented diet. Expression of transferrin was not significantly different for all LPS-fed groups after 7 days. All three groups showed elevated expression at all points of sampling with maximum upregulation at 1 DPC in comparison to control. Higher expression of IFN I was observed in all LPS-fed groups after 7 days and 30 days. A 3 fold increase in expression of IFN γ was seen in the group fed with dose 1 LPS supplemented diet after 7 days of feeding, whereas expression in all other groups was not significantly different. In conclusion, LPS stimulates both innate and adaptive immune parameters and also increases the RBC, WBC, protein, albumin and globulin in *L. bata*. The present results suggest that LPS at 100 mg kg^{-1} feed could be considered as a good supplement to improve the immune status of *L. bata*. It was observed that most of the immune parameters and expression of the immune genes had higher value on 7^{th} day and 1 DPC.

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Effects of different substrates on larval rearing performance of *Ompok bimaculatus*

Satyajit Das[a*], Himardi Saha[b] and Pradyut Biswas[a]*

College of Fisheries, CAU, Lembucherra, Tripura

*Correspondence: pradyutbiswas@gmail.com

Introduction

Pabda (*Ompok bimaculatus*) which is considered as state fish of Tripura has undergone severe population decline due to indiscriminate use of pesticides and other chemicals and was listed under the "threatened" category by IUCN (Ng *et al* 2010). It has attractive look and delicious taste which make the fish eagerly devoured by the consumers. In spite of its potentials for aquaculture, the short supply of desirable stocking materials has been felt for its aquaculture production. The rearing of pabda larvae to fry is usually carried out inside the hatchery during which the major challenge found is the lower survivability due to high cannibalism and territorial behaviour when cultured at high densities. The amount of surface area available in culture tanks is often a limiting factor leading to reduced larval survival. Due to the cannibalistic nature of the fish, it is recommended that use of artificial substrate reduce aggressive encounters. Different studies shows that the use of artificial substrates to increase the amount of spaces available of fish and shellfishes and less predation thereby, yielding an increase in survival and production. This study involved four different substrates to evaluate the effects on growth and survival of *O. bimaculatus* larvae.

Methodology

Four days old larvae of *O. bimaculatus* larvae with mean weight 0.00527g and mean total length 0.77 cm were obtained through induce breeding at the wet laboratory of College of Fisheries, Lembucherrra and transferred to fifteen rectangular aquarium (2ft×1ft×1ft) filled with 25 litre water keeping three tanks as blank and others with four types of artificial substrates viz. layered plastic mat, floating plastic mat, sand gravel which were assigned with three replicates each. The larvae were stocked at same densities 10 nos./litre and fed 4 times (7am, 12 pm, 5 pm and 10 pm) daily with the live tubifex. During the experiment, 50% water was exchanged and daily mortality of the larvae was recorded. Water temperature, pH and dissolved oxygen (DO) were measured daily at 6.30 am with mercury in-glass thermometer, pH meter and DO meterrespectively. Alkalinity, hardness, carbon-di-oxide and ammonia were measured at 5 days interval. Sampling for weight and length measurement was done at 7 days interval by anesthetising the larvae which has been release back into the experimental tanks after recovery. After 15 days of rearing, all the surviving larvae were collected from each tank and growth measurement was recorded in terms of mean weight gain, length increment, specific growth rate, survival rate, total biomass, net yield mean daily weight gain and Fulton's condition factor. The data obtained were calculated and analyzed using one-way analysis of variance (ANOVA) and the significant difference between the treatments determined by Duncan's Multiple Range Test (DMRT) using SPSS (Version 16.0) taking the level of significance at 0.05. Results will be reported as mean ± S.E.

Results and discussion

During the experiment, in the tank without artificial substrates, most of the pabda larvae stayed at bottom corner of tank for entire time but the balance of the larvae distribution percentage among tanks changed in the tanks with artificial substrates. With an increasing number of artificial substrates, more larvae attached to artificial substrates except the floating plastic mat. It might be due to the fact that the larvae remain at the surface for short period which did not allow the larvae to retain themselves with the mat for longer period. In the current study, larval development and survival of *Ompok bimaculatus* are affected by substratum which has been presented in the table. It is evident from the table that, average final weight and length were affected significantly by artificial substratum ($p<0.05$). Tanks that were lacking substrate had significantly lower survival (51.6%), but higher mean weight gain (0.27 g). Similar trend were followed in case of length increment, specific growth rate, mean daily weight gain and condition factor. The layered plastic mat and gravels showed significantly higher survival than blank and sand bed whereas floating mat showed the intermediate result. Though larvae stocked in the tanks with blank and sand substratum have a significantly lower survival, but grew in larger size (Molina 1990).

In the bare bottom tank the lower survivability may be due to lack of hiding place consequently resulting cannibalism which in turns increased size heterogeneity. As pabda does not exhibit the burrowing habit, the larvae could not find any better resting place which results low survival in the sand substratum tank. This distribution resulted by the addition of floating, layered and gravel bed improved the survival due to the reduction of territorial and cannibal behaviour. It is found that there is no significant difference between layered plastic mat and gravel bed but showed significant differences with the floating mat substrate. This was may be due to their bottom dwelling habit and tendency to move down resulting congregation of larvae at the bottom edges which lead to non-homogenous distribution of larvae in the tanks.

Layered substratum was found to be well utilized by larvae which created a homogenous distribution within the tanks. The improved survival of the larvae with gravel substratum might be due to their bottom dwelling habit and more surface area and better bacterial population (Sugumaran and Radhakrishnan 2012). The total biomass and net yield were found to be significantly higher ($p<0.05$) in gravel and layered substratum due to the improved survival. Therefore, the results of the present study suggest that the difference in growth and survival of pabda larvae in this study were affected mainly by living space added with the addition of artificial substrates.

Table 1. Mean growth parameters, net yield parameters in *Ompok bimaculatus* larvae reared with different substratum.

Parameter	Blank (T_1)	Layered plastic mat (T_2)	Floating plastic mat (T_3)	Sand (T_4)	Gravel (T_5)
Initial length (cm)	0.77	0.77	0.77	0.77	0.77
Initial wt.(g)	0.00527	0.00527	0.00527	0.00527	0.00527
Stocking density	250	250	250	250	250
Final length (cm)	3.10±0.05^{bc}	2.73±0.08^{a}	2.90±0.05^{ab}	3.13±0.08^{c}	2.73±0.03^{a}
Final wt.(g)	0.27±0.005^{bc}	0.24±0.007^{a}	0.26±0.005^{ab}	0.27±0.007^{c}	0.24±0.002^{a}
Body wt. gain (%)	5120.8±9.7^{bc}	4503.3±1.4^{a}	4784.0±9.72^{ab}	5177.0±1.48^{c}	4503.3±5.61^{a}
Length increment (cm)	2.33±0.05^{bc}	1.96±0.08^{a}	2.13±0.05^{ab}	2.36±0.08^{c}	1.96±0.03^{a}
Specific growth rate	3.95±0.01^{bc}	3.82±0.03^{a}	3.88±0.01^{ab}	3.96±0.02^{c}	3.82±0.01^{a}
Survivability (%)	51.6±1.89^{a}	68.8±1.38^{c}	59.4±1.73^{b}	52.53±1.39^{a}	69.20±1.22^{c}
Total biomass(g)	35.41±0.65^{a}	41.64±0.52^{c}	38.19±0.35^{b}	36.44±0.08^{a}	41.92±0.55^{c}
Net yield (g)	34.10±0.65^{a}	40.32±0.52^{c}	36.87±0.35^{b}	35.12±0.08^{a}	40.60±0.55^{c}
Mean daily wt. gain (%)	1.79±0.03^{bc}	1.58±0.05^{a}	1.67±0.03^{ab}	1.81±0.05^{c}	1.58±0.01^{a}
Condition factor	85.28±3.17^{bc}	66.39±4.31^{a}	74.45±2.96^{ab}	87.20±4.93^{c}	66.27±1.62^{a}

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Performance of mrigal and amur common carp in carp polyculture system in Tripura state of India

Hari Om Verma and Sagar C Mandal*

College of Fisheries, Central Agricultural University (I), Lembucherra, Tripura, India
*Correspondence: scmandal02@gmail.com

Introduction

The choice of fish species is very important to maximize the fish production. So, selection of bottom dwellers species are most important and most cultivable bottom dwellers species in Tripura are mrigal and common carp. It is necessary to find out for better production of mrigal (*Cirrhinus mrigala*) and/or amur common carp (*Cyprinus carpio*), an improved common carp variety, introduced in India recently. Thus, the comparative performance between amur carp and mrigal on their growth and survival was an important initial investigation.

Methodology

For this study, nine rectangular cement tanks of 20 m^2 each, at College of Fisheries, CAU (I), Lembucherra, Tripura were utilized. The bottom of the tanks was filled with 15cm soil bed. Independent water supply to each of the tanks was arranged from the ground water source. Tanks were applied with lime @ 250 kg per ha and then filled with water. All tanks were fertilized one week after liming with cow dung @ 5 kg per tank. After one week of fertilization, tanks were stocked with six fish species including catla (*Catla catla*, mean weight 22.76 g), rohu (*Labeo rohita*, mean weight 16.79 g), mrigal (*Cirrhinus mrigala*, mean weight 5.03g), silver carp (*Hypophthalamichthys molitrix*, mean weight 15.83 g), amur common carp (*Cyprinus carpio*, mean weight 8.18g) and puntius (*Puntius gonionotus*, mean weight 21.61 g). Tanks were stocked at different stocking ratio *viz.* Treatment 1- catla, rohu, mrigal, silver, puntius 15: 30: 30: 10: 15; Treatment 2- catla, rohu, silver, amur, puntius 15: 30: 10: 30: 15 and Treatment 3- catla, rohu, mrigal, silver, amur, puntius 15: 30: 15: 10: 15: 15, respectively. Tanks were stocked at a stocking density of 2 fish per m^2.

Fertilization of tanks was done weekly with urea and single super phosphate @ 60 g per tank and fortnightly with organic fertilizer i.e. cow dung (500 g per tank). Experimental sinking diet of crude protein level of 20% was formulated with available feed ingredients such as wheat flour, corn flour, mustard oil cake, rice bran and fish meal. Feeding was done daily at 9-10 am in the morning and was maintained at 2-4% based on the body weight of fish and feeding intensity of fish. Amount of feed was adjusted after regular fish sampling on fortnightly.

Results and Discussion

The results showed that mean weight gain (MWG) and specific growth rate (SGR) of both mrigal and amur common carp were higher in T3 compared to T1 and T2 groups and that of silver carp was significantly ($p<0.05$) higher in T2 than T1 and T3 groups. No significant differences in MWG and SGR were observed for mrigal, rohu and Puntius among the treatments. In T2 and T3 groups, net gain biomass (NGB), daily weight gain (DWG) and net fish yield (NFY) was significantly ($p<0.05$) higher than T1 group. Highest NGB (2866±309 g), DWG (19.11±2.1 g d^{-1}) and NFY (0.96±0.1 g m^{-1} d^{-1}) were obtained in T3 followed by T2 and T1 groups. No significant difference ($p>0.05$) for overall survivability of fish was found among three groups. Apparent feed conversion ratio (FCR), apparent feed conversion efficiency (FCE) and apparent protein efficiency ratio (PER) were reported better in T3 compared to T1 and T2 groups, but no significant differences ($p>0.05$) were reported. Therefore, it can be summarized from the present study that amur common carp performed better in terms of growth, yield and feed utilization than mrigal. Stocking ratio of 15% each of mrigal and amur common carp improved total fish production in carp polyculture system.

Pond-based integrated cage culture- scope and feasibility in Tripura

Chandan Debnath*, Lopamudra Sahoo, Rekha Das, Abhijit Singha, Gulab Singh Yadav, Mrinmoy Datta and SV Ngachan

ICAR Research Complex for NEH Region, Tripura Centre, West Tripura- 799210, Tripura

*Correspondence: chandannath23@gmail.com

Introduction

Fisheries occupy a unique place in the economy and livelihood of Tripura. With more than 95% of people of Tripura being eating fish at the rate of 20.07 kg $capita^{-1}$ $annum^{-1}$ (highest among the inland states of the country), there is huge demand for fish. In spite of 241% in production of fish during last decade (2003-04 to 2013-14) still there is supply gap of 18,873 MT of fish presently. The gap is increasing as a result of population growth and over-exploitation of the main commercial fish stocks. To reduce the gap between supply and demand, Govt. of Tripura is considering new technologies, such as cage fish culture in the vision plan for additional fish production from available resources. 186 numbers of large water bodies (>14 ha) which accounts for 2.4% of fisheries resources of the state could be utilized cage culture. The immense number of ponds (1,48,010 no., 16016 ha) in the Tripura presents potential for cage fish culture, a technology that demands less capital investment than the traditional pond fish production, and may allow the development of family scale production for extra income in local communities (Gomes *et al.* 2006). Pond-based integrated cage culture could be viable option if proper technological backup is ensured from local institutions. No works have been done on feasibility of pond based integrated cage culture in Tripura.

Methodology

With his context, ICAR, Tripura Centre demonstrated this technology in ponds of tribal farmers. The cages were of 3 m X 2.5 m X 1.0 m in size and made up of bamboo. PE netting having a mesh size of 5 mm was used for making the net cages for holding and culturing the fish. 50 such cages were installed and stocked with catla at the rate of 10 yearlings' m^{-2}. The fishes were fed on floating type pellet feed (20% CP) at the rate of 5% of their body weight.

Results and Discussion

The production of fish obtained over a period of 6-month was found 12 kg $cage^{-1}$ which is comparable with the finding of Osfero *et al.* (2009). Cage culture is very encouraging particularly for the farmers having limited water resources.

Cage culture could be promoted in pond for additional income. This could be an option to give employment and ownership to the women in their ponds for livelihood security.

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Normal range and seasonal variation of haematological and innate immune system in *Labeo bata*

Lopamudra Sahoo[1*], Chandan Debnath[1], Abhijit Singha[1], Janmejay Parhi[2], Rekha Das[1] Hemavati R[1], A Gangarani Devi[1], M Datta[1], and SV Ngachan[1]

[1]*ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura*
[2]*College of Fisheries, Lembucherra, Tripura*
*Correspondence: lucy2311@gmail.com

Introduction

Fish are poikilotherms and they live in close association with their environment. Fish appear to exhibit seasonal fluctuations in their susceptibility to different infectious diseases (Lillehaug *et al*. 2003). They show higher metabolic activity at higher temperature and adjust their food intake as per the environmental temperature. Thus, their rate of anabolism also depends on temperature of their surrounding (Hernandez and Tort 2003). The temperature at which the optimum immune response attained by the species is termed immunologically "permissive" and temperature below this but still within the physiological range is termed as "immunosuppressive" (non-permissive temperatures) (Manning and Nakanishi 1996). *Labeo bata,* F. Hamilton, 1822, commonly called as bata is an important cultivable minor carp having great demand and consumer preference in India. It grows to marketable size in 7-8 months of culture period. Hence, this species is having a lot of demand in North-Eastern states of India like Tripura where water available for culture period is for 7-8 months only. Very less work has gone into studying the health aspect of this species. Hence the present study was undertaken to establish the reference ranges of haematological and innate immune parameters and their seasonal and annual fluctuations.

Methodology

The experimental studies were conducted at the ICAR Research Complex for NEH, Tripura Centre for two years. The fish species employed in all the experiments of the study were fingerlings and yearlings of bata, *Labeo bata* . The fish were collected from the farm of ICAR RC for NEH, Tripura Centre. The water quality parameters like temperature, dissolved oxygen, pH and total alkalinity was recorded for the ponds. Blood samples were collected randomly from the fishes reared in the pond in three different seasons: summer (March-June), rainy (July-September), winter (October-January). TEC/RBC (Red blood cell) and TLC/WBC (White blood cell) was determined as per the procedure of Schaperclaus. Total serum protein was estimated according to Biuret method using the kit (Merck, Germany). Serum glucose was measured as per the method followed by Trinder using a kit manufactured by Abcam (UK). The Nitroblue tetrazolium (NBT) assay was carried out following the protocol of Anderson-Siwicki. The total myeloperoxidase activity present in serum was measured according to Quade and Roth. The lysozyme activity level was measured using the turbidimetric assay following Sankaran and Gurnani using hen egg white lysozyme (Himedia) as standard.

Results and Discussion

It was seen that TEC and TLC were significantly higher in summer season Table 1. Total protein was significantly lower in rainy seasons while albumin was significantly higher. Glucose was significantly higher in winter season. There was no significant difference in lysozyme in all the seasons.

Table 1. Establishment of normal ranges and mean values of haematological and innate immune parameters of *L. bata*

Parameters	Sample Size	Mean
TEC (10^6)cells/cumm	100	1.63±0.12
TLC (10^3)cells/cumm	100	38.20±3.10
Protein (g/dl)	100	11±0.48
Albumin (g/dl)	100	3.85±0.65
Glucose (mg/dl)	100	63.87±4.51
Lysozyme (ug/ml)	100	3.2±0.20
Myeloperoxidase (OD 450nm)	100	0.76±0.01
NBT (OD 540nm)	100	0.24±0.02

Myeloperoxidase activity was significantly higher in summer season while significantly lower respiratory burst activity was observed in winter seasons. Establishing base line and reference range of immune parameter for a species is necessary in order to use those parameters as markers for disease diagnostics/health status. In this study we could establish reference range for various haematological and immunological parameters like TEC, TLC, Total protein, albumin, glucose, lysozyme, MPO and NBT. We could also observe significant seasonal variation in various parameters. Lysozyme was not affected by the seasonal variations. These studies would provide basic information for further immunological studies in this species.

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Culture of pabda in polyculture with carps

Chandan Debnath*, Lopamudra Sahoo, Rekha Das, Gulab Singh Yadav, Mrinmoy Datta and SV Ngachan

ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura

*Correspondence: chandannath23@gmail.com

Introduction

With emphasis on diversification of the Indian aquaculture in recent years, attempts have been made to incorporate more potential candidate species into the main stream carp culture. *Ompok bimaculatus* (Bloch 1794), popularly known as Pabda (*Ompok bimaculatus*) or Indian butter catfish is an indigenous silurid catfish of excellent taste and high price. The fish has ornamental value too. Recently the fish has been prioritized by NBFGR (Lucknow) for aquaculture diversification and species conservation. Like other tropical catfish, it breeds in streams, rivers and floodplains during monsoon. However, its natural stock has depleted significantly (>50%) mostly due to habitat alteration and over-exploitation. Now the fish is endangered and facing high risk of extinction. So, it is of utmost importance to save this fish from extinction through development of appropriate culture technique. No systematic attempts have been made on mass-scale propagation of the fish in the country due to insufficiency of gravid stocks for experimentation and shortage of information regarding their breeding, rearing and culture technology (CAMP 1998). Therefore, development of a suitable culture method for nursing and rearing of pabda is very important to ensure reliable and regular supply of fish. Monoculture of pabda may not be a suitable proposition considering the low growth potential of the fish. Therefore, the fish may be accommodated in major carp-based polyculture where fish of different feeding habits are cultured together so that, all the food niches of the pond are utilized without detriment effect to one another which may increase the overall return from the farming system. Polyculture can yield an expected level of production if fishes are stocked in proper combination, ratio, and density; however no studies are available considering pabda as a component of polyculture system. As a first step towards this direction, the present study was attempted to assess the compatibility of pabda with the Indian major carps (IMCs) and exotic carps in grow-out polyculture system. Effect of protein supplementation (30 and 35%) on growth and survival of the fish was also evaluated at least performed stocking density.

Methodology

The experiment was conducted in earthen ponds having a size of 0.03 ha each. The duration of the experiment was six-months. Three stocking densities viz., 4000, 5000 and 6000 fingerlings ha^{-1} were evaluated. Padba was incorporated at 15% replacement of mrigal during culturing with IMCs, whereas, 10% replacement of bottom feeders was followed during culturing with the combination of IMCs and exotic carps. The standard methods of pre-stocking pond preparation, intermittent fertilization and liming were followed (Jena and Das 2011). Fingerlings in all the ponds were fed with RB and MOC (1:1) at 2 to 4%. The water quality parameters were analysed following the standard methods. Plankton analysed by direct census method. SGR and FCR were calculated following standard references. After 6 months, the fish were harvested by repeated netting, followed by dewatering the ponds. The live fish were counted and weighed individually. Survival (%) and production (kg/ha) of fish were then calculated and compared among the treatments. Two compounded diets having the protein levels of 30% and 35% were prepared and compared with application of conventional RB and MOC. The data were analysed through one-way ANOVA using SPSS v11.2.

Results and Discussion

The physicochemical parameters of water and plankton were at the optimum levels for fish culture (Boyd *et al.* 1990). The overall production of the culture system with the incorporation of pabda was unaffected; total biomass yield remained statistically same. This indicates pabda can be incorporated in composite culture of carps for additional income. A fairly high level of survival was recorded in different treatments in this study which could be due to the stocking of yearlings, regular feeding, fertilization, freedom from predation and maintaining favorable ecological conditions *etc.* (Rahman *et al.* 2011). The stocking density of 4000 fingerlings ha^{-1} was least productive among the stocking densities evaluated for production of pabda under composite culture. Hence, the fish of that treatment was supplemented with diet rich in protein (30 and 35%). The production of pabda was increased by 16.2% with 30% protein diet and 19.5% with 35% protein diet during culturing with 3-species of IMCs, while culturing with the combination of 3-species of IMCs and 3 species of exotic carps, the production of pabda was increased by 28.5% with 30% protein diet and 32.2% with 35% protein diet compared to conventional rice bran + mustard oil cake diet.

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Role of aquaporin 4 in *Clarias batrachus* reproduction

SC Mandal[1*], J Choudhury[1], SJ Monsang[1], L Sahoo[2], BK Behera[3], H Priyadarshi[1], J Parhi[1]
[1] College of Fisheries, CAU, Lembucherra
[2] ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra
[3]CIFRI, Barrckpore, WB
*Correspondence: scmandal02@gmail.com

Introduction

Aquaporins (AQPs) are a family of hydrophobic, integral membrane channel proteins (25-34 KDa) which have been strongly associated with rapid passive movement of water. In vertebrates, teleosts have the highest copy number with up to 18 paralogs reported in zebrafish. AQP4 is constitutively expressed in the basolateral cell membrane of principal collecting duct cells in the kidney and provide a pathway for water to exit these cells. Bebe *et al.* (2006) suggested participation of AQP4 in the oocyte hydration process based on strong up-regulation of AQP4 and slc26 genes prior to ovulation in ovary of rainbow trout. In teleosts, the final stage of spermatogenesis or "spermiation" principally involves the production of hydrated seminal fluid that facilitates the acquisition of motility and the passage of spermatozoa through the spermducts (Scott *et al*. 2010). In teleosts, as suggested for mammals, aquaporins may be involved in the hydration of the seminal fluid as well as in sperm physiology. But till date there is no report of the expression of AQP 4 in testis in teleost or mammal. Artificial seed production of Magur (*Clarias batrachus*) is hampered by the inability of spontaneous spermiation in males even after induction with synthetic hormones. In this study, AQP 4 has been identified and its expression was studied in testis of magur.

Methodology

The testis of the experimental fish, *Clarias batrachus* was collected aseptically and total RNA isolated using trizol method. cDNA was synthesized using the First Strand cDNA synthesis kit (Fermentas, USA) as per the protocol supplied by the manufacturer. Based on the available sequence of other species, degenerate primers were designed to amplify the AQP 4 gene. The amplified gene was cloned and sequenced. The partially identified sequence for AQP 4 gene was utilised to design primer sets for real time PCR to study expression levels using SYBR green chemistry. Acclimatized experimental fishes of around 200-300 g were injected with Ovaprim at 0.3 ml per kg of body weight. The fishes were then divided into two groups; group 1 was kept in a natural pond condition whereas group 2 was maintained in FRP tanks under controlled condition. After 16 hours of injection, spawning was observed in group 1 whereas no spawning was observed in group 2. Testis tissues from both groups were collected and the mRNA expression level was measured using Real time PCR for **AQP 4** and **prepro-catfish gonadotropin-releasing hormone (pcGRH)**. B actin gene was used as housekeeping gene.

Results and Discussion

PCR amplification with gene-specific primer set led to isolation of AQP 4 (314 bp) from *Clarias batrachus* testis tissue. It was then sequenced and submitted in the NCBI database (Accession No. KT158467.1). The available sequence of *Clarias batrachus* were used for phylogenetic analysis along with five other species. The phylogenetic analysis was performed using MEGA4, software by neighbour joining method. The expression of **AQP 4** was found nearly 5 times more in group 1 as compared to group 2, whereas, **prepro-catfish gonadotropin-releasing hormone (pcGRH)** transcripts were more in group 2 compared to group 1. This result provides evidence of possible role of AQP 4 in spawning of male cat fish through hydration of testis and sperm as well.

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Effects of stocking density and feeding frequency on larval growth and survival of *Ompok bimaculatus*

Satyajit Das, Pradyut Biswas* and Himardi Saha
College of Fisheries, Lembucherra, Tripura
*Correspondence: satyajitdas0098@gmail.com

Introduction

Butter catfish, *Ompok bimaculatus*, Bloch, 1794, an indigenous freshwater fish makes itself one of them which has been listed under near threatened category due to over exploitation of their habitat and human interference. Keeping this in view, the fish has been declared as "STATE FISH" of Tripura and efforts are being taken to protect this fish from declining through standardization of captive breeding protocol. But the major constraint lies with the maintenance of the population because of cannibalism and lack of appropriate larval feed. Larval rearing is the most crucial part for aquaculture production because it leads to seed production for stocking which is the key factor for marketable size fish production that will help the farmer to get maximum profit. The manipulation of stocking density as well as feeding frequency might be used to improve the larval growth and survival. The aim of this study therefore was to find the appropriate feeding frequency and stocking density and to know its impact on the growth and survivability.

Methodology

Four days old larvae of *O. bimaculatus* were obtained through induce breeding at the wet laboratory of College of Fisheries, Lembuchera. Seven thousand five hundred pabda larvae (mean weight 0.00436 g; mean total length 0.68 cm) were counted and transferred to twenty four rectangular aquarium (2ft×1ft×1ft) filled with 25 litre water. The larvae were stocked at four densities viz. 5 nos./litre (T_1), 10 nos./litre (T_2), 15 nos./litre (T_3), 20 nos./litre (T_4). The larvae were fed 2 times (7am and 5 pm) and 4 times (7am, 12 pm, 5 pm and 10 pm) daily with the live tubifex up to satiation level. Three replicates were used for each stocking density and for each feeding frequency. During the experiment, the waste was drawn off before feeding and leftover feed were siphoned out after 1 hours of feeding and daily mortality of the larvae was recorded. Alkalinity, hardness, carbon-di-oxide and ammonia were measured at 5 days interval. Sampling for weight and length measurement was done at 7 days interval by anesthetising the larvae which has been release back into the experimental tanks after recovery. After 15 days of rearing, all the surviving larvae were collected from each tank and growth measurement was recorded in terms of mean weight gain, body weight gain, length increment, specific growth rate (SGR), survival rate (SR), total biomass, net yield mean daily weight gain (MDWG) and Fulton's condition factor (K).

Results and Discussion

Average final weight and length were affected significantly by stocking density ($p<0.05$) which shows a negative relationship between stocking density and larval growth. The highest larval growth was recorded with the lowest stocking density (T1) and the lowest in the highest stocking density (T4). Larvae stocked at 5 larvae/L had significantly higher ($p<0.05$) mean weight gain than larvae stocked at 15 and 20 larvae/l whereas shows no significance ($p>0.05$) with the larvae stocked at 10 larvae/l. Similar trend were followed in case of body weight gain, length increment, specific growth rate mean daily weight gain and condition factor. It might be due to higher feeding frequency and lower competition for diet consumption and proper feed utilization. Survivability shows an increasing trend with the decreasing stocking density but show no significant different ($p>0.05$) between T1 and T2. The present result is in accordance with the finding of Mollah (1985) where lower stocking density enhanced the survivability in Magur. But the total biomass and net yield was significantly higher in stocking density of 10 larvae/L (T2). It was because there were no significant difference between survivability of T1 (5 larvae/L) and T2 (10 larvae/L) but the final harvest number was more in T2. Significantly higher growth rate of larvae were recorded in 2 times feeding than 4 times feeding which has been assessed through mean weight gain, body weight gain, length increment, specific growth rate, mean daily weight gain and condition factor. But Survivability, total biomass and net yield were found in higher feeding frequency. This experiment showed that 4 times feeding per day minimized aggression by keeping the larvae sufficiently satiated rather than keeping them starved for a period in two times feeding. By maintaining larvae sufficiently satiated, aggression and cannibalism are diminished because the larvae are not seeking out an alternative (conspecific) food source or vying for access to a temporally limited food supply (Manley *et al.* 2014). The individual length and weight increases in lower feeding frequency (2 times) may be due to cannibalism which creates size heterogeneity in the tank which had territorial behaviour among themselves. It is also found that the survivability, total biomass and net yield were significantly higher in 4 times feeding with the stocking density of 10 larvae/l. The current study shows that the stocking density of 10 larvae/l can be the recommended as appropriate stocking density for larval rearing of *Ompok bimaculatus* with 4 times feeding frequencies.

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Evaluation of fertility and hatchability of different chicken germplasms in agroclimatic condition of Tripura

Vinay Singh*, A Haldar, BJ Das, M Saha, M Datta and Mahak Singh[1]

ICAR Research complex for NEH Region, Tripura Centre, Lembucherra

[1] *ICAR Research complex for NEH Region, Tadong, Gangtok, Sikkim-737102*

*Correspondence**:** vinvet1@gmail.com

Introduction

The supply of day old chicks is very important for the success of the poultry production chain. Commercial operation depends on hatcheries for supply of day old chicks while the subsistence farmers hatch their chicks by natural incubation. Production of day old chicks is influenced by the fertility and hatchability of eggs. Fertility and hatchability are the major traits of reproductive performance which are most sensitive to environmental and genetic influences (Stromberg, 1975). Fertility refers to percentage of incubated eggs that are fertile while hatchability is the percentage of fertile eggs that hatch. Fertility and hatchability are the interrelated traits that vary among breed, variety and individuals in a breed or variety. Fertility depends upon many factors like age of flock, mating system and nutrition of birds, managemental and environmental factors. Hatchability also depends upon many factors like age of flock, nutrition status of bids, egg size, egg shell colour, egg shape, storage condition of egg, temperature, relative humidity, ventilation, turning of eggs during incubation period. Agro climatic condition of North**-** East region of India especially Tripura is hot and humid so fertility and hatchability of eggs is very much affected in this environmental condition. Therefore this study was carried out to evaluate the performance of fertility and hatchability of different chicken breeds/varieties/strains in agro climatic condition of Tripura.

Methodology

Hatching eggs was collected from different breeder stocks of poultry farm of ICAR **-** Research complex, Tripura Centre, Lembucherra and brought to the hatchery unit. After proper cleaning and fumigation, the hatching eggs were stored in the egg holding room at 65^{o}F (18^{0}C) and relative humidity 75**-**80% to curtail embryonic development completely. A total of 6622 eggs of Dahlem Red, Coloured Broiler, Tripura Black, ND Cross (50%) and NB Cross (50%) chicken were set for hatching in three different batches in the hatchery unit. Hatching eggs was kept in incubator for first 18 days and then transferred to the hatcher for last 3 days during incubation period. Proper temperature, relative humidity and ventilation were maintained in incubator as well as in hatcher during the period. Optimum temperature (99.5 0C) was maintained inside the incubator for the first 18 days and 99 ^{O}C was maintained inside the hatcher during the last 3 days of incubation. Eggs were turned at 3 hours intervals, at least 7- 8 times daily and candled at 7th day and 18th day to remove the infertile ones and dead embryo (dead in germs) respectively. Turning was stopped immediately after the last candling. A total of 4192 chicks of different breeds / varieties / lines were hatched out at 21th day. Estimation of fertility, hatchability on fertile eggs, hatchability on set eggs, embryonic mortality, dead in shell, normal and abnormal chicks were calculated.

Results and Discussion

A total of 4192 chicks of different breeds / varieties / lines of chicken were hatched out. The results revealed that the overall mean percent fertility was found 79.08 ± 1.70 in different breeds / varieties / lines of chicken. The highest percent fertility was found in Coloured broiler (84.15 ± 3.24) and lowest percent fertility was found in ND Cross (72.78 ± 1.53). The fertility of Coloured broiler was significantly (P > 0.05) higher than ND Cross, Dahlem red and Tripura black, but there was no significant difference between Coloured broiler and NB Cross. The lowest fertility in ND Cross may be due to the older stock of birds. Insko *et al.* (1947) also reported the general tendency for fertility and hatchability to decrease with age. The overall mean percent hatchability on total egg set (TES) and fertile egg set (FES) were found 60.09 ± 1.82 and 75.97 ± 1.55 respectively. The highest hatchability on total egg set (TES) and on fertile egg set (FES) was (68.69 ± 2.85) and (81.61 ± 0.28) respectively found in Coloured broiler. The lowest percent hatchability of total egg set (TES) was found in ND Cross (53.29 ± 1.62) and on fertile egg set (FES) were found in Dahlem red (71.11 ± 1.76). The lowest hatchability in ND Cross and Dahlem red was may be due to the older stock of birds. Hatchability on total eggs set (TES) of Coloured broiler was significantly (P > 0.05) higher than ND Cross, Dahlem red, Tripura black and NB Cross, however there was no significant difference between ND Cross and Dahlem red as well as in between Tripura black and NB Cross. Hatchability on fertile egg set (FES) in Coloured broiler and Tripura black was significantly (P > 0.05) higher than ND Cross, Dahlem red and NB Cross, however there was no significant difference between Dahlem red, ND Cross and NB Cross.

At last it was found that there was significantly (P > 0.05) different in fertility and hatchability among different breeds / varieties / strains of chicken in agro climatic condition of Tripura. Fertility and hatchability are traits that influenced by both environmental and genetic factors. Successful production of day old chicks starts with proper selection and management of breeding stock, proper post-lay handling of fertile eggs and correct incubation process.

Table 1. Fertility and hatchability of different chicken germplasms in Tripura

Breed/Variety/ Line	Total no of eggs set	No of fertile eggs	Fertility (%)	Total no of chicks hatched	Hatchability (%)	
					Total eggs set	Fertile eggs set
Dahlem red	1140	900	78.54 ± 3.53^{ab}	643	56.06 ± 3.74^{a}	71.11 ± 1.76^{a}
Coloured broiler	2912	2479	84.15 ± 3.24^{b}	2024	68.69 ± 2.85^{b}	81.61 ± 0.28^{b}
Tripura black	542	433	78.88 ± 4.28^{ab}	348	62.17 ± 4.61^{ab}	79.25 ± 1.77^{b}
ND cross (50%)	646	470	72.78 ± 1.53^{a}	344	53.29 ± 1.62^{a}	73.19 ± 0.75^{a}
NB cross (50%)	1382	1156	83.72 ± 1.54^{b}	833	60.27 ± 0.32^{ab}	72.02 ± 1.00^{a}
Total	6622	5438	79.08 ± 1.70	4192	60.09 ± 1.82	75.97 1.55

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Technology Dissemination

- Participatory research and extension
- Capacity building
- Market intelligence
- ITKs in Agriculture
- IPR issues

Poverty to prosperity: successful skill development interventions through Krishi Vigyan Kendras in North Eastern Region of India

AK Tripathi*, Sudipto Paul, Bagish Kumar, Amol K Bhalerao, AK Singha, PC Jat and R Bordoloi
Agricultural Technology Application Research Institute, Zone III, Umiam
*Correspondence: aktripathi2020@yahoo.co.in

Introduction

'Skill gap' is one of the most important retarding factors to realize the full potential of improved agricultural technologies, often resulting in poor productivity. Krishi Vigyan Kendras play a pivotal role in realizing the benefits of the Public Agricultural Extension System of the country. The KVKs are mandated to undertake skill development training programmes for the farmers, farm women, rural youth and extension personnel in frontier areas of technology development. The present paper attempts to point out the skill gap existing in different parts of the North Eastern region, and thereby presents some cases of success derived through skill development training interventions by the KVKs of the region.

Demographic dividend of India

As compared to the western economies where there is a burden of an ageing population, India has a unique 20–25 years window of opportunity called the "demographic dividend". This 'demographic dividend' means that as compared to other large developing and developed countries, India has a higher proportion of working age population vis-à-vis its entire population". This 'demographic dividend' is given below as potential learners in Table 1. The result is low dependency ratio, which can provide a comparative cost advantage and competitiveness to the economy. Further, it is expected that the ageing economy phenomenon will globally create a skilled manpower shortage of about 56.7 million by 2020. With the rising trend of outsourcing work globally, India has the opportunity to become a global reservoir of skilled manpower, accounting for 28% of the graduate talent pool among 28 of the world's lowest-cost economies. Only 10% of the total workforce in the country receives some kind of skill training (2% with formal training and 8% with informal training). Further, 80% of the entrants into the workforce do not have the opportunity for skill training (Anonymous 2011).

Demand and supply of human resources in North East India

India's North-East is comprised of eight states cover an area of 2,62,179 sq. km. 46million people (Census 2011). The Table 1 shows the demand, supply and estimated excess of different types of human resources in 2021. It can be interpreted from the table that in the year 2021, there will be excess supply of 1.52, 94.69 and 45.01 lakh of skilled, semi-skilled and minimally skilled category of human resources in this part of India. This excess supply of human resources is a challenge as well as an opportunity for the policy makers to mobilize them in a desirable direction for the growth and development of the region.

Employment scenario in agriculture and allied sectors in the north eastern region

Agriculture is the major sector which employs around 64, 932, 23 people in the North East India followed by fishery (241,320); animal husbandry (94,213) and lastly apiculture (37,129). In agriculture, the highest number of individuals is engaged in Assam (37, 30,773), followed by Tripura (700,000) and Nagaland (548,845). According to the Ministry of DONER, in 2009-10 the people living below poverty line were 150.9 lakh, out of that 130.82 lakh (86.68%) were in rural areas and 20.1 lakh (13.32%) in urban areas. As agriculture is the major occupation for the people of this region, it can be the panacea for poverty like evil.

Role of KVKs in skill up-gradation

Any technology is having two components at its client system end. First, customized technology and second skill training for "how to use" that technology. Krishi Vigyan Kendra through its mandated activities perform both the duties; firstly through Technology Assessment & Refinement and secondly through capacity building programmes. As technology is not a static entity, skill training should also not be constant, albeit, it should be dynamic and according to the need of end users as well as technology. As it is said that "second green revolution" will start from eastern part of the country, in that, the role of north eastern India will be very significant, so the part required to be played by the North Eastern KVKs will be formidable. The skill up-gradation programme of KVKs for the farmers of this part of the country is an uphill task, due to its diversity. Now time came for KVKs to customize the capacity building programmes according to the diversity of the region, and be the part of change.

Table 1. Demand and supply of human resources in North East India in 2021 (base year 2011)

State	Skilled			Semi-skilled			Minimally skilled		
	Demand	Supply	Excess	Demand	Supply	Excess	Demand	Supply	Excess
Arunachal Pradesh	0.11	0.18	0.07	0.20	1.95	1.75	1.15	5.36	4.21
Assam	1.11	2.49	1.38	1.80	61.58	59.78	9.43	28.49	19.05
Manipur	0.35	0.37	0.02	0.49	6.42	5.92	1.48	3.72	2.24
Meghalaya	0.27	0.28	0.01	0.29	5.00	4.71	1.92	1.23	-0.69
Mizoram	0.11	0.17	0.06	0.21	2.58	2.37	1.07	1.06	-0.11
Nagaland	0.17	0.11	-0.07	0.22	6.27	6.05	0.57	3.63	3.05
Sikkim	0.14	0.07	-0.06	0.22	1.91	1.69	1.12	0.81	-0.32
Tripura	0.27	0.38	0.11	0.29	12.71	12.42	2.48	19.96	17.48
Total	2.53	4.06	1.52	3.71	98.42	94.69	19.22	64.26	45.01

Source: IMaCS Analysis

The Agricultural Technology Application Research Institute (ATARI), Zone-III with its headquarter at Umiam, Meghalaya is primarily responsible for monitoring and reviewing the technology assessment, refinement, demonstration, training programmes and other extension activities conducted by KVKs in North East Region. The efforts put forth by ATARI, Zone-III in exploring new areas and initiatives for development of districts in agriculture and allied sectors through KVKs have brought the KVKs in the mainstay of district agricultural development plans and programmes. Some of the most significant interventions of North Eastern KVKs in providing skill development training programmes to the native farmers and rural youths, and thereby the success derived has been discussed below:

Exhilarating success in KVK intervened TPS production in Tripura

Potato is one of the important crops, cultivated in the state of Tripura, covering around 9040 ha, with the production of 159,466MT in 2013-14. The Demand- Supply gap of around 30% estimated for the table potato in the state. Major causes identified were – cultivation of potato tubers having lesser yield (avg. 11-12 t/ha), disease proneness and pest infestation. To counteract this problem, it was decided to enhance the knowledge and skill of farmers in potato production through

TPS (True Potato Seed).

The methodology adopted for this was skill development through appropriate training programmes on improved package of practices of TPS cultivation and demonstration on improved production technique. The main approach identified for implementing this methodology were cluster approach and contract farming as well as buy back arrangement by HRS, Nagichhera, Govt. of Tripura (Selling price of TPS @ Rs. 20,000.00 per kg, and procurement price of potato tubers @ Rs. 25.00 per kg). The programme has created positive impact in the state and total area under TPS increased to 1605 ha with 6300 beneficiaries in the year 2014-15. Approximately 70% of area under potato cultivation in West district of the state was brought under TPS cultivation. Net return earned by TPS growers was on an average- Rs. 1,55,000 as compared to only 60-70 thousand in normal potato tubers with B:C ratio estimated around 3.4:1.0. The major reason for the success were participatory monitoring by the formation of 6 member committee among potato growers for effective monitoring of the programme at each and every stage of implementation as well as regular monitoring through field visit by concerned KVK SMSs.

Commercial floriculture village: Successful interventions in inspiring transformation

Mr. Pankaj Kalita, a resident flower grower of *Balitara* village of Nalbari district obtained technical guidance and skill training from KVK, Nalbari in flower cultivation and started scientific cultivation of tuberose in an area of 0.05 ha. After that, he gradually incorporated few other flower crops like gerbera, gladiolus etc. in the farming system model. His earning increased more than Rs 3.0 lakhs through sale of both flower and planting materials. The success of Pankaj Kalita inspired the other farmers of the village and the entire village has transformed into a Commercial Floriculture Village**,** with the Horizontal expansion of 8-10 ha. in adjoining villages (more than 10 villages). Before the floriculture intervention, farmers used to grow upland rainfed rice and vegetables, with a meager income of Rs. 25,000-40,000/ha. But, after the KVK intervention, their income was reported to rise to Rs. 210,000.00- 250,000.00 per ha.

Skill development for promotion of small scale fnterprises

Toria is the main oilseed crop grown throughout Assam. But, the productivity is not upto the mark, so, to increase the productivity of toria and provide subsidiary source of income to the farmers, bee keeping was considered as the intervention. Training and demonstration on bee keeping in toria field were organized. As an impact, 8-10 % increase in toria crop has been observed due to enhanced pollination by bee, average per unit profit has gone upto Rs. 23400.00 (Rs. 4400.00 (honey)+ Rs 19000.00 (toria)) with the B:C ratio of 2.95:1. More than 50 farmers have adopted this enterprise mix.

Although a notable extent of adoption of various improved technologies and enterprises based on field crops, fruits, vegetables, flower crops, livestock and small scale income generating activities as promoted through various skill development training programmes by KVKs, has taken place in various parts of the North East region, considerable scope remains still further. Following are some of the niche areas in which further skill development interventions have been planned in NEH region in the near future: 'Secondary Agriculture' including processing and value addition to check post-harvest losses.

- ✓ Development of location specific 'Integrated Farming System' models.
- ✓ Efficient utilization of locally available resources for low cost livestock feed formulation.
- ✓ Composite fish farming and fisheries based small scale processing units.
- ✓ Organic farming, quality seed production and farm mechanization.

For any country, the work force is the major most assets only if it is literate and skilled. Any sector can be prosperous, any venture can be profitable and any activity can be successful, if the manpower engaged is skilled enough to carry out the assigned works efficiently. From a policy perspective, the agriculture sector as whole is not an exception. In fact, in India the major section of our population depend on agriculture for their livelihood, implying that to be a successful and prosperous industry, the constituent stakeholders in general and the primary stakeholders, i.e., the farmers in particular have to be skilled enough. The future of the sector is going to be very susceptible to the external factors such as climate change, open economy, gap in the demand-supply of human resources and so on. Skill upgradation therefore, remains to be the most important way out by which our farmers can cope up to the externalities, and in that the Krishi Vigyan Kendras can become an important positive influence.

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Sustainable intensification of farming system for livelihood and nutritional security

N Prakash*, MA Ansari, SS Roy and SK Sharma
ICAR Research Complex for NEH Region, Manipur Centre, Imphal
*Correspondence: nprakashicar@gmail.com

Introduction

Sustainable intensification of farming system (SIFS) introduction in North East India helps to safeguarding agricultural systems for better livelihood and food security of tribal farmers with biodiversity value. Despite its importance, SIFS has been declining due to agricultural abandonment and afforestation in marginal farming areas, coupled with non strategic and systematic intensification in the most productive areas. It is also possible to integrate different components of ecosystem (land, water, plant species etc.) to obtain sustainable production from rainfed and degraded lands to check natural hazards like floods, drought and soil erosion. IFS ensure that wastes from one form of agriculture become a resource for another form. We selected farmers from Churachandpur district of Manipur for the comparative study of integrated farming system development in Manipur with objectives i.) to study the change in the farming techniques for maximum production in the cropping system ii.) to evaluate the suitable integration of enterprises in a given agro-climatic conditions. iii.) to study the impact of IFS on food and nutritional security.

Methodology

This study was conducted on the field of Henkpao (tribal farmers) in Tollen village, Churachandpur district of Manipur during 2011–12 to 2014–15. A model of integrated farming system was developed on farmer's field. Base line survey on socio-economic as well as their agriculture farming was been done in 2011-12. In 2014-15, survey was done to know the socio economic status of the farmers.

Table 1. Technological interventions under SIFS at farmer's field

Components	Changes on	2010-11(practices followed before intervention)	2011-12 to 2014-15 (Technological interventions)
Paddy cultivation	1. Variety 2. Seed quality 3. Techniques 4. Weed management	1. Local or improved cultivars 2. Old cultivars 3. Conventional package and practices 4. Hand weeding	1. Improved varieties 2. Good in quality 3. Improved package and practices 4. Cono/rotatory weeder
Vegetable cultivation	1. Cultivars 2. Seed 3. Method of cultivation 4. Manure & fertilizers	1. Local cultivars 2. Uncertified seed 3. Conventional methods 4. Less than recommended dose	1. Improved cultivars 2. Certified seed 3. Improved methods 4. Balance nutrition
Fruits cultivation	1. Training and pruning 2. Fertilization 3. Irrigation	1. Not timely and regularly 2. Below recommended dose 3. Not properly	1. Timely and regularly 2. Optimum dose 3. Proper at certain interval
Piggery	1. Breed 2. Feed 3. Health management	1. Local 2. Based on house hold wastage 3. Rarely	1. Cross breed and improved 2. Quality feed 3. Proper deworming and vaccination
Backyard poultry	1. Breed 2. Feed 3. Health management	1. Local 2. Scavenging 3. Rarely	1. Improved birds 2. Quality and concentrated feed 3. Proper vaccination
Fishery	1. Fingerlings 2. Pond liming 3. Stocking density 4. Feed 5. Fertilization	1. Local 2. Rarely 3. Below stocking density 4. Natural feed 5. Raw cow dung	1. Improved 2. Proper at certain interval 3. Optimum stocking density 4. Natural + Concentrated 5. Fertilization with well rotted organic and inorganic fertilizers
Water management	1. Water harvesting unit	1. No water harvesting structure	1. Jalkund/Farm pond

The holding size of the farmer was enhanced from base year to 2014-15 due to technological interventions like terracing and thereby fallow land have been put under cultivation of crops. We kept the same enterprises which the farmer were interested (rice, groundnut, maize in kharif season, pea and mustard in rabi season, fishery, poultry, piggery, vegetable production, fruit cultivation, apiary and water management). Training and inputs were given to the farmers for adoption of scientific management practices in the integrated farming system.

Results and Discussion

Farmer was having total 4 ha area but it was monoculture with rice before intervention. But, after intervention the area expansion was very much successful and gross area reached from 3.75 ha to 7.95 ha (Net cultivated area was 4 ha). The lower yield of rice in 2010-11 was mainly due to use of poor quality seeds, that he had procured from neighbouring farmers and use of conventional methods in rice cultivation with very poor nutrient and weed management. In 2010-11, rice productivity was 3.25 t/ha as compared to 4.97 t/ha (mean 4 years) due to adoption of improved package of practices (Fig 1). The vegetable yield was poor in 2010-11 due to local cultivars, imbalanced fertilization and other management practices. But, after intervention the yield of cabbage and cauliflower were increased due to adoption of improved cultivation methods and use of quality seeds and better management practices under integrated farming system. In 2012-13, number of piglets increased from 3 to 18.

However, it increased the pork production from 30 kg in 2010-11 to 311.5 kg (mean of 4 years). The improved breeds were healthy and their body weight was more than the indigenous pigs. In poultry farmers also, the first intervention was introduction of better breeds. Earlier farmer was rearing local strains, but under the farming systems approach, he started rearing of Gramapriya and Vanaraja. In the present study, on an average 394% per cent more chicken and 567% more egg production, respectively was recorded as compared to 2010-11. In 2010-11, the farmer was having small farm pond. But, after adoption of integrated farming system, he dug two pond in 2011-12 and one more ponds in 2012-13. In 2011-12, he started fish production and produced 800 kg and it increased to 920-920 kg fish production in 2014-15. In this system, family members are gainfully employed due to production and maintenance of several components. A special feature of farming system is value addition due to employment of family members and non-farming families.

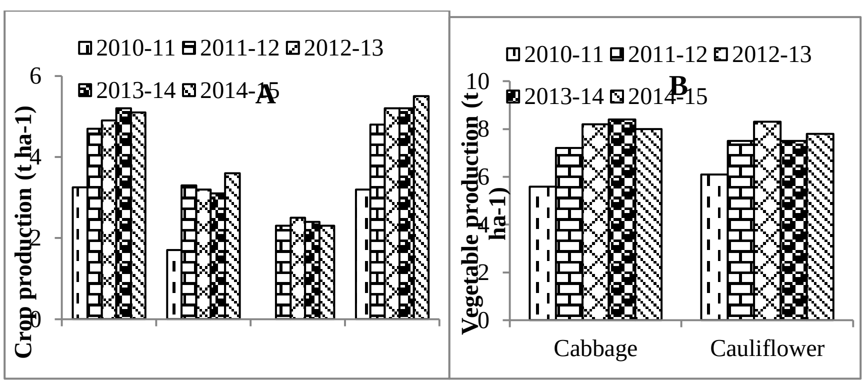

Fig 1. Crop and vegetable production under SIFS

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Marketing of horticultural crops in North-East India: some policy issues

SB Singh*, T Boopathi, SK Dutta and AKR Singh
ICAR Research Complex for NEH Region, Mizoram Centre, Mizoram
*Correspondence:basantasinghsoibam@rediffmail.com

Introduction

The northeastern hill region of India, comprising of eight states, viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura represents a distinct agro-climatic feature for growing different horticultural crops including fruits, vegetables, spices, plantation crops, medicinal and aromatic plants. A wide range of tropical, sub-tropical and temperate fruits such as banana, Mandarin orange, pineapple, jackfruit, papaya, hatkora (*Citrus microphylla*) etc. and vegetables, both indigenous and exotic, are grown in the region. The high altitudinal places in the region provide good opportunities to grow off-season vegetables, including potato etc during the rainy season. The region has a huge potential of horticulture development both in terms of market expansion and production growth. Total production of fruits in the region is estimated about 23.35 lakh tonnes, which is only 5.1% of the total production of the country. As regards production of vegetables, the contribution of the region is only 4.5% of the total production in the country. The North Eastern Region has three potential to be a major player in the emerging South East Asian Markets in view of its close proximity to those markets.

Methodology

The study was based on the secondary data collected from various sources like Basic Statistics of North-East India, Statistical Abstracts of different states, Economic Survey of India and publications of different departments. Besides, the findings of different studies pertaining to marketing of horticultural crops in NEH region were also reviewed.

Results and Discussion

The total area under horticultural crops is around 822.5 thousand hectare which is around 3.14 percent of the total geographical area of the region and it gives total production of 6818.4 thousand tonnes. The production of fruits and vegetables increased by 28.18 and 20.84 per cent respectively in 2007-08 over 1993-1994. The highest increase in area (115.60 percent) and production (63.28 percent) of fruit crops were noticed in Assam and Mizoram, respectively over 1993-1994. However, production of fruit crops decreased in Nagaland (8.42 percent) and Sikkim (44.33 percent) over 1993-1994. In vegetables, maximum increase in area and production was noticed from Mizoram (120.83 and 75.72 percent). Floriculture is commercially a new introduction in the region cultivating in 0.08 thousand hectares with a production of 76 thousand MT.

Market regulation

In north-east region there are 387 wholesale assembling markets, 127 in Assam, 20 in Manipur, 101 in Meghalaya, 10 in Nagaland and 84 in Tripura. Out of this, 53 markets (32 in Assam and 21 in Tripura) have been brought under regulation. In other states, the local autonomous administrative bodies and private persons are the controlling authorities of the markets. For example, Shillong market being one of the biggest markets of the region is owned and managed by the Syiem of Milliem whereas the Jowai market is under the Jaintia Hill District Council whereas the Tura Market is under the Tura Town Committee. Besides, there are about 2200 primary markets in rural and tribal areas which is still out of the ambit of regulation. The present density of regulated markets in the country is about 1.84 per thousand sq. km implying on an average area of 543 sq. km. per market. In case of northeast region, a regulated market covers an area of 2469 sq. km. in Assam and 476 sq. km. in Tripura. It indicated that the condition of regulated markets in the region is highly unsatisfactory.

Enactment of market legislation

Agricultural Produce Market Act was enacted in different states of India basically to safeguard the farmers in getting a fair deal. However, the process of enactment and enforcement of these acts is not uniform all over the region. In Assam, the Assam State Agricultural Produce Act, 1972 was implemented in 1976. But enforcement of the act in state is very poor. No transaction is practically done in any yard. The market committees are collecting market cess and the rural markets are still in the hands of the local body. Tripura is the first state to extend the Bombay Agriculture Produce Market Act, 1939 in 1956. Later Tripura Agriculture Produce Market Act was passed in 1980. The Meghalaya Agriculture Market Act 1980 has been enacted. However, not much progress has been made in enforcement and notification of markets. In Manipur, the Bihar Agricultural Produce market Act, 1960 was extended in the state in 1963. The state has not made any progress in enforcing the act. In the state of Nagaland the bill has been enacted and for the state of Mizoram and Arunachal Pradesh the draft bill is under process. No state of the northeastern region has a separate Directorate of Agricultural Marketing for market administration. The State Agricultural Marketing Board usually continues to function as the market committee. North Eastern Council (NEC) had set up the North Eastern Regional Agricultural Marketing Corporation (NERAMAC) in 1982 with the objective of organising and promoting the marketing of major agricultural and horticultural produce and also, the processed products in the region. However, the performance of the corporation in regards to horticultural products is not encouraging as the corporation has confined its activities only to pineapple products and some dealings in green ginger where the corporation has incurred losses of Rs 3.70 lakhs (Krishnaswamy 1986).

Market infrastructure

Transportation net-work

The horticultural crops are characterised by peculiar problems of high seasonality, perishability and bulkiness. This condition necessitates quick and efficient means of transportation with good packing. Further the production of horticultural crops in the northeast region, particularly fruits and vegetables are localised due to the diversified agro-climatic and soil conditions. It is due to lack of transportation net work, particularly roads and railway lines in the region to connect the different growing centres of fruits and vegetables with primary, secondary markets and other parts of the country. States like Arunachal Pradesh, Mizoram, Manipur, and Meghalaya are still out of the railway map of the country. In other states of the region also, the total length of railway line are very poor. The region suffers isolation from the mainstream of the nation due to the geographical remoteness and relative inaccessibility. The development of railway tracks in the region is constrained by the existing hilly and mountain terrains. Therefore, roads have to play an important role in meeting the transport needs of the region. The road length per 100 sq. km. of area in Arunachal Pradesh, Meghalaya, Mizoram, Manipur and Nagaland being 8.9, 34.9, 17.6, 30.3 and 53.1 km respectively was far lesser than the all India average of 62.8 km. The average length of road is 45.69 km per 100-sq. km. in NEH region as a whole. Due to these problem, most of the farmers bright their produce by head load from distance ranging from 1 to 16 km on hilly slopes.

Storage facility

In the entire region, storage facilities in rural markets and primary wholesale assembling markets do not exist. There is no community storage in the producing areas. At the moment cold storage facilities are far behind even to keep the minimum requirement of any state in the region. The region has only 7 cold storage unit with an installed capacity of 6453 MT. For example, even in the state like Meghalaya where area and production of potato in the year 1998 accounted for about 63 per cent of the NEH region, there is no provision for cold storage. This compelled the farmers to dispose of their potato immediately after harvest at throw away prices offered by the traders.

Processing facility

Processing can play a very important role in marketing of fruits and vegetables. It is estimated that about 25 to 40 per cent of the production of fruits and vegetables is lost in the post harvest operation (Verma, 1981). If the proper processing facility can be organised a lot of waste could be avoided. The region has about 30 processing units mainly for pineapple, orange, peaches and plum. Out of these, 11 are in private sector, 2 in co-operative sector, and 11 in public undertaking. The total installed capacity is about 3000 tonnes but the utilisation is only about 40 per cent of the capacity.

Post-harvest care

The post-harvest care like sorting, grading, and standardisation and packaging, etc. are not quit common in this region. Factor like degree of maturity, damaged ones mixed with better ones, undersized, ripened and unripe ones are sold together. Banana is not packed during transportation. Most of the conventional packing developed on the basis of easy availability of the row material is not much suitable for the purpose. Mature and immature ginger is harvested together including damaged and diseased and marketed, which will have poor shelf life in storage and long distance transport. The losses of transport are estimated at 35 to 50 per cent in case of some fruits and vegetables.

Marketing intelligence

The progress of market information system is also inadequate in the region. Tripura state only broadcasts daily bulletin on wholesale price of important commodities with respect to few markets. Weekly price bulletins are distributed in Tripura, Meghalaya and Manipur only among few departments of state and central Government. None of the state Government has been issuing handouts containing daily prices of any commodity to local newspapers. Bulletins are also not distributed to rural institutions like panchayats, community development centres, etc. A study conducted by Rao (1987) revealed that 78, 64 and 58 per cent farmers in case of potato, pineapple and ginger come to know about price through fellow farmers. But 18, 26 and 40 per cent farmers come to know about the price only after visiting the market. Rest of the farmers had come to know about price through middlemen. Thus tribal farmers have no access to market information through mass media like radio, newspaper and bulletins, etc.

Market performance

Horticulture produce which comprises mainly fruits and vegetables needs a sound marketing system for its development. Rao (1987) observed in Meghalaya that producer share in consumer rupee was as low as 23, 20 and 49 per cent in pineapple, ginger and potato, respectively. On the other hand, middlemen retained their margin 41, 54 and 21 per cent of the consumer rupee, respectively. The above situations revealed that the performance of marketing of horticultural crops is very poor leading to very low producer share in consumer rupee, high share of traders margin and wide variation in price spread in different fruits and vegetable markets.

The foregoing discussion revealed that the northeastern region has ample scope for increasing horticultural sector. However, the main problems in the region are lack of adequate market infrastructure such as transportation network, storage facilities, efficient processing industries, market intelligence and extension and finally, efficient market legislation and regulation. These problems leads to low producer share in consumer rupee, higher degree of post harvest losses, high middlemen margin, deterioration of quality, spatial and temporal disequilibrium affecting market demand and supply over time and space make the market inequitable. Introduction of an efficient market regulation and legislation would make the marketing system more transparent and perfect. Multiplicity of middlemen can be reduced by intervention of State Government agencies, co-operatives and farmer's own organization establishing direct link with the terminal or consumers markets.

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SWOT analysis for determining farmers' adoption- decision towards innovative technology

AK Mohanty*, AK Tripathi, GAK Kumar[1], A Roy and D Kumar
ICAR Research Complex for NEH Region, Umiam, Meghalaya
[1] ICAR-NRRI, Cuttack, Odisha
*Correspondence: dramulyakumar@gmail.com

Introduction

Endowed with rich natural resources, India's North-East region mostly rely upon agriculture that drives the economic growth of the entire region. Due to lack of improved technological intervention and non-availability of appropriate technological information, the farming community of north-east agriculture suffers from low and unstable productivity, which results in large scale rural exodus, straying rural youths away from agriculture, decrease in agricultural productivity and also impedes the farmers interest towards agriculture thus jeopardizing the sustainable food security of the region to a greater extent. In order to address this concern, there is need to empower the farming community of NEH region with the adoption of improved technologies. Adoption models are generally based on the theory that farmers take decisions in order to maximize their expected profits or utility. On the contrary, farmers' utility is dependent upon optimizing the productivity with minimum cost of cultivation to attain maximum profits. Feder *et al*.(1985) suggested that farmers adopt new technologies on the basis of priorities when they expect a more cost-effective outcome than that gained from existing technologies.

Under these circumstances, SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis has been proposed to determine the priorities of the farming community of the region for identifying the internal and external factors that are favorable and unfavorable for better adoption of technologies systematically. SWOT analysis is a method for analyzing both internal and external environments in order to attain a systematic approach and support for decisions. (Kotler 1988;. SWOT analysis adopts the concept of Multiple-Attribute Decision Making (MADM), which uses a multi-layer scheme to simplify complicated problems.

This study is a combination of Innovation- decision paradigm of Roger (1995) and adopter-perception paradigm proposed by Wossnik *et al*. (1997), where farmers are assumed to hold specific perception regarding the effects of an innovation and their subjective evaluations that become significant factors for their adoption- decision. Here an attempt has been made through SWOT analysis to determine the adoption- decision of farmers in Meghalaya towards innovative technologies with respect to successful technology index (TI),

Methodology

The study was conducted in the Ri-Bhoi district of Meghalaya. Out of four blocks of Ri-Bhoi district, Umsning block was selected. On the basis of 16-point criteria measured with 4-point continuum scale, Nongthymmai village was selected out of 12 adopted villages earmarked for the study through rank analysis. Further, the selection was validated on the basis of secondary data and personal observations. SWOT analysis was carried out among the selected beneficiaries and non-beneficiaries through semi-structured interview schedule to know their elicit responses regarding TOT system with respect to perceived attributes of SWOT. SWOT parameters were decided through participant discussion with village elders, teachers, public representatives and extension personnel linked with village. Mean rank, standard deviation (SD) and Coefficient of Variance (CV) were used for giving final rank to the perceived response of each of the SWOT parameters. Kendall's Coefficient of Concordance test was calculated to see the degree of association/agreement among the ranks/marks assigned by different experts of both the groups of respondents on various perceived attributes of TOT system.

Results and Discussion

The result of SWOT analysis showed that *Kendall's Coefficients of Concordance* were significant in all the four cases with coefficient values 0.37 in case of strength (w_s), 0.48 for weakness (w_w), 0.40 in case of opportunity (w_o) and 0.39 for threats (w_t) which indicated that there are discrepancies/ differences within the perceived attributes of SWOT and there is certain degree of association/agreement among the ranks/marks assigned by different experts on various perceived attributes of TOT system (Table 1).

Table 1. SWOT analysis of TOT system in Nongthymmai village as perceived by respondents

SWOT factors	*Kendall's Coefficient of Concordance (w)*	Calculated X^2	CV of X^2 at 5 % LS	Result
Strength	0.37 (w_s)	11.12	11.07	Significant
Weakness	0.48 (w_w)	14.4	11.07	Significant
Opportunity	0.40 (w_o)	12.00	11.07	Significant
Threat	0.39 (w_t)	11.70	11.07	Significant

Through SWOT analysis it was observed that in case of strength, well connectivity with roads was ranked as first attribute followed by easy access to source of information as second and frequent contact with extension agencies as the third rank. Similarly, rainfed farming was the major attribute of weaknesses and lack of storage and processing facilities was found to be biggest threat of the Nongthymmai village in respect of transfer of technology system. But it was remarkable to note that scope for area expansion under cultivation was ranked first according to the experts' ranking among the perceived attributes of opportunities. The SWOT analysis result showed the viability of the proposed interventions envisaging a good output at the end.

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How farmers perceive climate changes and need for climate smart farming interventions: A case of farmers of North eastern region of India

Amol K Bhalerao*, AK Tripathi, AK Singha, Sudipta Paul, PC Jat, R Bordoloi and Bagish Kumar

ICAR-ATARI-Zone-III, Umiam, Meghalaya, 793103

*Correspondence: amolbhalerao.ars@gmail.com

Introduction

The Northeastern region of India is group of eight states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The nature of agriculture of north eastern region is primarily subsistence farming. Most of the tribal communities depend on agriculture and allied activities for their livelihood which is greatly affected by adverse and continuously recurring impacts of climate change. Das *et al.* (2009) reported that the Northeastern Region of India is becoming more vulnerable to the consequences of climate change due to its geo-ecological location and its inherent socio-economic instabilities. This assumption is substantiated by the severe climatic phenomenon observed after year 2009 to 2014. Many experts feel that this is a high time for intervention otherwise the cost of inaction will be more in future (Pachauri *et al*. 2014). Therefore, to explore the perception of farmers in Northeastern region, ATARI-III, Umiam, Meghalaya conducted a research study. To organize any public utility programme it is better to understand the perception of concerned stakeholders. This scientific methodology of investigating actual felt needs of peoples contributes hugely for the success of any planned programme.

Methodology

Ex-post facto design of research was used to conduct this scientific investigation. The study was conducted in all states, by identifying its most vulnerable districts. Two districts were chosen from Assam state and from remaining states only one district was targeted for sampling. The systematic, scientifically reliable and valid data collection schedule was developed and data was collected from 457 respondents. The online data collection methodology was adopted with the help of open source software to reduce the paper use and to achieve faster data collection. The personal interview method as well as focused group discussion method was used to collect data as per the need of all three objectives of study. The selected respondents were personally approached and interviewed at their place of residence / farm by the investigators along with scientific staff of the concerned KVK and their responses were carefully recorded in the schedule. The data is analyzed using descriptive statistics and appropriate statistical tools like mean, frequency average, etc. along with Google tools and MS-excel.

Results and Discussion

The results in Table1 clearly indicates that present studies' sample population perceives climate change at near to medium level. Respondents agree that they perceive the changes in monsoon cycle as well as food, health, environment etc. but they have "little" amount of concern for it and they don't feel much responsible about it.

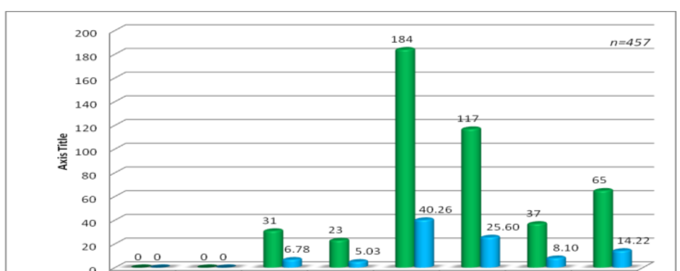
The significant number of respondents (40 % and 25 %) feels that, the rate of changing climate is at medium pace. This obviously means that people of North Eastern region are also able to observe and perceive the changes in climatic pattern at medium intensity. The 14.22 per cent, i.e. 65 of respondents out of 457 also reported that they perceive speed of climate change at very fast speed which is alarming. Surprisingly, not a single respondent rated that they are not able to perceive no change in climatic patterns. It means, 100 per cent respondent agree that climate is changing and speed of change is medium to very fast.

The majority of respondents perceive on "frequent" basis that they are observing reduced health standards and less life expectancy (46 %), respondents are forced to make changes in agricultural practices (40 %) and they also perceive that there is frequent increase in soil erosion-degradation (40 %). Moreover, on "little" quantity around 46 per cent respondents perceive that they are experiencing disturbances in food chain and almost all of them are ready to contribute to minimize those impacts of climate changes.

Table 1. Perceived awareness of respondents about climate change

Statements	Nothing at all	A little	Frequently	Much	Too Much
Aware and heard about climate change term before this survey	23 (5.03)	128 (28.01)	**192 (42.01)**	80 (17.51)	34 (7.44)
Amount of concern about climate change in present situation	17 (3.72)	**145 (31.73)**	123 (26.91)	120 (26.26)	52 (11.38)
Able to feel the positive or negative association of climate changes	21 (4.60)	160 (35.01)	**172 (37.64)**	91 (19.91)	13 (2.84)
Degree of agreement with being responsible for changed climate scenarios in North East region	42 (9.19)	**197 (43.11)**	143 (31.29)	65 (14.22)	10 (2.19)
Degree of agreement that climate changes are affecting the health, food and environment	25 (5.47)	111 (24.29)	**169 (36.98)**	119 (26.04)	33 (7.22)
Experienced monsoon cycle is changing	13 (2.84)	62 (13.57)	**158 (34.57)**	157 (34.35)	67 (14.66)

Secondly, around 34 percent of respondents feel "much" that these effects will worsen the situation in future and 32 per cent believe that there is "much" loss of biodiversity in North Eastern region. Around 28 per cent of respondents significantly perceive that there is much need to conserve forest as well as natural resources in NE region on priority. Due to severity and regular occurrence of adverse impacts of climate changes, agriculture is turning in to non-remunerative business. Out of 457 respondents, 15 per cent have no will to continue agriculture whereas, around 29 per cent



	1	2	3	4	5	6	7	8
Frequency	0	0	31	23	184	117	37	65
percentage	0	0	6.78	5.03	40.26	25.60	8.10	14.22

Fig 1. The speed of climate change perceived by respondents

show "a little" will to continue agriculture. The tribal people are able to feel it from medium to very fast speed of change (Fig 1). The respondents, who are relatively less affected by impacts of climate change coupled with good coping ability, are perceiving climate change at very slow speed. Respondents from all places of study locale perceive climate change unanimously, with relatively medium or faster speed.

Peoples' participation coupled with mass climate change awareness can trigger the reaction of successful management of climate change adversities. To make this happen, farmers need climate smart agricultural interventions and technological backstopping from ICAR institutes, SAUs and KVK network across the Northeastern region.

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Farm resource uses for social benefit through fish-cum-livestock farming in Tripura – a case study

B. Debnath*, C. Debnath, M. Datta, S.V. Ngachan and A. K. Tripathi

Krishi Vigyan Kendra, ICAR Research Complex for NEH Region, South Tripura, India

*Correspondence: debnath_biswajit@rediffmail.com

Introduction

Populace of northeast India have high preferences for animal protein in general and fish in particular. Tripura, one of the landlocked states of northeast India, witnessed an impressive growth in fish production during last decade where fish culture is recognized as a vital activity for economic development. Aqua-farming activities by several entrepreneurs in this state are the key strength of fisheries development (Debnath *et al.* 2009). This study estimated the farm resource utilization capacity of an integrated farming system based enterprise through resource cost ratio approach. Integrated fish farming refers to a combination of practices that incorporate recycling resources from one farm enterprise to another to optimize production efficiency. Integrated farming can make a significant contribution to food security for lower income people in the developing world. Krishi Vigyan Kendra, South Tripura initiated an Integrated Fish-cum-Livestock farming demonstration programme since 2009 in a rural village, Bagma of South Tripura district. This paper examines the resource cost economics of an Integrated Fish-cum-Livestock farm that has been demonstrated by KVK during the year 2012-13.

Methodology

The primary cross section data on farming inputs and outputs for the year 2012 – 13 were used in this study. The Resource Cost Ratio (RCR) approach was used to estimate the farm resource use for social benefit of the integrated enterprise. RCR approach is a variant of Domestic Resource Cost Ratio (DRCR) that Morris 1990 has applied to determine the comparative advantage between countries. Debnath *et al.* 2010 reinterpreted DRCR and suitably adapted to be applied at micro-level i.e. at individual farm level. Present study assessed the social costs and benefit at individual farm level besides the conventional private cost and benefit.

In the RCR approach, all the possible inputs and outputs of a production unit are categorized as marketable and non-marketable. Here, factors of production (inputs) which enter in the production system from the market by the producer are considered as marketable input and those which enter in the market from the production system (it must not be used as an input in production system) are the marketable outputs, for example, produced fish, produced milk in fish-cum-livestock farm etc. (even if it is consumed by the producer's family also). The valuation of these inputs and outputs are done in both producer prices as well as at economic prices. Here, producer price is the price of inputs/

outputs items expressed in monetary term that are paid or received by actual producer in the localized market and the economic price is the real price of inputs/outputs items expressed in monetary term without the effect of all possible externalities (third party effect: either good or bad, or parties not directly involved in the production or use of commodity). All the inputs and outputs of both marketable and non-marketable categories were structured in a matrix considering its producer's price and economic (or opportunity) price. The matrix termed as Policy Analysis Matrix (PAM) has been used to calculate several indices of RCR. All these indices are self-explanatory in their terms, but the characteristic of RCR and its possible results should be illustrated to make it more simple and convenient to understand. RCR is the ratio of net cost of non-marketable resources (H - F) and the net value addition effected through marketable route (E - G). Usually, RCR value lies between 0 and 1, with the assumption that (E - G) > 0. Social profit is inversely related to RCR. When Social profit = 0 and (E - G) > 0, then (1 - RCR) = 0 and hence RCR = 1. The RCR may fall for integrated aquaculture because of two reasons: (1) decline in the difference between the economic value of non-marketable outputs and inputs, when non-marketable input costs decrease, decline in non-marketable input cost or the value of non-marketable outputs increases; (2) rise in the economic value of the difference between marketable outputs and inputs that occurs with a rise in the marketable output or a fall in the cost of a marketable input. Addition of a new product like biogas or biogas slurry may result in a less-than proportionate increase in input costs due to the large scale of integration.

Results and Discussion

The farmer's (S. Majumder's) farm that provided the stimulus for this study has produced fish, milk, egg, duck meat, biogas and manure. The system was diversified by integrating fisheries and duckary (khaki Campbell) besides installing a biogas plant (capacity = 5.5 m^3). Biogas plant was vertically integrated to the system for efficient utilization of cattle manure for cooking and manuring of fish pond though it's a byproduct. The livestock unit consisted of one cow-shed that accommodate 10 cattle and one duck-house having capacity of rearing 30 Khaki Campbell ducks (male = 07, female = 23). Beside the supplemented feed, the cows were fed with grass and fodder produced from the farm. Major portion of produced milk was sold to nearby milk marketing society besides home consumption of small quantity. Ducks were feed with supplemented feed procured from market alongside wasted kitchen rice and farm produced low-priced rice. Fish of any size group (small to large) is demanded by consumers of Tripura and fetches a good market throughout the year. Such fish market in local situation creates the opportunity for multi-stocking and multi-harvesting approach in fish culture. Using this principal and keeping the pond water volume-fish biomass ratio in mind, supplementary fish feed was provided @ nearly 2 % fish weight. Lime application was carried out with split dose of 12 kg bimonthly for whole culture period of one year. The analysis was carried out with primary data and relevant impute different cost of marketable and non-marketable inputs and outputs of Shri Majumder's integrated farm were compiled. The RCR analysis and policy analysis matrix revealed that the farm earned a private profit of Rs. 1,54,510 from 0.30 ha area during 2012 – 13. The farming system was able to earn a private profit of Rs. 1.14 per unit of private cost. Hence, the opportunity cost of livestock manure was considered in economic price in resource cost ratio analysis. Total social profit of the farming system was estimated to be Rs. 2, 13,130 and the system earned 1.36 units of social benefit per unit of social cost. The resource cost ratio of the integrated farming unit during the year 2012 – 13 was 0.07 indicating higher social profitability. The resource alteration and transformation capacity of integrated farming system was reflected in this study. The farm spent only 0.07 units of non-marketable resources i.e. local factors of production to produce one unit of marketable output in the form of fish, milk, egg, and duck meat. Present study quantified the concept in terms of resource cost ratio. Further, the system ensured Food and Agriculture Organization's technical guidelines (FAO 1997) for diversification of aquaculture for income generation with responsible resource utilization and minimum adverse impacts on the environment and local communities.

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Knowledge, attitude and practices of fishers on fisheries resource conservation in Rudrasgar lake, Tripura

Biswarup Saha* and MK Datta

College of Fisheries, Central Agricultural University (CAU), Lembucherra, Tripura

*Correspondence: biswarup.ext@gmail.com

Introduction

Wetlands play vital role in ensuring fish production and income security of the fishers depends on the lake. In Tripura, fishing is one of the important economic activities in rural areas and supports the livelihood of 73,264 fishers population (Anon 2002). The state is blessed with an important Lake i.e. 'Rudrasagar' covering 365.61 ha water area with annual fish production of 41,683kg (2006-07) (Upadhyay and Singh 2010). Rudrasagar Lake is declared as National Lake No. 13 and also it is declared as an International Lake numbered 1572 as a Ramsar site. The lake situated between latitude 23°29´ N and longitude 90°01´ E, with water depth varies from 2 to 9 m. This lake has the perennial connection with one of the major rivers (Gomati) of the state facilitating the natural breeding ground of the valuable indigenous endemic fishes. Fishing and other activities in this Lake are solely monitored by Rudrasagar Fishermen Cooperative Society which earns around Rs. 13 Lakh annually from it. Altogether, 1996 fishermen families belonging to 15 fishermen villages are earning their livelihood through fishing in this lake. However, the lake at present is under threat from a variety of human induced changes to their hydrology. The Rudrasagar Lake has now shrunk to around 100.46 hectares due to encroachments and is turning into a paddy field. With pollution levels rising and threatening the ecological balance of the region, the families of around two thousand fishers around the lake have been facing a threat in livelihood as the lake is dying. Local communities will need to take more responsibility for solving local problems. In order to do this, however, communities must be empowered and resources provided to make decisions locally and to take actions that meet local opportunities and problems. Keeping all these in the background it is worthwhile to study the existing knowledge, attitude and practices of fishers on fisheries resource management in the Rudrasagar lake.

Methodology

The *ex post facto* research design is resorted in the study under cross sectional approach. From 15 fishers villages, which are mainly dependent on fishing in Rudrasagar Lake, 7 villages were randomly selected by using simple random sampling method. Then twenty fishers were selected randomly from each village. Thus, altogether 140 fishes were included for the study. Keeping in view the objectives of the study and the variables to be measured, an interview schedule was developed. Apart from information on the socio-personal characteristics of the respondents, fifteen closed ended questions were used to collect information regarding knowledge, attitude and practices of the fishers in the line of IDAF 1994. Of the 15 questions on fisheries resource management of the lake, to which they could reply with: "yes, I agree", "no, I don't agree" or "I don't know". The responses to these questions cannot always be defined as "correct" or "incorrect". However, a favourable answer (favourable to fish resource management) was defined beforehand, marked by X in Table 1 by consultation with the experts of fisheries resource management. It is this favourable answer that is referred to when speaking of "correct" responses in the analysis. The responses to the questions were analyzed in three groups: knowledge-, attitude- and practice questions as per the original sequence of the survey, where questions were grouped in 5 subjects.

Result and Discussion

The age of the respondents ranged from 22 to 70 years. Around 53.57 per cent fishers were found to have an experience more than 20 years in fishing. Most of the fishers (41.43%) of the selected area did schooling upto primary level. Around 20 per cent of the fishers had high income level i.e., up to Rs. 57,500/- annually from fish sale. Whereas, 60 per cent of the fishers had medium income level between Rs. 8,000 to Rs. 57, 000/- annually from fish sale. Although non-fishing activities (e.g. agriculture, livestock rearing, non-farm and off farm) often supplement their fishing income. Majority of fishers (67.85%) realize that the amount of fish in the lake is limited (K1). But, when asked whether "there is always enough fish in the lake for every fishers to have a good catch" (K2), 120 out of the total of 140 respondents answers correctly no. For the seasonal fishers this response numbered 100%. This seems to prove that the respondents are very much aware of the limited nature of the fish resource. But the majority of respondents (58.57%)

does not realize that "when the fish you catch is getting smaller in size, it means that the fish resource is being overfished (K3). Majority of the fishers (65%) were confused about the "fishing laws to regulate fishing activities". Majority of fishers (67.86%) opined that their fishing community alone is not able to take care of its fishery resource itself (A1). When we look at the questions on attitude towards authority (A4 and A5), we can see that about 40% of the fisherfolk did not opine any feeling that "the government fishery department can help us to solve the problems that occur in our fishery (A4)"

More than half of the respondents agreed that "our community is currently doing something to regulate fishing activities in this community (P1)" The responses to P2, "do you allow new fishermen to start fishing here in your fishing grounds?" denied strongly. Around 97 per cent of fishers denied access to new fishers. There was a mix response on the third practice question i.e., 'Are you doing something to prevent the fishery resource from being overfished?'. Of all the respondents, 68.57% were either confused or doing nothing "to prevent the fishery resource from being overfished (P3). It is no surprise that the fishers cannot accept that "all the fish in all the lake might one day be finished". But they do realize it is not always there for them to catch. It might also be very difficult for these fishers to admit that their fish resource is overfished, since they depend completely on it for their livelihood. That there is some realisation that the fish resource is a fragile and limited resource can be deducted from the concern for the future of fishing activities, especially amongst the seasonal fishers.

It is becoming increasingly clear that governments, with their finite resources, cannot solve all fishery problems. Local communities will need to take more responsibility for solving local problems. In order to do this, however, communities must be empowered and resources provided to make decisions locally and to take actions that meet local opportunities and problems. The assistance and support of government will still be needed to achieve these results, although the role and responsibilities of government will also need to change. It is important for the fisheries manager to be creative and innovative.

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Production potential of improved over existing cropping sequence followed in Karbi Anglong district of Assam

C Thakuria*

Krishi Vigyan Kendra, Karbi Anglong, Assam Agricultural University, Diphu

*Correspondence: chayanika_thakuria@yahoo.com

Introduction

Increase in human population in the country at a faster rate, the per capita of land has been decreasing year after year. To meet the food requirement of the increasing population it becomes very imperative to increase the production per unit area per unit of time. In earlier days, farmers grow only one crop in a year and remaining periods were kept fallow but now a days farmer are interested to grow more than one crop per year to meet up their food requirement. In Karbi Anglong district of Assam, farmers generally grow winter rice followed by winter vegetables mostly brinjal in sequence with local varieties. Hence, an attempt was made under in Krishi Vigyan Kendra, Karbi Anglong, Diphu located in the Hills Zone of Assam, to convince the farmers about the yield performance and economic benefits of growing winter rice-cabbage-greengram crops in sequence over the winter rice-brinjal sequence which is prevalent in the district.

Methodology

On farm trials were conducted in the randomly selected locations in farmers' field during 2014-15 in Bokolia subdivision of Karbi Anglong district to compare the production potential and economics of improved cropping sequence over the existing sequence. The trial included two cropping sequences, one improved cropping sequence winter rice (cv. Basundhara)- cabbage (cv Green Express)- greengram (cv. Pratap) with inclusion of high yielding varieties of all the crops along with recommended practices and another sequence with 200 percent cropping intensity viz. winter rice (local)- brinjal (local) which was commonly followed by most of the farmers of the district using local varieties as well as without application of fertilizers/ improved practices except for application of 2t/ha of FYM to each crop. The cropping sequences were tested in ten locations in the farmers' field of the district. The area allotted in each of the sequence in each location was one bigha of land. The average yield of all crops included in each of the sequences were considered for estimation of individual crop yield as well as rice equivalent yield and to compare the economic benefit of both the sequences. The experimental soil was sandy loam, having pH 5.4 and organic carbon 0.64 percent. The optimum sowing/ planting time was maintained in both the sequences and crops were harvested at proper stage.

Results and Discussion

Results of the trail revealed that there were slight variations of yields of all the crops included in both the cropping sequences with variable locations. However, higher grain yield of winter rice was recorded in the improved crop sequence over the existing farmer's crop sequence which was 35.7 percent increase due to inclusion of HYV of rice Basundhara, in the improved sequence (Table1). The total rice equivalent yield obtained in the improved sequence was higher than the farmer's crop sequence.

Table 1. Average yield and economics of improved and existing cropping sequences in farmer's field

Cropping sequence*	Yield (t/ha) Winter rice	Cabbage/ Brinjal	Greengram	Total rice equivalent yield (t/ha)	Net return (Rs/ha)	Benefit-Cost ratio
A	3.80	22.50	1.00	16.48	1,00,026.00	1.80
B	2.80	13.20	-	10.56	50,664.00	1.47

*A:Improved cropping sequenceWinter rice (Basundhara)-Cabbage(Green Express)- Greengram (Pratap); B: Existing/ farmers cropping sequenceWinter rice (local)- Brinjal (local)

The percent increase in rice equivalent yield as a system basis was 56 in case of improved over the existing farmers cropping sequence which was due to increased yields obtained in all the crops and inclusion of three crops in the sequence in case of improved sequence. Similarly the net return and benefit-cost ratio were also recorded higher in the improved cropping sequence over the existing farmer's crop sequence.

It can be concluded that improved crop sequence with 300 percent cropping intensity was better than the existing sequence followed by the farmers of the district with 200 percent cropping intensity for getting higher production with economic returns.

Traditional knowledge based management practices on cucurbit pests in Unakoti district of Tripura

Dilip Nath*

Holy Cross College, Agartala, Tripura

*Correspondence: nathjim@rediffmail.com

Introduction

Agriculture is the backbone of the economy of Tripura. The warm and humid climatic condition of Tripura is perfect for producing plenty of fruits, spices and vegetables. More than half of the population dependent on agriculture and allied activities, but due to hilly terrain and forest cover, only 27 per cent of the land is available for cultivation.

Unakoti District is rich with economically important vegetable crops (Nath 2014) where cucurbits under the family Cucurbitaceae enjoy a unique status. Many insect pests infest the crops and affect the appearance of the marketable yield. Several insect pests cause heavy loss of crop production in this district (Nath 2014). Among insect pest Leaf beetles or Chrysomelidae are one of the important family mainly infests the cucurbitaceous crops (Kalaichelavan 2000). The insect pest causes heavy damage during early phase of plant growth. Pumpkin beetles are usually found in aggregations within the crop on both young and old leaves.

To control the pest menace, farmers of the district are mainly depending on chemical pesticides. Along with such chemicals they also use to practice some traditional pest management strategies (Nath 2014). The growth of cucurbit crops are severely affected by a number of insect pests among which, the beetle and other insects are the most damaging and major pests. Local farmers of this region are practicing the management processes of this pest by their own way since time immemorial.

Methodology

Farmers' traditional belief for the management of insect pest has been followed by questionnaire method. Total sixty farmers from three villages (Chandipur, Govindapur and Kinairchar) were interviewed during September, 2013 to January, 2014. Constructs from the pest belief model and the theory of reasoned action were used to analyze farmers' pest management decisions. Draft of the questionnaire prepared in English, translated into Bengali at the time of interaction with the farmers was used. The mathematical and statistical equations have done from the collected data. The damage by the insect pests on crops was confirmed by eye observation on the host crops. The insect pests were collect by handpicked method and insect collection net. The collected samples were kept in 70% ethyl alcohol and brought in laboratory. They were identified under microscope and with the help of catalogue.

Results and Discussion

The survey among the farmers of three villages in Unakoti district revealed that the farmers involved in cultivation of vegetable along with cucurbitaceous crops. The average land area for agricultural crops was occupied by them was recorded to be 3.4 Kani (1 kani = 0.16 ha) per family whereas maximum land area was recorded in Kinairchar (4.14 kani) followed by Chandipur (3.08) and minimum in case of Govindapur (3.0 kani). The farmers of all the villages were involved in cultivation of cucurbit crops and the average land area occupied for cucurbitaceous crops were recorded as 2.47 kani where maximum respondents were recorded from Kinairchar (3.1 kani) followed by Chandipur and Govindapur which was recorded to be 2.16 kani per house hold.

The farmers' belief in infestation of pest was recorded as cent percent respondents from the district and the belief on beneficial pests on cucurbit crops were recorded to be the highest from Kinairchar (87.0%) followed by Chandipur (67.00%) and the minimum response was found from Govindapur (16.00%) The study revealed that cent per cent farmers from all the villages were used chemical pesticides whereas the traditional methods for pest management were used by 37% villagers. Regarding traditional methods of pest management practices the highest respondents were recorded from Chandipur (84%) followed by Govindapur (17%) and the lowest in case of Kinairchar where only 10% farmers were involved in practicing the traditional methods. No records of using bio-pesticides which are available in market for the management of the beetle had been observed from all over the district which might be because of ignorance and inaccessibility. Total two pest species on cucurbit crops were collected and identified form the area *viz.*, (i) Red Pumpkin beetle (*Aulacophora foveicollis*) and (i) Melon fruit fly (*Bactrocera cucurbitae*). Those pests were recorded from several cucurbitaceous crops *viz.*, Cucumber, Pumpkin, Teasel gourd, Ridge gourd, Bottle gourd, Ash gourd etc. Total seven (7) different varieties of cucurbit crops were cultivated by the farmers of this area which included Cucumber, Pumpkin, Teasel gourd, Ridge gourd, Bottle gourd and Ash gourd.

As traditional practices local farmers used major five types of treatments, *viz.*, cow dung, cow urine, fly ash, lime water and tobacco and lime water mixture to control different insect pests. Raw cow dung was mixed with water (1:5 w/v) to prepare a suspended solution and sprayed on pest infested field. Fly ash (wood ash after burning) was sprayed over the crop (100 % powder). Cow urine was used directly on plant leaf. 100 gm of tobacco leaf mixed with 10 lit lime water, kept for overnight and sprayed on next day by mixing the liquid soap. The farmers' respond in insect pest management by using various traditional practices revealed that cent per cent farmers of Govindapur and Kinairchar were using fly ash and cow dung as traditional methods. The farmers of Kinairchar were also practicing cow urine for pest management. Tobacco and lime water mixture in water were practicing by the farmers of Chandipur which repelled the insects. Cow urine, tobacco and lime water decreased the infestation rate may be due to repellency. Only about 37% farmers practice these methods (ITKs) in study area. The present investigation clearly indicates that the trend of the uses of traditional practices is going to be decreased now days though these practices are unique in nature. Here, it is observed that the farmers of the study sites use tobacco, cow dung, cow urine, fly ash, chilly powder, etc. as traditional practices for insect pest control. Except lime water all ingredients are originated from biological origin.

Fly ash, cow dung, Cow urine, lime water and tobacco have an ethnic importance among the local farmers of this district which are frequently practiced by the farmers. These methodologies are to be documented and encouraged as a part of sustainable pest management practices. However, the use of traditional practices may help to a great extent to check an increasing pest problem because these practices are eco-friendly.

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Association of knowledge level of the farmers about sprinkler system of irrigation with independent variables in the Jhunjhunu district of Rajasthan

D Kumar[1,2]*, A Roy[2] and AK Mohanty[2]

1S.K.N. College of Agriculture, Jobner, Rajasthan

[2]ICAR Research Complex for NEH Region, Umiam

*Correspondence: dkdkdangi@gmail.com

Introduction

In India it was proposed to reach a production target of 225 million tonnes of food grains, 968 million tonnes of fodder and 225 million cubic centimetre of fuel wood from the existing lands to meet the requirement of about one billion population in 2000 A.D. This implies that if food production is to be increased sufficiently, enough crop production in rain fed areas will have to be increased. Two possible alternatives exist to increase the crop production, one is that the rain fed areas have to be brought under irrigation which could not be crossed the 50per cent of the cultivated areas. Second is improving crop production in rain fed area by promoting the adoption of watershed technology. Therefore, improved crop utilization of available rainwater, dryland crop yield per unit area. India's huge agricultural potential is embodied in its abundant and diverse natural resources. Wide spread availability of arable land and a largely non- hostile and conducive climate has provided India with a natural advantage in agriculture unlike most parts of the world, which has to battle a cold and hostile winter on a relatively small proportion of arable land, India is blessed with bounteous nature. This vast potential, of course, is still largely untapped.

Methodology

The present study was conducted in the Jhunjhunu district of Rajasthan. Jhunjhunu is situated in the northern part of Rajasthan and this district is divided into six tehsils constituting eight panchayat samities, 288 gram panchayats and *865* villages the total geographical area of the district is 591681 hectares, out of which about 436901 hectares is cultivated. The net irrigated area is around 155476 hectare. The land is mainly plain. This study was proposed because of the of the following reasons: (i) This district has highest irrigated area under sprinkler irrigation system *ie*. 82 per cent of its net irrigated area. (ii) Jhunjhunu district is ranked third in Rajasthan as per the total number of sprinkler sets available in the state. Jhunjhunu district consists of eight panchayat samities, out of these in Chirawa (15200 sets) and Jhunhunu (9300 sets) panchayat samities the maximum number of sprinkler sets were installed in last four years (1995—1999). Taking into account this statistics. Above two panchayat samities were purposely selected for present investigation. Selection of gram panchayats a comprehensive list of all those gram panchayats having sprinkler sets under. Chirawa and Jhunjhunu panchayat samities were prepared with the help of information sources. Out of this prepared list two gram panchayat Narar (405) and Devram(317) of Chirawa panchayat samiti and two gram panchayats Bakara (185) and Bharu (105) of Jhunjhunu panchayat samiti having maximum sprinkler sets were retained for preset study. For the purpose of selection of respondents, a list of farmers (adopters and non-adopters of sprinkler system) was prepared with the help of village patwari, local leaders and agriculture supervisor of respective villages for selecting the respondents.

Results and Discussion

Knowledge as a body of understood information possessed by individual is one of important components of adoption behavior. About sprinkler irrigation information. It is considered as a pre-requisite for adoption by many authors and scientists. On this ground it is imperative to examine the extent of knowledge of the respondents sprinkler irrigation system. The present investigation was therefore, sprinkler system of irrigation". it measure the knowledge level of the farmers.To get an overview of the knowledge level of respondents were grouped into (i) low (ii) medium and (iii) high knowledge levels on the basis of calculated mean and standard deviation of respondents of the obtained schedule. The results (Table 1) reveals that more than 50 per cent of the adopter respondent's fall in the medium knowledge group where as both level respondents have same percentage *i.e.* adopter respondents high and low further indicates that in total nearly 80 per cent sprinkler holders were found in the medium and high knowledge group. It means that the respondents had fairly good knowledge about sprinkler irrigation technology.

Table 1. Distribution of adopter respondents on the basis of their Level of knowledge.

Knowledge Level	Knowledge score	Number of respondents	Percentage of total
Low	Below 57.43	15	18.75
Medium	57.43to 73.83	50	62.50
High	Above 73.83	15	18.75

The present findings are in line with the findings of Yadav (1993) Who found 65 per cent of the respondents were in medium knowledge level about sprinkler system of irrigation Nearly half of the of respondents (49 possessed medium knowledge level followed by 35.25 per cent 18.63 per cent low and high knowledge Level regarding modem technology. It wasnoted that majority of adopter respondents (65 per cent) were in medium knowledge levels about sprinkler system while 58.75per cent adopters were in low knowledge level group about sprinkler system of irrigation. While in case of non-adopters it was noted that 3 1 .25 per cent, 58.75per cent and 10.00 per cent farmers were in medium, low and high knowledge levelsrespectively.

Farmers of the study area appear to be enthusiastic to participate in training for different aspects of sprinkler irrigation technology. Therefore, state agriculture Department in collaboration with Agricultural Universities and sprinkler manufacturing agencies should prepare and chalk out the programmes for area specific comprehensive educational training for the farmers.

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Identification of suitable and profitable *rabi* crops for high altitude and tribal areas of Tripura

Dipankar Dey, Dipak Nath, Subhra Shil, Ardhendu Chakraborty and Suresh Biswas

Krishi Vigyan Kendra, West Tripura, Khowai, Tripura

*Correspondence: dkvkwesttripura@gmail.com

Introduction

Crop diversification identified as an important and essential strategy to improve farm income, and to maintain soil and environment health. Viable cropping system with new rewarding crops may infuse new opportunities and challenges and demonstrate the potential for land productivity with use of resources efficiently. Identification of appropriate crop in a system is necessary to get higher yield, returns and maintain soil health, preserve environment and meet daily requirement of humans and animals (Samui *et al.* 2004). Continuous adaptation of same cropping sequence years after years result in declining the efficiency and productivity of the system (Kumar and Yadav 2005).But there is hardly any crop grown as second crop over the years in tribal areas of Tripura. Therefore it is thought to be worthwhile to study different nontraditional crops during *rabi* season instead of paddy fallow.

Methodology

Field experiments were conducted at North Pulinpur ADC Village of Khowai district of Tripura under the project National Initiative on Climate Resilient Agriculture (NICRA) to find out the suitable and profitable *rabi* crops for high altitude and rainfed areas of Tripura during three consecutive *rabi* seasons 2012-13,2013-14 and 2014-15.Crops.The soil was sandy loam in texture, P^H having 5.8,organic carbon 0.59 percent and available Nitrogen 282 kg/ha, Phosphorus 22 kg/ha and Potassium 147 kg/ha. After the harvest of *kharif* rice, the *rabi* crops were grown before 15^{th} of November in all the three years of investigation and harvested at maturity. Grain yield from the plots expressed in Kg ha^{-1}. Economic parameters like gross returns, net returns were invested and worked out treatment wise taking prevailing market rates.

Results and Discussion

Results revealed that among different crops cultivated during *rabi* after *kharif* rice, maize recorded highest grain yield followed by lentil, mustard and ground nut. The benefit cost ratio was also higher in maize Var. HQPM-1(2.62), followed by lentil Var. HUL-57 (2.06), Mustard Var. B-9 (1.75) and Ground Nut Var. ICGS-76(1.26).The post-harvest soil available nitrogen status significantly declined with cultivation of maize after 3 years than initial due to its exhaustive nature and higher nitrogen requirement. There was no marked change in status of available phosphorus after three years of the study over initial with different test crop except maize. It shows that current phosphorus status application was not in line with the crop requirement and it suggests slight increase in phosphorus dose over existing in case of maize. The available potassium status was declined sharply with maize which shows that there is a need of higher replenishment of potassium in double cropped areas with maize as second crop.

Table 1.Performance of different *rabi* crops in terms of yield, economics and post-harvest available NPK status.

Rabi Crop	Yield (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net Return (Rs ha^{-1})	BCR	Post-harvest available NPK status (kg ha^{-1})		
						N	P	K
Maize Var. HQPM-1	4100	31187	82000	50813	2.62	240	16.5	117
Lentil Var. HUL-57	1100	32000	66000	34000	2.06	277	21	134
Mustard Var. B-9	950	32500	57000	24500	1.75	275	19	141
Ground Nut Var.	1050	49999	63000	13001	1.26	279	20	133

Data on economics of different crops after rice in sandy loam soil reveals that groundnut recorded significantly higher cost of cultivation while maize recorded the lowest. Net returns were significantly higher in maize followed by lentil and mustard. So it can be concluded that maize, lentil, mustard are most viable option as these three crops recorded higher net return along with Higher BCR. However, while selecting crops sound nutrient management strategy must be followed to maintain soil fertility especially in case of maize due to its exhaustive nature.

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Joint Forest Management program and constraints of villagers in participation: a case of Malrajura village of Akola district, Maharashtra

MB Thigale, HK Deshmukh*, YB Taide, UR Chinchmalatpure and AS Khandagale

College of Forestry, Dr. Panjabrao Deshmukh Agricultural University, Akola, Maharashtra, India

*Correspondence: hkdeshmukh1@rediffmail.com

The study was conducted in Malrajura village of Akola District, Maharashtra with a view to assess the constraints faced by the respondents for participation in JFM programme. The total Sixty respondents were selected randomly on the basis of land holding i.e. landless, up to 1.00 ha, 1.01 ha to 2.00 ha, 2.01 to 4.00 ha and above 4.00 ha. The independent variables such as age, education, land holding, livestock, family size, sources of information and attitude with the dependent variables such as annual income, employment, and availability of non-timber forest produce were used to find out the impact of JFM programme on livelihood of rural people. The study revealed that majority of respondents faced the problems of less price of NTFP in market. The major constraints like; non availability of processing units in village, lack of training, lack of knowledge to the respondents were observed among the villagers in the participation in JFM programme. It was observed from the study that the independent variables are positive and highly significant with dependable variables like availability of Non-timber forest produce, Annual income and Employment. However, the training programme should be organized and the information source should be available for villagers to increase their participation and make programme more effective.

Intelligence in agriculture: techniques to deal with variations and uncertainties

K Bhagawati and R Bhagawati*

ICAR Research Complex for NEH Region, Arunachal Pradesh Centre, Basar-791101

*Correspondence: kaushik.iasri@gmail.com

Intelligence may be described as situation-specific behavior and analyzing power of an entity based on the known or stored set of information. It is the ability of an entity or a system to learn from a set of conditions, store the acquired knowledge in a well-defined hierarchical manner and apply it in a unique situation-specific and logical way. Learning is the process of acquiring knowledge through experience and instruction. Learning consequently change the approach of doing certain things, gradually and finally changing the behavior of the entity. Information is the basic means or tool for learning or to teach an entity. The acquired information associated to a certain subject or object is knowledge. And the process of extracting information relevant to a given context from a pile of raw data is knowledge discovery. Thus, the ability of a system to discover knowledge from available data and use it for some future unseen and new situations comes under the domain of intelligence. Lot of practical significance and emphasis is being given to intelligence, because of its ability to deal with complex or variable situations. The novelty or ambiguity that the variable environment presents, demands for the development of self-adaptive intelligent systems.

Agriculture depends on the decision making, with right decision at right time. Even a marginal difference may yield big gain or losses over time. Agriculture system needs to be intelligent for optimum and sustainable use of limited resources and to increase its resilient to ongoing changes in climate and social structure. Agriculture is enterprising, and consequently demands use of information technologies. Information emerges as fifth vital factor of production. Agricultural system in particular and biological system in general is a complex system that depends on multitudes of biotic and abiotic factors. Moreover, these factors in turn depend on several other factors. Thus, to study such system we need to consider, simultaneously, several interrelated factors that cannot be dealt with normal mathematical or statistical methods. Thus, intelligence and intelligent systems were introduced in agriculture to deal with such non-linear problems. Emerging information and related technologies revolutionized agriculture and offer it a novel outlook. New approaches like Artificial Intelligence, Artificial Neural Network, Fuzzy Logic, etc. find wide application in agriculture and allied sectors. These are information processing system models that are built from human thought process to mimic human brain's decision making abilities. In fact they are part of the natural functioning of the human cognitive process. There has been behavioral change in agriculture. Firstly agriculture become 'Smart' by acquiring the behavior like predictive ability, quick learning, decision making etc., and secondly, acquire those behavior that we associate with "Street smarts" like localized knowledge or know-how. How a system performs certain task or job is the measure of the general ability of an intelligent system. This article presents those attributes of intelligence viz. prediction, forecasting, stored memory, ability to learn, ability to recognize, etc. that find wide application in agriculture and allied sectors and also those attributes viz. smartness, innovation, imagination etc. that have wide scope of potential application biological systems.

Performance of dairying in NE region and policy intervention for mainstreaming smallholder's milk producers

Kh Rishikanta Singh*, LK Baishya and N Prakash

ICAR Research Complex for NEH Region, Manipur Centre, Imphal, Manipur

*Correspondence: *rishikanta.ndri@gmail.com*

Introduction

Dairy is the single largest contributor to the agriculture Gross Domestic Product (GDP) in the country. Our country is the world's single largest producer and highest consumer of milk. During 2012-13 milk production is estimated to be about 132 million tonnes (Basic Animal Husbandry Statistics 2013-14) and is growing at the rate of 4-5% per annum. Maximum quantity of the milk in India is produced by millions of smallholder resource poor farmers having one to three milch animals. About 70 million rural households of which about 75 percent are landless, marginal or small farmers are engaged in dairying. It contributes close to a third of the gross income of rural households and in the case of those without land, nearly half of their gross income. Since the last few decades our country has emerge from a milk deficit to milk surplus country. Though we are surplus in milk production, milk production and per capita availability in North Eastern Region is very less. The region is deficit in milk production and depends on milk and milk product imported from other states. The compound annual growth rate of milk production in the last decade *i.e.* form 2000 to 2010 was 3.74% for the country as a whole but for the NER it was only 1.27%. In view of these facts this paper is an attempt to examine the status and performance of Dairying in North Eastern Region and to frame suitable policy measures for development of Dairying in the region. To study the status and performance of Dairying secondary data has been used from various sources. To calculate the growth rate the average annual growth rate and compound annual growth rate has been used.

Since the year 2007 to 2012 at all India level, the number of cross bred cattle has increased at the rate of 4 percent. But in the NE Region except for Meghalaya, Mizoram, Sikkim and Tripura there has been a reduction in the number of crossbred animals. Overall there has been a negative growth of 1 per cent and number of crossbred animals has been reduced from 949 thousands to only 899 thousands. For local cow at all India level thought there has been a decline in the number, for NE Region the number of local cow remains almost same. In case of buffalo, there has been decline in the number from 643 thousand to 579 thousand which is in contrast compared to all India where there is an increase. A unique feature of milk production pattern in NE region is that more than 90 per cent of the milk is produced by cattle consisting of Local cow and cross bred cows. With respect to per animal milk productivity for local cow, Nagaland has the highest milk productivity with 1.86 litre per animal followed by Sikkim and Mizoram states. The lowest milk productivity has been recorded in Meghalaya with only 0.77 litre per animal per day. In case of crossbred cow, Meghalaya state has the highest milk productivity ie 8.98 litre per animal per day followed by Manipur (7.31 litre) and Arunachal Pradesh (7.28 litre). The lowest milk productivity has been recorded in Assam with only 4.05 litre. Interestingly the milk productivity of Meghalaya, Manipur and Arunachal Pradesh is more than the national average i.e. 7.02 litre. In case of buffalo, Sikkim has the highest milk production followed by Nagaland and Manipur but the productivity in all the NE region is far less than the national average ie 4.80 litre.

With regard to the milk production, the total milk production of NE region is only 3.25 million tonnes while for all India level it is 132 million tones. The milk production of the region constitutes only 2.45 per cent of the total milk production of the country. Assam is the highest milk producing state with a production of 800 thousand tonnes of milk followed by Tripura (118 thousand tonnes) and Meghalaya (80.52 thousand Tonnes).On the other hand Mizoram has the lowest milk production producing only 13.63 thousand tones. As per BAHS 2013-14 the overall per capita milk availability of the country is 299 grams per day which is far above the nutritional requirement of 220 grams per capita per day recommended by Indian Council of Medical Research (ICMR). But in case of NE region, all the states have per capita milk availability far below the national average, ranging from 186 grams for Sikkim to only 36 grams for Mizoram. This shows that there is lot of disparity in milk availability in the country though we are surplus in milk production.There has been a very poor and erratic trend in milk production in the region over the years in the last few decades. In some years the milk production is high while in subsequent years there is a sudden fall. In order to make up the deficit and to uplift overall sector dairy a thorough policy planning is required right from the grass root stage i.e. dairy farmers up to the top level by incorporating all the stakeholders.

Policy intervention for mainstreaming smallholder dairy farmers in NE region

Dairy production and consumption improve overall welfare of the small milk producers by addressing their income, employment and nutritional requirements. To improve the production capacity of small holders, the policy interventions are required at two points- one, to strengthen the public veterinary services and another is to target breeding program at small holders. The veterinary services include artificial insemination (AI), animal health care including vaccination and veterinary extension. These services are provided by public animal health department, cooperative unions and private veterinarians. The animal health department provides services through veterinary dispensaries, AI centres and sub-centres, veterinary polyclinics and first aid veterinary care centres. The breeding programme is comprised of AI, crossing with exotic breed, distribution of better quality semen, and upgradation of local breeds. The breeding programme generally lacks breeding policy. A formulation of a breeding policy targeted at small farmers where more emphasis is required on upgradation of local high milk producing breeds and improving their reproductive performance.

The major share of the milk (80%) is marketed through unorganized sector and the rest by the organized sector. The orientation of the organized sector in favour of small producers is in the interest for long run. In the event of many unsuccessful cooperatives in the country, other models of dairy farmer organizations are being explored, such as mutually aided cooperative societies (MACS) and producer companies. The policy issues are related to reduction of high transactions costs involved in market participation of smallholders. The analysis recommends better institutional support, improved milk storage and transportation facilities to avoid milk losses and quality deterioration (which are approximately 3%).

Majority of the dairy farmers depend on seasonal grasses to feed the dairy animals. But during winter and summer season there is acute shortage of fodder. And these pose a threat especially for framers rearing high yielding animals. Suitable fodder bank should be developed and good quality nutritious fodder crops should be grown. Also concentrate feed should be made available to farmers at reasonable price.

Knowledge level of the trainees under different trainings on farming practices of Rohilkhand region in Uttar Pradesh

KL Meena[1]*, P Chowdhury[1], Manoj Kumar[1] and BC Deka[2]

KVK, Longleng, Nagaland

[2]ICAR Research Complex for NEH Region, Jharnapani, Nagaland

Correspondence: drklmeenakvk@gmail.com

Introduction

The main objective of a training programme is to bring about a desired change in the trainee. According to Ebel *et al.* (1991), this change, if it is important, must make an observable difference in the behaviour, *i.e.* under the same circumstance, a person who has more of training must behave differently from a person who has less of it, or not had it at all. Thus the main problem is that of making training effective. The KrishiVigyan Kendra (KVK) is meant to be an innovative science based institution which under takes vocational training of farmers, farm women and rural youths, conducts on farm research for technology refinement and frontline demonstrations to promptly demonstrate the latest agricultural technologies to the farmers as well as the extension workers. It acts as a technology transfer centre. The KVK functions on the principles of collaborative participation of scientists, subject matter experts, extension workers and farmers. IVRI, KVK, Izatnagar organizes trainings on subsidiary occupations like Pig farming, Fish culture, Health care of animals, Bee keeping, Poultry, Dairy, Mushroom cultivation, Horticulture and Vegetables and production of hybrid seeds of different crops, which increase the income of farmers. Besides these, other training related to Home Sciences like, prickle preparation, interior decoration and Artificial Insemination, Progeny diagnosis are also organized by this institute.

Methodology

The study was conducted in Rohilkhand region of Uttar Pradesh. The state has a geographic area of 29.44 million ha which is about 9% of the land area of the country. It lies between lat. 23º 52' and 31º 28' N and long. 77º 5' and 84º 38' E. total animal population in the state is 661 lakhs (1988). The IVRI, KVK Izatnagar, Bareilly organized various training programme on different aspect of agricultural science. In this study we includes training programme organized between 2002 to 2007 during this five years more than 10 training programme were conducted at KVK in each subject/ topic as listed 1) animal husbandry 2) Horticulture, 3) fishery science, 4) IPM management, 5) INM management, 6) home science, 7) piggery farming and 8) fodder cultivation and production. In this way only 8 training programme was included in the study. In order to have accurate and valid information an exhaustive list of participants, who have been the beneficiaries of any of the training programme was made from each selected subject. Twenty five respondents from each subject were selected applying proportionate random sampling hence, total of 200 respondents were interviewed.

Results and Discussion

Result revealed that the majority of trainees gained knowledge regarding colostrums feeding (80.00%), prophylactic measures against FMD & HS (70.00%), balanced feeding for lactating cow (60.00%), cleanliness of calf (52.00%), cultivation of multi cut fodder crops (50.00%), pregnancy diagnosis (45.00%), scientific calf rearing practice (42.00%), clean milk production (40.00%), deworming of calf (40.00%) and other notable improvement in knowledge about technologies / practices like artificial insemination, cross breeding, balanced feeding of heifers, green fodder round the year, tick control, urea molasses straw treatment, improved breed of goat, stall feeding of goat, hay and silage feeding, full hand milking, preparation of balanced ration and management of common reproductive diseases.

Result indicates that important technology knowledge gained about crops science as expressed by the respondents were scientific management of summer pulses: mung and urd (33.00%), paddy nursery raising (36.00%), plant protection management in paddy & sugarcane(35.00%), cultivation of Rabi fodder crop: Barseem and Oat (35.00%), fertilizer management and weed control in wheat & sugarcane (25.00%), cultivation of Rabi oilseed *toria* (35.00), scientific cultivation of Rabi cereals : wheat (45.00%), plant protection in Rabi cereals (35.00%), scientific cultivation of sugarcane and ratoon management (50.00%), scientific cultivation of Rabi pluses: lentil (33.00%), paddy soil testing (40.00%), integrated pest management (40.00%), management practices of Sunflower cultivation (45.00%), Hay and silage making (30.00%), cultivation of *Kharif* season fodder crop (55.00%) and 45 per cent of farmers gained knowledge regarding management of *Kharif* season crops.

Result revealed that majority of respondents gained knowledge such as breast feeding (80.00%), proper grain storage practices (70.00%), and preparation of milk products (50.00%) and they were in 1st, 2nd and 3rd ranks, respectively followed by care of lactation mother (47.00%), wool knitting (42 per cent), care of pregnant women and care of one year old child each (40.00%). Some other notable home science practices were different stitches of embroidery, drafting, cutting & stitching of common garments, balanced nutrition in human diet, home gardening and food preservation, etc. as indicated in table.

Study revealed that trainees gained knowledge in topics like fish culture (70.00%), construction, renovation and cleaning of pond for fish culture (60.00%), composite fish culture (60.00%) and fish disease and its control (50.00%) were 1st, 2nd 3rd and 4th. ranks, respectively. Whereas common carp breeding and seed production, integrated fish farming, fish preservation and by products, net making, cat fish culture and Fish seed production and transportation were 5th, 6th, 7th, 8th, 9th and 10th ranks, respectively as know-how gained by the farmers.

Knowledge is a pre-requisite to the proper utilization of improved farming practices by the farmers, and is ultimately linked with the increased socio-economic status of the farmers. Therefore, it was thought essential to work out the knowledge level of farming operators. The data pertaining to the knowledge level of respondents regarding farming practices revealed that knowledge about animal science practices 41.00 per cent of respondents belonged to medium level of knowledge followed by 30 and 29 per cent belonged to low and high level of knowledge respectively. In case of crop science practices, 46 per cent of respondents belonged to medium level of knowledge, followed by 38.50 and 15.50 per cent belonged to high and low level of knowledge, respectively. Further, in case of home science practices 43.50 and 42.00 per cent of respondent had medium and high level of knowledge followed by 14.50 per cent low level of knowledge.

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Participatory evaluation of lentil in rice-fallow with residual in-situ soil moisture under different tillage practices

MA Ansari*, N Prakash, LK Baishya, Kh Sanatombi, Ch Bungbungcha and T Basanta Singh

ICAR Research Complex for NEH Region, Manipur Centre, Imphal- 795004

Correspondence: merajiari@gmail.com

Introduction

In North Eastern India, farmers grow rice during rainy season (June–September) and land remains fallow after rice harvest in the post-rainy season (November–April) due to lack of sufficient rainfall or irrigation facilities. But in valley area of Manipur, sufficient carry-over residual soil moistures are available in rice fallow in the post-rainy season (November–March), which can be utilized for growing second crops in the region. During the post-rainy season when irrigation facilities are not available and rainfall is meagre, effective utilization of carry-over residual soil moisture and conservation agriculture becomes imperative for second crop production after rice. Implementation of suitable tillage and other agro-techniques are thus very much important to achieve this objective.

Methodology

The study was conducted at Sekmai Hijam Khunou, Sabaltongba and Haokha village of Thoubal district and Ngairangbam, Khumbong, Kamong village of Imphal West district during two post-rainy seasons (2013-14 and 2014-15). The region belongs to central valley region of Manipur, where cropping season is mainly confined to rainy season. The total rainfall was 1628.7 mm and 1445.2 mm in 2013-14 and 2014-15, respectively. The maximum amount of rainfall, 74 and 78% occurred during May –September, in 2013-14 and 2014-15, respectively. During the experimental year, the mean monthly maximum temperature of the region ranges from 35.9 ^{0}C in May and July to 19.5 ^{0}C in January. On the other hand, mean minimum temperature varies from 23 ^{0}C in May to 0-3 ^{0}C in December. We started with 162 farmers in first year and reduced the number of farmers to 81 in second year. Each year, some of the original farmers discontinued the trials due to personal reasons or because they decided to use land for other purposes, while some new farmers showed interest and joined the trials as latecomers in same location. However, required number of farmers was maintained for the replication (farmers) variation under each treatment in both years. Data from these farmers grouped into three cluster based on sowing was done during 1st-5th November (CS I), 15th-20th November (CS II) and 1st-5th December (CS III) as first, second and third cluster, respectively. After harvesting of rice, the land was prepared under different tillage practices viz., reduced tillage (one ploughing) (RT), conventional tillage (CT), zero tillage (ZT) to grow second crops in rice fallow. The on farmer's field trial was conducted in split plot design. Grain and straw yields of lentil were determined from 20 m^{2} in the centre of each treatment plot in the farmers' fields.

Results and Discussion

The highest mean grain yield of lentil was recorded, when it was sown during CS I (682.55 kg ha^{-1}) followed by CS II (651.8 kg ha^{-1}), which were significantly higher than CS III (525.6 kg ha^{-1}). Under the tillage effect, the mean maximum grain yield was recorded under reduced tillage 715.5 kg ha^{-1} followed by ZT (639.8 kg ha^{-1}) and minimum yield was recorded with CT (504.7 kg^{-1}). On an average, first cluster sowing (1st -5th Nov.) gave maximum net returns of 25193 INR ha^{-1}, which was about 82% higher than CS III (1st -5th Dec.) and 66% higher than CS II (15-20th Nov.). This I cluster sowing also provided significantly higher INR per INR invested (1.93) than that of the III cluster sowing (1.48) (Table 1). Under tillage methods, RT enhanced more mean net returns by 27708 INR than ZR (24999 INR) and CT (9777 INR), respectively. Participating farmers were selected based on their willingness, interest, and their commitment to participate in multi-year on-farm trials by agreeing to follow the trial protocols and to provide in-kind contribution (i.e., family labour, land, etc.).

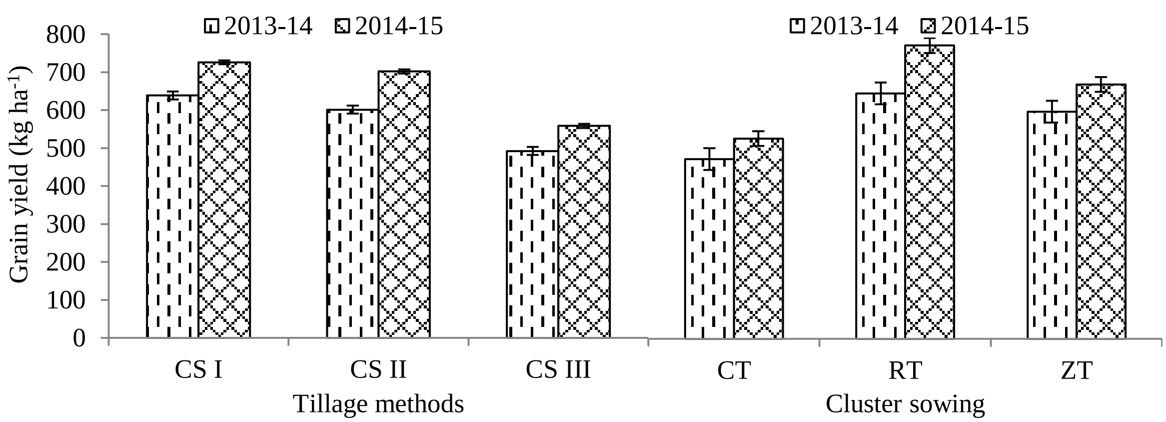

Figure 1. Effect of cluster sowing on various dates and tillage on grain yield of Lentil

Study revealed that 60.6, and 84.9 mm winter rainfall (November to March) occurred in 2013-14 and 214–2015, respectively, which have played a crucial role in the establishment and growth of second crops along with carry-over residual soil moisture. From the weather analysis of two study years it was reflected that actual weather parameters were close to normal weather of the region during the post-rainy season. The study revealed that cluster of sowing on different dates and tillage had a significant effect ($P < 0.05$) on grain yield of second crop (lentil) grown in rice fallow during the post-rainy season (Figure 1). Repeated ploughing under conventional tillage system might have favoured rapid depletion of soil moisture and as a result, less moisture was available in the field in later part of the growing period under this CT treatment. Higher grain yield from second crops in rice fallow was achieved with reduced tillage than that of no tillage by earlier workers (Kar *et al.* 2004). Simultaneously, RT gave higher net returns and B: C ratio as compared to CT due to more combined yield with nearly lesser cost of cultivation (Kar and Kumar 2009).

In another hand, the present study demonstrated the potential to incorporate lentil into the rice fallow system, i.e., post rainy season for rainfed agriculture, where moisture is the scarce input. The date of maturity of rice is dependent on the rice cultivar and rainfall pattern, which is variable. In turn, the timing of the harvest of monsoonal rice and underlying soil moisture content determine when the land is available to sow the following lentil crop. Time of sowing is very important for lentil growth to maximize yield. Specifically, in the North-Eastern plain zone the yield was reduced by 20% when sown in mid-December and by 65% when sown in late December, compared to the optimum mid November sowing. In the same way we have found that, due to one month delay (from 1st November) to 1st December, 82% yield was penalize, while 15 days delay reduced 66% yield as compared to sowing on 1st November.

The yield of second crop was enhanced when tillage was applied after harvesting rice which might be due to improved physical conditions of the soil. The highest yield was obtained with RT treatment than that of CT which might be attributed to better land preparation and more penetration of rainwater in RT treatment. On the other hand, sowing of lentil during 1st to 5th November was more profitable than delayed sowing.

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Performance of frontline demonstration on *kharif* rice in Garo Hills, Meghalaya

M Mokidul Islam* and T Samajdar

ICAR Research Complex for NEH Region, Umiam, Meghalaya

Corresponding author: mislam01d@yahoo.co.in

Introduction

Rice is the major crop and stable food as well as the means of livelihood security for small and marginal farmers' and farming community in Garo Hills of Meghalaya. The productivity of sali rice in GaroHills district of Meghalaya is lower than the national average. It is attributed to use of tall, long duration traditional varieties, improper method of sowing and transplanting, inappropriate management practices, rainfall condition, climatic aberrations, insect pest, diseases and less use of other resources in rice cultivation. Even under favourable conditions, the productivity of rice in this part of the country is nearly stagnant and the farmers in North- East India in general and Meghalaya in particular are losing interest in rice cultivation as its profitability is declining with the rise in input costs.

The productivity of sali rice could be improved by using high yielding varieties following improved management of soil, water, weeds, organic nutrients and other resources. Thus, there is a need to adopt new technologies including high yielding varieties for higher productivity and income to reduce the wider gaps. So, the present study was undertaken to study the production potential of high yielding varieties in Garo Hills through front line demonstrations (FLDs).

Methodology

The present investigation was carried out five years from 2011 to 2013 during kharif season in 22 different villages in five different blocks viz., Rongram, Selsella, Betasing, Dalu, Gambegre and Zikzak in West and South West Garo Hills district of Meghalaya. Materials for the present study comprised of three HYV varieties of Sali rice viz., Ranjit, Swarna Mahsuri and Gomati. Locally popular Champali was used as local check. Each demonstration plot was 0.44 ha and full package of practices with recommended dose of fertilizer 60: 60: 40 kg NPK/ha was applied. The frontline demonstration (FLD) was conducted to study the technology gap, extension gap and the technology index. In the present evaluation study, the data on output of rice cultivation was collected from the FLD plots, besides the data on local practices commonly adopted by the local farmers of this region were also collected. To estimate the technology gap, extension gap and technology index, formulae given by Samui *et al.* (2000) had been used.

1. Technology gap = Potential yield – Demonstration yield
2. Extension gap = Demonstration yield – Farmers yield
3. Technology index = [(Potential yield – Demonstration yield)/ Potential yield] x 100

Results and Discussion

The highest yield of 5.02 t/ha was recorded under FLD plots of variety Gomati during 2011 (Table 1) with three consecutive years average yield of 4.71 t/ha. However, among the four varieties tested, Gomati produced highest average yield of 4.96t/ha. The results indicates that the front line demonstration has given a good impact over the farming community of Garo Hills as they were motivated by new agro-technologies applied in the demonstration plots. The high yielding varieties of rice performed extremely well when compared with local check variety Champali. The percentage increase in yield was 68.89, 73.64 and 77.0 in Ranjit, Swarna Mahsuri and Gomati, respectively with average increase of 73.18 in yield of three HYVs (Table 2).

The technology gap which corroborates to the gap in demonstration yield over potential yield ranged from71 kg/ha for Ranjit to 544 kg/ha for Gomati. The technology gap observed may be attributed to dissimilarity in soil fertility status and weather conditions. Hence, location specific recommendations appear to be necessary to bridge the gap between the yields of different varieties. A very wide gap was recorded in yield of demonstration variety and local check variety of Champali. The highest extension gap was found in the variety Gomati, closely followed by Swarna Mahsuri and Ranjit which emphasized the need to educate the farmers through various means for adoption of improved high yielding varieties and improved agro-technologies to reverse the trend of wide extension gap. More and more use of HYVs by the farmers may subsequently change this alarming trend of galloping extension gaps. The technology index showed the feasibility of evolved technologies at farmer's field (Table 2). The lowest technology index of 1.48 for the variety Ranjit and highest technology index of 9.89 with Gomati. But the range of technology index showed that the gap of new technologies evolved at research stations and farmers' field was 1.48 to 9.89percent (*Mitra and Samajdar* 2010), who opined that lower the value of technology index, more is the feasibility of the technology demonstrated. The technology index indicated that the Ranjit variety of sali rice had performed its optimum under the Garo Hills condition and this will accelerate the newer varieties to increase the productivity of rice in Garo Hills condition. One of the main reason associated with the non-replacement of local varieties are their taste and aroma as well as adaptability to climatic aberrations, but the gross as well as net return was higher in high yielding varieties because their exist wider yield gap of 19.29 to 21.56 q/ha.

The higher net returns of Rs. 32972/ha was fetched by the Gomati variety closely at par with Swarna Mahsuri variety which might be due to higher productivity. The benefit cost ratio was also recorded higher in Gomati followed by variety Swarna Mahsuri and Ranjit.

Table 1. Mean performance of HYV Rice (q/ha) pooled over different locations in Garo Hills

Rice varieties	2011	2012	2013	Pooled
Ranjit	48.00	47.50	46.37	47.29
Swarna Mahsuri	49.81	48.15	47.54	48.62
Gomati	50.18	48.57	49.93	49.56
Champali (Local check)	30.0	28.3	25.7	28.00

Table 2. Productivity of rice, yield gaps and technology index

Rice varieties	Demonstration (No.)	Productivity (kg/ha)			% increase over check	Technology gap (kg/ha)	Extension gap	Technology index
		Potential	Demonstration	Local check				
Ranjit	45	4800	4729	2800	68.89	71	1929	1.48
Swarna Mahsuri	10	5000	4862	2800	73.64	138	2062	2.76
Gomati	6	5500	4956	2800	77.00	544	2156	9.89
Total/Avg	66	5075	4849	2800	73.18	251	2049	4.71

The high variability in rice yield was observed among farmers even in homogeneous domains. The high yielding varieties of rice performed extremely well in Garo Hills when compared with local check variety Champali. The highest extension gap was found in the variety Gomati followed by Swarna Mahsuri and Ranjit which reflects the need to educate the farmers through various means for adoption of improved high yielding varieties and improved agro-technologies to reverse the trend of wide extension gap.Identification of problems/causes for such gaps and development of possible mitigation measures and minimize the knowledge gap between researchers, extension staff and farmers by developing and using viable mechanisms to transfer new knowledge and techniques from researchers to farmers and collect feedback to re-orient research on issues critical to farmers.

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Farmers' perception about agricultural advertisements in leading newspapers in Siang Province, Arunachal Pradesh, India

PC Jat[1], AKTripathi[1] and Manish Kanwat[2]

[1]*ICAR –ATARI-III, Umiam, Meghalaya*

[2]*KVK Anjaw, ICAR RC for NEH Region, AP Centre, Basar, Arunachal Pradesh*

Agricultural extension, being a specialized form of adult education in agriculture is an educational process. It is mainly a communication process between extension agents and rural dwellers. It is very useful for involving rural dwellers in the agricultural development process, to teach them better farming practices with the aim of increasing their productivity and enhance their standard of living. Being mainly communication process, it requires efficient communication process. Agriculture is becoming increasingly information intensive. At the same time, information and communication technology provides a range of sophisticated methods for enhancing communication with farmers. But much work remains to assess the effectiveness and feasibility of various communication strategies. Although electronic media are playing an ever more important role in agricultural communication, print media will surely remain an important source of agricultural information in many parts of the world for some years to come. It is important to assess the degree to which media such as newspapers and magazines can play an important role in fostering the diffusion of useful information to farmers. Emphasized that leading newspapers editors place more importance on national, regional and local politics, spicy news of big personalities of the country and revenue generating content than agricultural subject matter, which is necessary in stimulating development of farmers. Farmers who read newspapers and farm magazines are more likely to adopt more of all types of improved practices than those who do not. This can have effect on their perception of such advertisements. The newspaper has pioneered the idea of encouraging farmers to regard themselves as sources of material and as authors of articles, and operates with the philosophy that farmers are most interested in hearing about the experiences of their counterparts rather than the formulaic recommendations of 'experts'.

The study area is Siang province. Multi stage sampling was used to select sample for the study. Firstly, all the three Siang districts were selected for sampling. Secondly, a list of literate farmers was obtained from the local government offices from where thirty percent of the farmers were randomly selected to represent the sample population for the study. A list of four hundred and one (401) farmers was obtained from the local government office and out of that thirty percent (30%) of the farmers were randomly selected for study purpose. A structured questionnaire guide containing open and close questions was used to elicit information from the respondents. The result of the analysis revealed that majorities (79.50%) of the respondents were in 30 to 50 years, it means that they are in their productive age. The results also show that 83.00% of the farmers are married indicates that the farmers have responsibilities for their families hence the need to seek for newspaper agricultural advertisements so that it can boost their production and also their sale. The results have also reflects that 67.2 per cent of the respondents were literacy level above primary education. 78.6% of the farmers practiced farming as prime occupation, appreciable number (27.5%) have above 26 years farming experience. Quite high (63.11%) level of readership is recorded among respondents reads newspaper, this is an indication of the high literacy level among the farmers. This means that the farmers are conversant with newspaper content and they are more likely to see and read agricultural advertisements placed in the newspapers and respond to the advertisements. Respondents' perception and attitude (66.4 and 74.6%) were favourably disposed to advertising respectively. The inferential statistics analysis shows education (chi-square=21.07:$p \leq 0.01$) significantly related with respondents' perception of agricultural advertisements. However, marital status (chi-square=10.48; $p \geq 0.57$) and farming experience (chi-square=25.25; $p \geq 0.11$) were not significantly related. Correlation analysis of farmers attitude and perception of agricultural advertisements in newspapers was found to be significant($r=0.385$; $p \leq 0.000$). The results revealed that farmers' educational level and primary occupation have influence on the perception of farmers to agricultural advertisements in leading newspapers of the Siang province of the Arunachal Pradesh.

Factor influencing the farmers to likelihood of access different enterprises under farming system in Tripura

Pampi Paul* and B.S.Meena

ICAR-National Dairy Research Institute, Karnal

*Correspondence: pampindri@gmail.com

Introduction

Economy of Tripura is predominantly rural and agriculture oriented where Agriculture has 22.10 per cent share in State domestic product in the year 2013-14 (indiastat.com). But the declining trend in the average size of the farm holding poses a serious challenge to the sustainability and profitability of the farming community. It is imperative to develop strategies and agricultural technologies that enable adequate employment and income generation for the farming community. Under the gradual shrinking of land holding, it is necessary to integrate land based enterprises like fishery, poultry, duckery, apiary, field and horticultural crops, etc. within the bio-physical and socio-economic environment of the farmers to make farming more profitable and dependable (Behera *et al.*, 2004). In North-east India also not an exception of it, with the different crop cultivation dairy, piggery, poultry and fishery also plays an imperative role as important accompanying options of livelihood for small and marginal farmers of the state who constitute more than 90 per cent of the total farming community of the state which helps them to get year round earning and to sustain. Hence, a study was conduct to assess the factors affecting the choice of combination of enterprises to follow by the farmers under integrated farming system.

Methodology

The study was conducted in Tripura, one of the North-eastern states of India and for this ex- post facto research design was followed. Basically crop and vegetables farming were common to all of the respondents, therefore analysis was carried out based on the collected data to assess the factors influencing to make choice of combination of different enterprises by the respondents under their farming system and for that multinomial logit model was applied. For this study, total 100 farmers were interviewed with the help of pretested structured interview schedule. For the multinomial logit model the following formula was applied.

$$P\left(y = \frac{j}{x}\right) = \frac{\exp\left(x\beta_j\right)}{[1 + \sum_{h=1}^{j} \exp\left(x\beta_h\right), j = 1, \dots, j}$$

Where βjis K x 1, j=2..........J.

The estimated coefficients of the Multinomial logit model give only the direction of the effect of the explanatory variables on the dependent variables; they do not represent actual magnitude of change or probabilities. But, the marginal effect from the MNL, measures the expected change in probability of a particular choice.

Results and Discussion

The majority of the respondents belonged to middle age (35-50 years) and falls under primary and middle level of education. Majority of the respondents in the region had medium (5-8 members) family size. The study found that 93 per cent of the total respondents were marginal farmers in which 77 per cent of them had more than 5 years experience in integrated farming systems. The integrated farming system is a kind of approach which is able to give year round income generation and the annual income of majority (57.00%) of respondents varies from Rs. 143400-184890 of the respondents. Crop and vegetable farming were general to all respondents of the study, so other than these dairy, piggery, poultry and fishery were vital enterprises which were playing a important role in livelihood of the farmer, hence nominally enterprises were categorised (from where more than 15 per cent of annual income were coming). Here, the different socio-economic variables such as age, family education status, land holding, experience in farming and utilisation of source of information are were considered as explanatory variable and the result shows that out of 5 different explanatory variables, two variables to dairy based system, three variables to pig-fish base system, two variables were affected to pig base system and only one variable to poultry based farming were found to affect the choice of combinations to follow under farming system.

Table 1. Multinomial logit regression on choice of enterprises of farming system

Independent Variables	Coefficient Estimates				Marginal effect			
	Dairy based	Pig+Fish based	Pig based	Poultry based	Dairy based	Pig+ Fish based	Pig based	Poultry based
Age (years)	0.13 (0.011)*	0.08 (0.53)	0.06 (0.02)**	0.12 (0.059)	0.01	0.04	0.01	0.02
Family Education Status	1.06 (0.12)	-1.19 (0.032)**	-1.63 (0.0671)	-0.34 (0.47)	0.03	-0.09	-0.14	0.01
Experience in IFS	-0.08 (0.03)**	-0.23 (0.28)	0.30 (0.144)	-0.62 (0.581)	-0.03	0.00	-0.01	-0.04
Land Holding	-7.57 (0.00)	0.91 (0.024)**	1.25 (0.56)	0.58 (0.005)*	-0.28	0.24	0.24	-0.18
Utilisation of source of information	2.36 (0.38)	2.10 (0.068)	1.28 (0.16)	-3.13 (0.28)	-0.14	0.20	0.08	-0.04

** Indicates significant at 5 % level of significance, in a two tail test* Indicates significant at 10 % level of significance, in a two tail test

The marginal effect shows that the likelihood accessing to dairy based farming system increases by 1 per cent for an increase in age of the respondents and in case of pig-fish based farming system the marginal effect shows that the likelihood accessing to pig-fish based farming system decreases by 9 per cent for an increase in family education status of the respondents. Again, the marginal effect shows that the likelihood accessing to pig-fish based farming system increases by 24 per cent for an increase in land holding of the respondents in the study area. Hence it has found that as apart from crop and vegetables cultivation dairy, poultry, piggery and fishery remain as critical source of livelihood for the farmers of the state on the other hand there are some social or economical belongings which are directly or indirectly influencing the choice of include any particular enterprise by the respondents under their particular farming system.

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Indigenous knowledge and improved practices in large cardamom cultivation in Sikkim

R Gopi*, RK Avasthe, Ashish Yadav, H Kalita, M Singh, SK Das and Chanda Poudyal

ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok

*Correspondence: ramaraj.muthu.gopi2@gmail.com

Introduction

Sikkim is a small multi-ethnic state, located in the Eastern Himalayas covering a geographical area of 7096 sq.km, representing a meager (0.22%) portion of India's geographical area (Rahman and Karuppaiyan 2011). The State is divided into four districts, North, West, East and South. Sikkim, constituent state of Northeastern Region of India has a diversified ecosystem. Great diversity is found in most of the food crops and large part of the arable land is planted with local cultivars. Large Cardamom (*Amomum subulatum*), a member of Zingiberaceae family is one of the main cash crops cultivated in Sikkim and Darjeeling District of West Bengal covering an area of about 26,060 ha. In recent years, there has been a gradual decline in yield of large cardamom. Various factors such as., pests and diseases, poor plantation management, lack of sufficient irrigation during winter months, migration of farmers to urban areas and change in climate have been attributed to this yield decline in large cardamom. Traditional or Indigenous Technical Knowledge (ITK) is the actual knowledge of a given population that reflects the experiences based on tradition and includes more recent experiences with modern technologies (Atte 1989). This study aimed at collection of various information on indigenous large cardamom cultivation practices and effect of improved practices on disease incidence and yield characters of large cardamom.

Methodology

During survey for insect pests and pathogens associated with various crops cultivated in Sikkim, information on indigenous methods used for large cardamom cultivation adopted by the farmers were collected. Simple questionnaire and participatory rural appraisal (PRA) tools were used to collect the information. The study was carried out in different villages of Sikkim. The survey included group and individual interviews of farmers in villages and officials in State Agriculture Department. More than 100 farmers from different communities with varying age group were interviewed during 2013-15 to record information about ITKs on large cardamom cultivation in Sikkim. In addition, various literatures were surveyed to know the ITKs used large cardamom cultivation.

Results and Discussion

In the study, it was found that farmers plant large cardamom in the months of May to October. Weeding is done only twice a year during flowering and harvest. Only 30% of farmers go for irrigation. Flowering starts in the month of April and farmers are of the opinion that irrigation should be stopped during flowering and that will lead to rotting of capsule. The harvesting period varied from September to October. Although there are number of diseases, farmers know only about two diseases i.e, chirkey and foorkey. The shoot fly infected tillers are locally called as foolangey by the farmers. The traditional bhatty system is more prevalent among the farmers. There are many ITKs like use of botanicals, lime, kerosene for the management of pests and diseases in Sikkim. In large cardamom, farmers use only cow urine, wood ash for the nutrient management and also for the management of pests and diseases. Storage period of large cardamom lasts for 3-4 years. Farmers, traditionally use Dhikuti, bhakari, jute bag for large scale storage whereas they use cloth bags for small scale storage. At ICAR Sikkim Centre, A field study was conducted to study the effect of shade, irrigation and other improved management practices on plant growth characters and disease incidence. It was found the plants with maximum height (190 cm) and highest number of flowers (38.8) and maximum yield was obtained in partially shaded areas whereas the plants with minimum height (46.8) and lowest(12) number of flowers and lowest yield was found in open area. Incidence of blight was very low (0.4%) in completely shaded areas whereas the incidence of blight was high (22.4%) in open area. The blight incidence in partially shaded areas was 2.6%. The maximum number of tillers was found in open area (30). Irrigation also improved the yield and other characters in large cardamom. In the study, it was also found that water stress and planting in open conditions without any management makes the plant susceptible to blight disease caused by *Colletotrichum gloeosporioides*.

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Cost-benefit analysis of tomato cultivation: A case study in Meghalaya

Ram Singh*, Koijam Johny Singh[1], Deotrephy K Dkhar[2], Damewan Muliar[3], Sanchita Roy[4] and SM Feroze[5]
College of Post Graduate Studies, CAU, Umiam, Meghalaya
*Correspondence: ramsingh.cau@gmail.com

Introduction

Tomato (*Lycopersicon Esculentum L)* belongs to Solanaceae (the Poisonous Nightshade family). The agro-climatic condition in Meghalaya is favourable for the cultivation of vegetables throughout the year. It was initially felt that tomato could not be cultivated during summer months in the high altitude regions due to heavy blight infestation. However, formulation of a spray schedule has been successful in controlling the disease. This advantage is reflected in good prices fetched by vegetables during the off-season. Any rejection and adoption of the crop in the region depends upon its cost and return. Keeping the economic importance of the tomato in view, the present study is an effort to assess its cost-benefit to make it more commercialize in the state.

Methodology

The present study was conducted in East Khasi Hills and West Jaintia Hills districts (carved out on 31st July 2012 from jaintia hills district) of Meghalaya as it has the highest area under tomato. A sample of 200 farmers comprising of 100 number of tomato growers each from West Jaintia hills and East Khasi hills district was selected. The primary data on cost and price of input and output of tomato crop were collected through well-structured pre-tested schedule by means of personal interviewed method.

Results and discussion

Cost A_1, hired labour worked out to be highest (₹61645.05/ha) followed by farm yard manure, fertilizer, plant protection chemical, seed, interest on working capital and depreciation. Cost A_1, Cost A_2 and Cost B_1 (₹109970.70/ha) worked out to be equal as there was no leased in land and fixed assets excluding land. Cost B_2 worked out to be ₹ 121970.70 per ha, Cost C_1 worked out to be ₹ 205530.98 per ha and Cost C_2 found to be ₹ 217530.98 per ha. Fertilizer, Application of plant protection chemical and labour found to be significant at one percent of level of significance Table 1. Output-input ratio over total cost worked out to be 1.65 and ratio over paid out cost worked out to be 3.27, hence, tomato cultivation is profitable crop. The GFI was calculated to be ₹359341.7 per ha. Net return including family labour and net farm income worked to be same (₹141810.76/ha). Net return including family labour and family level income calculated to be same (₹237371.04/ha). Farm business income worked out to be ₹249371.04 per ha, and farm investment income worked to be ₹153810.76 per ha. Therefore benefit from the crop should be realised among the farming community to encourage its cultivation. At the same time, initiation of sound price policy of inputs, outputs, establishment of processing and storage unit are needed.

Table 1. Benefit cost ratio analysis of tomato cultivation

Output/input ratio over	
i)Total cost(Gross income/CostC_2)	1.65
ii) Paid out cost (Gross income/CostA_1)	3.27
Returns over cost	₹/ha
Gross farm income	359341.74
Net return including family labour	141810.76
Net return excluding family labour	237371.04
Farm business income(GFI-CostA_2)	249371.04
Family level income(GFI-CostB_2)	237371.04
Net farm income (GFI-CostC_2)	141810.76
Farm investment income (Farm business income-wages of family labour)	153810.76

Enhancing rice productivity through demonstration of System of Rice Intensification method of rice cultivation in Bishnupur District, Manipur

RK Imotomba* and Sakhen Sorokhaibam

Krishi Vigyan Kendra, Bishnupur District, Manipur

*Correspondence: imotombadrrajkumar@gmail.com

Introduction

Manipur, one of the seven sisters of the North Eastern Region of India, is an isolated hill-girt state stretching between $92^0$58'E to $94^0$45'E longitudes and $23^0$50'N to $25^0$42'N latitudes. The economy of the state being primarily dependent on agriculture, emphasis has been given on augmenting agricultural production of the state. Agriculture sector contributes a major share to the total state domestic product and provides employment to about 52.19 percent of the total workers in Manipur. Rice is the major pre-dominant staple food crop of Manipur, covering an area of 68.66% of the total cropped area in 2003-04 as against 70.15% of the total cropped area in 2002-03 producing about 71.88% of the total food grains in the state. The estimated area and production of rice during 2007-08 was 166.15 thousand hectare and 406.15 thousand tonnes respectively. Bishnupur District had the highest production of rice with 90.94 thousand tonnes (22.39 percent).

Thus, Sytem of Rice Intensification (SRI) needs to be compared with conventional method of rice cultivation in order to elucidate the parameters contributing for yield determination under system of rice intensification method.

Hence, a front line demonstration was carried out in farmer's field of Bishnupur district to evaluate SRI in comparison to the traditional system of rice cultivation.

Methodology

Front Line demonstration comparing SRI and conventionally transplanted rice (CTR), were conducted during *kharif* seasons of 2009 and 2010 at farmer's field of Kabowakching village of Bishnupur District, Manipur. Experiment was conducted in split-split plot design by assigning water regime in main plots, age of seedling in sub-plot and plant spacing in sub-sub-plot and was replicated thrice. The rice variety was RCM-9. Henceforth, for convenience, transplanting of younger seedlings will be referred as SRI and transplanting of older seedlings as CTR (Conventionally Transplanted Rice). SRI was transplanted at about 2 leaf stage i.e. 8 days old and transplanting of seedlings in CTR was at about 3-4 leaf stage i.e. 25 days old. The plots were dug manually with spades to about 15 cm depth, submerged with water and puddle with a power tiller. The recommended dose of fertilizer (60:40:30 kg NPK/ha) was applied through urea, single super phosphate and muriate of potash. Nitrogen was applied in three splits at planting time, at maximum tillering stage and seven days before panicle initiation, while entire phosphorus and 50 % potassium were applied as basal. Remaining potassium was applied at 20 DAP (Days after planting).

Transplanting was done at 20X10 cm and 25X25cm plant-hill spacing, with one seedling/hill for 8 yrs old seedling and 3 seedlings/hill for 25 days old. In continuous flooding treatment, the rice plots were kept submerged under ±3 cm water layer for first 15 days and ±5 cm water layer during rest of the cropping season. In alternate wetting and drying treatment, the plots were irrigated to 2.5 cm depth after the formation of hair line cracks on the soil surface from planting to panicle initiation. And was drain out 15 days before harvesting. Need based plant protection measures were given whenever the incidences were more than economic threshold level. Economics was calculated based on the input and output prices.

Results and Discussion

Water regime, age of seedling and plant spacing exert significant influence on plant height of rice. Alternate wetting and drying produced significantly taller plant height than continuous flooding and also younger seedling recorded significantly taller plant height than older seedling. Between the two spacing tested, 25 X 25 cm led to significantly taller plant height than closer spacing. Vijayakumar *et al.* (2006) also reported taller plants with SRI (14-d old seedlings) than with conventional system of transplanting (21-d old seedlings).

Alternate wetting and drying have significant influence on no.of effective tillers hill^{-1} and effective tillers m^{-2} but did not exert any significant influence on filled grains panicle^{-1} and test weight. Sharma and Effective tillers hill^{-1} and effective tillers^{-2}, filled grains panicle^{-1} and 1000 - grain weight was significantly influenced by age of seedlings. SRI produced significantly higher yield attributes than CTR. Effective tillers hill^{-1} were significantly affected by plant-hill spacing but effective tillers m^{-2} were non-significant. The effective tillers hill^{-1} were higher at 25x25 cm (24.43) than at 20x10 cm hill spacing (7.78) by about 2.5 times; effective tillers m^{-2} on the other hand were not significant. Number of grains panicle^{-1} and 1000-grain weight were significantly affected by plant-hill spacing. Data pooled over two years and two water regimes indicated about higher grains panicle^{-1} (79.48) at 25x25 cm than at 20x10 cm (76.88). Similarly, 1000-grain weight was higher at 25x25 (23.43 g) than at 20x10 cm (22.30 g). Wider spacing favoured number of grains panicle-1 and grain weight probably through advantage of space, nutrition and sunlight. The water regime could not bring any significant effect on rice grain and straw yield. However, grain and straw yield was significantly influenced by age of seedling and spacing. Significantly higher grain (4.35 and 4.20 t/ha) and straw yield (5.82 and 5.67 t/ha) was recorded with SRI (8 days) and plant hill spacing at 25 x 25 cm, respectively (Table 1). Higher yield under younger seedling and wider spacing was mainly due to more number of effective tillers m^{-2} and grains panicle^{-1}. So, compared to farmer's practice of CTR with closer spacing, rice grain yield with SRI and wider spacing was higher by about 5% and 6.35% respectively. Alternate wetting and drying water regime registered highest net return and return per rupee investment compared to continuous flooding. Highest return and return per rupee investment were also recorded in 8 days old seedling as well as in 25 x 25 cm spacing.

Table 1. Effect of water regime, age of seedling and spacing on yield and economics of rice.

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Gross Return (Rs.)	Net Return (Rs.)	Return per rupee invested
Water regime					
AWD	4.13	5.67	50032	26730	2.15
CF	4.00	5.57	48491	25190	2.08
CD (*p*=0.05)	NS	NS	583	583	0.024
Age of seedling					
SRI (8 days)	4.35	5.82	50430	27128	2.17
CTR (25days)	3.78	5.41	48094	24792	2.06
SEm(±)	0.02	0.02	416	416	0.018
C.D.$_{0.05}$	0.08	0.08	1630	1630	0.071
Spacing					
20cm×10cm	3.94	5.56	47719	24662	2.07
25cm×25cm	4.20	5.67	50805	27259	2.16
CD (*p*=0.05)	0.07	0.10	798	798	0.052

AWD-Alternate Wetting and Drying, CF-Continuous Flooding, SRI- System of Rice Intensification, CTR- Conventionally Transplanted Rice

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Value-addition to Maize using an ITK in hills of Uttarakhand

RK Khulbe*, Salej Sood, RS Pal, Lakshmi Kant and A Pattanayak
ICAR-Vivekanand Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand
*Correspondence: rkkhulbe@gmail.com

Maize, a cereal crop cultivated widely throughout the world, is an important food staple in many countries. In India, maize is the third most important crop after rice and wheat in terms of area and production. Of the total maize produced in India, about 20 per cent is consumed directly in various forms, with *roti* (Indian flatbread) being the most common form. However unlike wheat, *rotis* made from maize flour fail to puff up due to absence of gluten in maize. A solution to this is provided by an ITK practiced by the local communities in the hills of Uttarakhand to impart puffability to finger millet (another non-glutenous crop) *rotis*. The ITK, which involves incorporation of powdered bark of Gethi (*Boehmeria regulosa*) tree in a definite proportion into the crop flour, was found to be effective with maize also, that is, the bark powder imparted elasticity to maize dough and puffability to maize *rotis* also. Though *Gethi* is a common tree in the low-mid altitudes of Himalayas (Uttarakhand to Bhutan, including North-Eastern region), the knowledge about use of its bark for improving bread making quality is very limited. Since the bark powder contains appreciable amounts of iron and health promoting nutritional factors, it has wider potential implications in nutritional amelioration of populations (in combination with QPM) in developing countries where protein and iron deficiency is prevalent. The TK has commercial potential as well and the use of this TK on commercial scale can play a significant role in livelihood enhancement of the holders of this TK.

Traditional system of yak rearing in the state of Arunachal Pradesh

S Deori*, Vijay Paul, Joken Bam and SM Deb
ICAR-National Research Centre on Yak, Dirang, Arunachal Pradesh
*Correpondence: sourabhd1@rediffmail.com

Introduction

Livestock is an integral part of any farming systems in India. In the high altitude yak (*Poephagus grunniens* or *Bos grunniens*) is one of the most remarkable domestic animals adapted to living under harsh conditions. The yak rearing system followed by highlanders is different from other livestock. They are usually reared under free-range system with zero input. It is a multipurpose animal adapted for living at high altitudes between 3,000 to 4,500 m above msl. It can even thrive at an altitude of 6,000 m above msl. They have good adaptation to the hypoxic condition of the high altitude as haemoglobin content is higher as compared to cattle. Red blood cells (RBC's) are larger in yaks (4.83µm) than local cattle (4.38µm) and RBC number is also higher, thus increasing its blood capacity to retain more oxygen (Zhang *et al.* 1994). A low pulmonary vasoconstriction and high oxygen affinity of haemoglobin (Weber *et al*. 1988) favours survival of yaks at high altitude. Therefore, a study was carried out with an objective to study the traditional system of yak rearing in the state of Arunachal Pradesh.

Methodology

A survey was conducted in the yak rearing tracts of West Kameng (Lubrang and Mandala) and Tawang (Sela and Zemithang) districts to assess the status of yak rearing practices. Door to door surveys were carried out to collect the data regarding traditional feeding, breeding and health status.

Results and Discussion

The surveys revealed that traditionally, the yak rearers practices two-pasture utilization strategy. During hot and humid season they migrate to high altitudes (8,500-14,000 ft. above msl) or even to the 16,000 ft. above msl when lush growing pastures are available. The summer pasture extends for about 190 days (May to October) and the winter pasture for about 138-150 days (November to April). The remaining period is spent on transit. The traditional system of yak rearing is to allow them to put on weight as much as possible in summer and utilize the fat as an energy reserve for survival in winter months, when there is scarcity of feed. The milk yield is reported to be highest during summer pasture when the grasses are at its best in terms of both quality and quantity. The puberty in female yaks are reported to occur at around 36-40 months of age and most of calve once in every two years or twice in three years. The age at first service is around 3-4 years and gestation period is about 258 days. Crossing male hill cattle with female yak is a common phenomenon. The F_1 males are called Dzo and the females as Dzomo. The hybrids are reported to be superior to yaks in performance and preferred by the yak rearers. It was recorded that yak suffers from disease mainly when they are in winter pastures at mid altitudes level. Many of the diseases have been transmitted may be because they often share the grazing land with the cattle and other livestock. Ecto-parasites (ticks) and leech infestations are reported to be the main problems. The major health problems encountered in yak tracts are FMD, Hemorrhagic septicemia, Black quarter, poisoning due to consumption of certain toxic plants, tympanitis etc. It was found that remoteness of the yak rearing tracts is the major problem to receive the preventive and curative measures to handle the diseases.

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Momentum of pigeonpea cultivation in Tripura- an economic analysis

Sujoy Hazari*, Debashish Sen, Biman De and Partha Das
All India Co-ordinated Research Project on Pigeon Pea- Tripura Centre,
College of AgricultureTripura, Lembucherra, West Tripura, India
*Correspondence: sujoy.eco@gmail.com

Introduction

Pigeonpea (*Cajanuscajan* (L.) Millsp.) is an important pulse crop in Indian agriculture. Agro climatic condition of Tripura (22° 56′ N to 24° 32′ N latitude, 91° 09′ E to 92° 20′ E longitude and 10 - 940 m MSL altitude) favours cultivation of Pigeonpea in the uplands in rain fed condition. Prolonged rainy days (May-September) and shallow water table supports cultivation of drought tolerant Pigeonpea with tap root system (Postel 2000). There are several desirable traits in Pigeonpea which separates the crop from other pulses and cultivation of the crop is feasible and profitable. In the present paper, increasing acceptance in terms of area, production and productivity of Pigeonpea by the farming community over last four decades is discussed. An attempt has also been made to quantify the cost components and study the economics of Pigeonpea cultivation in Tripura.

Methodology

The performance study is based on secondary data compiled from various published source. Data were collected from the Directorate of Economics and Statistics (DES), Ministry of Agriculture, Government of India. For the performance study, data were collected for 40 years period (1975-76 to 2014-15). The study period divided into three phases to identify the performance of the crops. As such, Period- I, Period II and overall period represented 1975-76 to 1994-95, 1994-95 to 2014-15 and 1975-76 to 2014-15 respectively. The performance of Pigeonpea crop was estimated by compound growth rate and coefficient of variation for the period I, period II and overall period of study. The compound growth rate was estimated using the exponential model.

$Y = a.b^t$

Where, Y is area, production and productivity, a is Intercept, b is Regression coefficient and t is time variable. From the estimated function, the compound growth rate was worked out by,

CGR (r) = [(Antilog (log b) – 1] x 100. Where, r is compound growth rate.

The economics of production of Pigeonpea was worked out by using Commission on Agriculture Cost and Prices (CACP) concept.

Cost A_1 = All actual expenses in cash and kind incurred in production by the producer. The items covered in cost A1 are costs on: i) hired human labour, ii) hired bullock labour., iii) owned bullock labour, iv) home produced/purchased seed, v) plant protection chemicals, vi) home produced/purchased manure, vii) fertilizers, viii) insecticides and pesticides, ix) depreciation on farm machinery, equipment and farm building, x) irrigation, xi) land revenue, land development tax and other taxes, xii) interest on working capital, xiii) interest on crop loan and xiv) miscellaneous expenses.

Cost B_1 = Cost A_1 + Rent paid for leased-in land + Interest on value of owned capital assets (excluding land).

Cost B_2 = Cost B_1 + Rental value of owned land (net of land revenue) and rent paid for leased-in land.

Cost C_1 = Cost B_1 + Imputed value of family labour.

Cost C_2 = Cost B_2 + Imputed value of family labour.

Cost C_2* = Cost C_2 + estimated by taking into account or actual wage rate whichever is higher.

Cost C_3 = Cost C_2* + 10 per cent Cost C_2* to (on account of managerial functions performed by farmers).

Results and Discussion

Overall growth rate of area under Pigeonpea was 4.23 per cent which was significant at 5 per cent level of significance this indicates that area under Pigeonpea is increasing over the years. As regard to period I the area under

Pigeonpea was 5.24 per cent which increased 5.93 per cent on period II. The result was in conformity with results obtained by Marawar *et al*. (2003).

Table 1. Compound growth rates of area, production & productivity of Pigeonpea in Tripura

	Compound Growth Rates (%)		
Particular	Period I: 1975-1994	Period II: 1995-2014	Overall: 1975- 2014
Area	5.24***	5.93**	4.23**
Production	8.1***	7.12***	5.95***
Productivity	2.71***	0.9*	1.58**

Note: *, **, *** significant at 10, 5, 1 per cent level respectively

Growth rate of Pigeonpea production for overall period was positive and significant being 5.95 per cent which is significant at 1 per cent level of significance. During period I and period II the growth rate was also positive and significant i.e. 8.1 per cent and 7.12 per cent respectively. The result was in conformity with results obtained by Sharma and Dupare (2013). Productivity is most important criteria in measuring the growth of any crop output. The success or failure of any improvement in the art of agriculture is measured by resultant increase or decrease in the productivity as seen in the Table 1 Pigeonpea productivity in Tripura for period I was positive (2.71 per cent) and significant at 1 per cent level, in period II indicated it was 0.9 per cent which was significant at 10 level of significance and at overall period the productivity also showed positive and significant (1.58 per cent) which indicated that increased in productivity of Pigeonpea. In variable Costs, the expenditure was highest on human labour (₹11,737.49), followed by fertilizer (₹2471.05), plant protection (₹2347.50) and manures (₹1166.64). Thus, human labour was main component of variable Cost. The rental value of land was major component of the overhead costs (2471.05). The total variable cost and the total fixed cost was found to be ₹20230.79 and ₹5489.77 respectively. The results are in conformity with findings of Singh and Singh (2001). The overall total cost on cultivation (Cost C_3) of Pigeonpea crop was found to be ₹25720.57 per ha, The Cost A_1 was found to be ₹18365.15 per ha, and share of Cost B_2 in total cost was 83.89 per cent. The Cost C_1 was 93.50 per cent of the total cost, which depicting a direct relationship with farm size. The study revealed that significant growth rate of area, production and productivity under Pigeonpea crop in Tripura over last four decades. Profitability of the crop in terms of gross return, net return and return per rupee endorse the future promotion of Pigeonpea cultivation in the state of Tripura.

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Knowledge, attitude and practice of different tribes of Garo Hills of Meghalaya towards scientific horticulture

Tanmay Samajdar*, Tarun Kumar Das, Biswajit Lahiri[1], AK Tripathi[2]

Krishi Vigyan Kendra, ICAR, Tura, West Garo Hills, Meghalaya
[1]*College of Home Science, CAU, Tura, West Garo Hills, Meghalaya*
[2]*ICAR RC for NEH Region, Umiam, Meghalaya*
*Correspondence:tsamaj@rediffmail.com

Introduction

In Meghalaya, the Garo Hills has highest tribal population of different communities The tribal population is highly dependent on horticulture for their livelihood. Most of the tribal, whether young or old have limited knowledge about modern horticultural methods and food production(Nidheesh2009).The development and dissemination of new technology is an important factor determining the future of horticulture. The Government of Meghalayarecognizes the importance of horticultural sector in terms of its potential to address the key challenges of unemployment and poverty in the tribal region of Garo Hills districts. So, this study was mainly conducted to explore the knowledge, attitude and practices of different tribal groups towards scientific horticulture.

Methodology

The study was conductedin Garo Hills districtsof Meghalaya,India namely West Garo Hills, South Garo and South West Garo Hills during April to September, 2013because the districts are dominated by different communities(Garo, Rabha, Hajong, Koch and Banai). Four blocks i.e, Dalu and Selsella in West Garo Hills, Zikzak and Betasing in South West Garo Hills and Gasuapara in South Garo Hills were selected for the study. Two villages from each block were selectedon the basis of distribution of inhabit of the five different tribes. Fifteen numbers of respondents were selected from each village through simple random sampling (without replacement). Therefore 30 respondents were selected from each tribe making the total number of respondents to 150. The selected respondents were interviewed with the help of a semi structured interview schedule in order to get relevant information. The data collected were tabulated and statistically analyzed using simple statistical tools to interpret the results.

Results and Discussion

Result of the study has been presented with the help of following tables

Table 1. Distribution of the tribes according to their knowledge level

Knowledge level	Garo	Hajong	Banai	Rabha	Koch	Total
Poor	20 (13.3)	23 (15.3)	9 (6.0)	26 (17.3)	25 (16.7)	103 (68.7)
Average	10 (6.7)	2 (1.3)	2 (1.3)	4 (2.7)	5 (3.3)	23 (15.3)
Good	0 (0.0)	4 (2.7)	7 (4.7)	0 (0.0)	0 (0.0)	11 (7.3)
Very good	0 (0.0)	1 (0.7)	12 (8.0)	0 (0.0)	0 (0.0)	13 (8.7)
Total	30 (20.0)	30 (20.0)	30 (20.0)	30 (20.0)	30 (20.0)	150 (100)

*Data in parenthesis indicates % of total count

The above Table 1 reveals that 68.7 percent of the respondents have poor level of knowledge in modern horticultural package and practices and 8.7 percent of the respondent have very good level of knowledge. Among the five major tribes, the Rabha tribes are found poor level of knowledge.

Table 2. Distribution of the tribes according to their attitude

Attitude	Garo	Hajong	Banai	Rabha	Koch	Total
Poor	0 (0.0)	0 (0.0)	0 (0.0)	6 (4.0)	0 (0.0)	6 (4.0)
Average	25 (16.7)	13 (8.7)	12 (8.0)	24 (16.0)	28 (18.7)	102 (68.0)
Good	3 (2.0)	17 (11.3)	18 (12.0)	0 (0.0)	0 (0.0)	38 (25.3)
Very good	2 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.3)	4 (2.7)
Total	30 (20.0)	30 (20.0)	30 (20.0)	30 (20.0)	30 (20.0)	150 (100)

*Data in parenthesis indicates % of total count

The above tables shows that 68.0 percent of the respondents have average attitude towards the scientific horticultural cultivation and among the five tribes Rabha tribe found more on it.It is also seen that only 2.7 percents of the respondents have very good attitude towards modern horticulture.

Table 3. Distribution of the tribes according to their horticultural practices

Practice	Garo	Hajong	Banai	Rabha	Koch	Total
Poor	28 (18.7)	12 (8.0)	22 (14.7)	30(20.0)	29(19.3)	121(80.7)
Average	0(0.0)	16(10.7)	7(4.7)	0(0.0)	0(0.0)	23(15.3)
Good	1(0.7)	1(0.7)	1(0.7)	0(0.0)	0(0.0)	3(2.0)
Very good	1(0.7)	1(0.7)	0(0.0)	0(0.0)	1(0.7)	3(2.0)
Total	30(20.0)	30(20.0)	30(20.0)	30(20.0)	30(20.0)	150(100.0)

*Data in parenthesis indicates % of total count

The above table 3 reveals that 80.7 percent of the respondents used poor level of horticultural practices and which the Garo tribe found more. Only two percent of the tribes have very good level of horticultural practices.

Among the five tribes, the knowledge level of all the tribes was poor accept the Banai tribes which has average level of knowledge.The knowledge level of all the tribal farmers on scientific horticulture still needs to be improved by imparting training and awareness programme.As their attitude level towards scientific horticulture among all the tribes is neutral, it can be converted to favourable condition by pursuing the viable modern technology through method & result demonstration etc. In terms of practices, all the tribes still depend on traditional method.It is essential to make tribal farmers aware of the benefit of scientific horticulture. So, the institution, both governmental and non Governmental, need to join hand to enhance their knowledge leading to favourable attitude towards scientific horticulture and persuade them to practice the same in their life which will lead to better productivity of the horticultural crops in the Garo Hills and ultimately better livelihood for the farmers of the region.

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Good agricultural practices (GAPs) for hill horticulture

Sukhen Chandra Das[1*], KS Thingreingam Irenaeus[2] and TN Balamohan[3]

[1&2] *College of Agriculture, Tripura, Lembucherra*

[3]*College of Horticulture and Research Institute, TNAU, Tamil Nadu.*

*Correspondence: sukhenchandra@rediffmail.com

Introduction

Good Agricultural Practices (GAPs) is the application of available knowledge to the utilization of the natural resource base in a sustainable way for the production of safe, healthy food and non-food agricultural products, in a humane manner, while achieving economic viability and social stability. GAPs is a set of principles to make agriculture less dependent on chemicals, less aggressive to the environment and more socially conscious, therefore, more sustainable. Aims of GAPs are 1. Healthy food production with minimum chemical use, 2. Safe and safety foods towards zero microbial loads and 3. Preservation of the environment and value addition to the products of small, medium and large farmers.

Methodology

GAPs for selected components are soil, water, crop and fodder production, crop protection, animal production, animal health, animal welfare, harvest and on-farm storage and processing, energy and waste management, human welfare, health and safety, wild life and landscape. The underlying theme is one of knowing, understanding, planning, measuring, recording, and managing to achieve identified social, environmental and production goals. This requires a sound and comprehensive management strategy and the capability for responsive tactical adjustments as circumstances change. Success depends upon developing the skill and knowledge bases, on continuous recording and analysis of performance, and the use of expert advice as required. The framework portrays the guiding principles of good agriculture within 11 elements of resource concerns, disciplines and practices. Using the framework, detailed management guidelines can be prepared for individual production systems within specific agro-ecosystems. EUREPGAP is a private certification system driven by 22 large-scale retail chains and large fresh produce suppliers/producers in Europe that form the core members of the Euro-Retailer Produce Association (EUREP). There are also associate members (mainly suppliers of agrochemicals, certification bodies and consultancy firms) who may participate in meetings but are not part of the Eurep Gap decision-making process. Under Eurep Gap, there are about fifteen selected agricultural components to be adhered to which are listed as: Traceability , Record keeping, Varieties and Rootstocks, Site history and Management, Soil and substrate management, Fertilizer use, Irrigation and Fertigation, Crop Protection, Harvesting, Produce handling, Waste and pollution, Worker Health and safety, Environmental Issues, Complaint form, National Legislation. GAP is nothing but self auditing by the grower to make sure that all genuine practices are adopted as per the standards. It helps in better management of farm and to indicate operations that are vital for successful management of any farm.

Result and Discussion

There is an urgent need to raise awareness among all stakeholders and governments, in particular farmers and consumers, on what constitutes sustainable agriculture. Governments and private institutions need to enact and implement supportive policies. Farmers will respond to incentives of improved market access and added value by adopting those production methods that satisfy the demands of processors and consumers. For this, individual farmers require unambiguous guidance of what is required and how it can be implemented. Farmers must be efficient and competitive but at the same time they must receive adequate prices for their products. To meet this need, it is proposed to develop a framework of guiding principles for Good Agricultural Practices within which agriculture can best proceed to meet the needs of society. They will serve as the basis for the development of guidelines for production systems within specific agro-ecosystems.

Traditional farming system: a case study of Garo tribe in West Garo Hills district of Meghalaya, North-Eastern India

Tarun Kumar Das*,Tanmay Samajdar, Mokidul Islam, Greatush Marak and A.K. Tripathi

Krishi Vigyan Kendra, ICAR Research Complex for NEH Region, West Garo Hills, Meghalaya

*Correspondence:tarunkd2011@gmail.com

Introduction

Traditional knowledge is also a fundamental component of natural resource management. We define indigenous knowledge as traditional knowledge used by the local people for natural resource management relating to agriculture, fisheries, livestock, health practices and other activities. The main livelihood activities of Garos are agricultural practices in the plain land, homestead gardening, *Jhum* or shifting cultivation and in the forestland. The Garo people plough plain land in the foot hills/valley for cultivation of rice through transplanting but in hills they follow the dibbling method of cultivation. The farmers store grains in structures, made of soil and plant materials. The seed storage structures are traditional and resistant to insects.

Hence, the present study was undertaken to explore the traditional farming system of Garo tribes in West Garo Hills district of Meghalaya. The objective of this study is to provide insights of the indigenous knowledge related to agriculture in Garo Hills of Garos.

Methodology

The study was conducted in four Garo inhibited villages in Dalu block and Rongram block of West Garo Hills. So, the totals of 270 respondents were selected from the four villages. The ethnographic approach was applied for conducting the study. The primary data on socio-economic parameter collected through interview schedule, focus group discussion and informal discussion from the key informants of the villages. Information on traditional farming system of Garo tribe were also collected from the secondary source like books, article, research paper etc. The primary data were analyzed using suitable statistical tolls and methods.

Results and Discussion

The farmers of Garo Hills mainly follow mixed cropping system. The land is prepared for nursery bed by ploughing, watering and laddering. The total area of bed is fragmented into several10m × 1.25m of size of unit plots. In between the two units, a drain of50cm wide and 20 cm depth is prepared for draining, watering, and care of seedlings. Seeds are soaked in water for 3-4 days by covering it with straw/bamboo leaves or gunny bags for sprouting. These sprouted seeds are then broadcasted in the muddy nursery bed. Proper watering is done in the seedbed for uniform germination of the seedling. The seedbed is wetted about 6-8 hours before uprooting of seedling. The uprooted seedlings were kept in bundles. Generally transplanting is done in the month of June-July after 40-45 days of sowing in nursery beds. Seedlings are transplanted is 4-6 nos. per hill. They follow random spacing of 25 cm from row to row and 15cmfrom plant to plant. If the seedlings are too old, they cut the upper portion of the seedling before transplanting into the main field.

They cultivate *sali rice* as mono crop into their field and kept the land weed free at least for 40-45 days after sowing. Weeding is done by manually only once. They never apply the fertilizer into their field resulted low yield. They harvest paddy only the earhead of rice with 10-20cm length of straw and after harvesting they kept the harvested rice in the field itself for 5-6 days. Rice is dried in the sun and stored in traditionally made store house or *Jam* (inGaro). Generally they obtained yield is 2.8-3.6quintal per hectare. It is a permanent system of cultivation practices. Three components mainly trees, crops and livestock are consider as main under this farming system. Land preparation pattern for tree species is done by spot clearing, making pits/hole and digging. But for crops the preparation is involves tillage operations. In general the purpose of field preparation is to provide a proper biophysical environment for the crops. Garo use seed, seedling and vegetative propagules to generate the plant in their home garden. Some trees are grown from vegetative propagules by layering and cutting.

For cultivation, every Garo participant gets the land nearly 1ha or a complete hillock from their *Nokma* / Headman of their village with a condition that he/she can't sold it without his/her permission. The size of plot allotted to each house hold varies from 0.2-1.25 ha depending upon household size and capacity of family labour **(**Saurabh Debi *et al.* 2013). The plot size somewhat smaller compare to the range (1.0-2.5ha) reported by Ramakrishnan (1992). Land preparation pattern for crops and tree species is done by cutting, clearing and burning of jungles in the month of February to March followed sowing by digging in the month of April. They use seed, seedling and planting propagule as planting materials for cultivation purpose. Seeds are sown in the month of April to June. They use seed, seedling and vegetative propagules to generate the plant which is storage in last year and sometimes from their friends, neighbours and market and line departments.

Garo follow mixed cropping system. Turmeric and Ginger are the cash crops mostly grown as annual and biennial crops. They start sowing some of the crops when soil remains minimum heat after burning of the jungles followed by dibbling with diblers. They prefer to have arecanut and citrus plant in their fallow land. Weeding is done twice in a year manually. During weeding, they collected fodder for their cattle. They use ash and some local indigenous pesticides for insect pests management in vegetable crop. They never use chemical fertilizers except FYM and ash and dried plants leaves for mulching. They used to make a small bamboo house which is locally called *Borang* on the top of the tree to take care of crops to be destroyed by wild animals. Harvesting of cereal crops is done by picking up the ear heads only, using a knife or sickle where others crops by *Gitchi*/small spade. After harvesting, proper drying of grains is done by them before storage (locally called *Jam)*. Farmers use indigenous plant materials as insect pest and rodents repellent.

This system was practicing from their ancestor and still it is going on successfully. Tree and bamboo are considering main two components under this system. In social forestry, the local landless and small farmers living in and around the forest area and encroacher were selected as participants. The land is under the jurisdiction of headman *or Nokma* of the village. Under the social forestry villagers select the place where forest was already established naturally. For management of that area, villagers formed a committee namely village forest management committee for its utility and maintenance with a security guard. If the committee thinks that the forest has abundant of tree then they decide to harvest or sale. After selling, 5% percent of that amount was given to security guard and rest amount was deposited to the fund of village forest management committee. The plantation are established on participatory basis are being harvested at the end of rotation and the sale proceeds are deposited on the basis of agreement approved by the village forest management committee. If the reserved forest falls to the position of shortage, they are being stopped from harvesting for a period of 4-5 years until the reserved forest regains its maxima.

Considering the present findings concluded that the indigenous knowledge of Garo tribes is helpful for the conservation of natural resources. Modern suitable technology on agroforestry or soil and water conservation should introduce to them and motivate them to adopt it, which will result to increase their income, uplift lifestyle and reduce their dependency on forest for their livelihoods.

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Yield gap of rice and its causes in Tripura

Pallab Debnath, Ram Singh and Monika Aheibam

College of Post-Graduate Studies, CAU, Umiam, Meghalaya
**Correspondence*: pallab2015@gmail.com

Introduction

India's population is expected to reach 1.45 billion by 2025, from the current level of 1.17 billion. The cereal requirement of India by 2020 will be between 257 and 296 million t, depending on income growth. It is necessary that food production in India must increase by about 5 million tonnes annually for the next 25 years to ensure food and nutritional security to the burgeoning population. Tripura, one of the seven states in the NEH region of India is predominantly an agrarian state. Rice is grown in both the hills and plains as the staple food crop. The varying nature of yield gap of rice becomes a matter of serious concern especially when the state is not self-sufficient in its production. At present there is a gap between actual production of food-grains and requirement of food-grains in the state. Under the above mentioned constraint and in a situation where both horizontal and vertical expansion is a hard task to complete and a difficult goal to achieve, minimizing the yield gap may be a better solution. Thus finally, the study on yield gap analysis will reveal the extent of yield gap, the various factors contributing to yield gap so that the gap can be narrowed.

Methodology

Tripura state will be selected purposively for the present study since the state ranks first in area, production and productivity of rice among the states in the North Eastern Hill Region (NEHR) during the year 2012. Rice is cultivated in both hill and valley region of the state. In order to have a more comprehensive rice scenario of the state, therefore, areas representing both hill region and valley region will be purposively selected for the proposed study. At the first instance, amongst all the primarily hilly districts of the state, Dhalai and North Tripura will be purposively selected as these two districts are having highest area under upland rice. At the second instance, Sipahijala and South Tripura districts from amongst valley regions of the state will again be selected purposively as these two districts are having highest area under lowland rice. Thus, altogether four districts will comprise the study area for the proposed research endeavour. Having selected the districts, one block from each of those and two villages from each of the blocks will then be selected randomly. A sample of 120 farmers in total will be drawn from the selected villages by applying Probability Proportional to Size (PPS) Sampling.

Yield gap and its components

Narrowing yield gaps not only increases rice yield and production, but also improves the efficiency of land and labour use, reduces production costs and increases sustainability. According to FAO (2004) there are three components of yield gap.

The first component – yield gap I

It is the gap between the theoretical potential yield and the experiment station yield for which scientists breed potential varieties (such as super rice). It is therefore, difficult to narrow this component and Gap I is often not economically exploitable.

The second component – yield gap II

It is the gap between the experiment station yield and the potential farm yield, and is caused mainly by factors that are generally not transferable, such as environmental conditions and some of the built-in component technologies that are available at research stations. It is therefore, difficult to narrow this component and Gap II is often not economically exploitable.

The third component – yield gap III

It is the gap between the potential farm yield and the actual farm yield. It is hypothesized to be caused by biological and socio-economic constraints; biological constraints stem from the non-application or differences in the application of essential production inputs and socio-economic constraints from the social or economic condition of the farmers. This component is manageable and can be narrowed.

As the first and second components are not economically exploitable so for the purpose of this study this two components will not be taken into consideration. Hence, the third component (Yield gap III) which is manageable and can be narrowed will be taken into consideration under the study and can be measured as follows: Yield gap III = Potential farm yield (Yd) - Actual farm yield (Ya).

Results and Discussion

Fragmentation of land holding is continuing as a part of social phenomenon. The average size of holding has declined from 1.25 hectares in 1976-1977 to 0.97 hectares in 1990-1991, which is the lowest amongst seven sisters of NE Region (GoT, 2014). However, recently as per the sample estimates of the study there are 86.66 per cent marginal, 10.83 per cent small and only 2.5 per cent medium and large farmers.

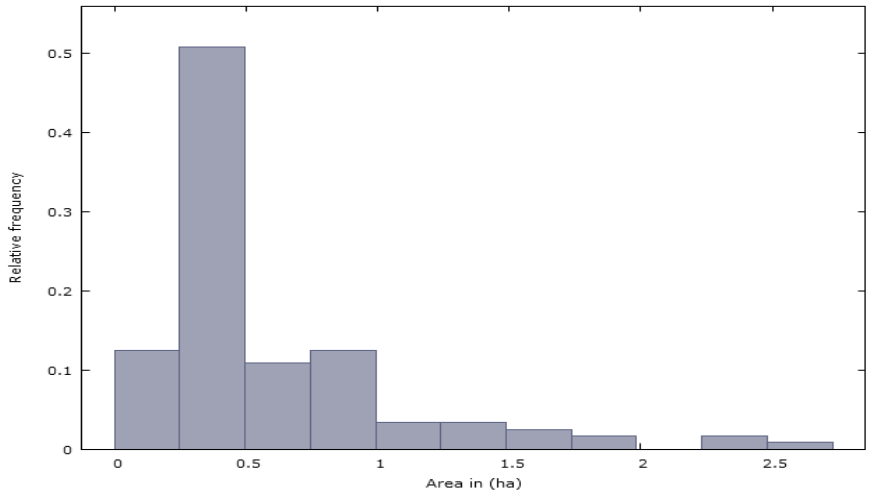

Table 1. Yield gap among the farmers

Yield Gap in Kg/ha	Frequency	Per cent
<500	28	23.33
501-1000	23	19.17
1001-1500	20	16.67
1501-2000	36	30.00
2001-2500	8	6.67
>2501	5	4.17

The yield of Tripura *i.e.*, 2.7 t ha $^{-1}$ is higher than the national average of 2.3 t ha $^{-1}$ (Table 1). Yet there exists a considerable yield gap ranging from less than 500 kg ha^{-1} to more than 2501 kg ha^{-1}. Interestingly, around 36 per cent of the farmers are having yield gap of 1501 to 2000 kg ha^{-1}. Hence, solving the problem of yield gap may play a vital role in restructuring the food security of the state. It has been observed that some of the parameters like unavailability of desired variety of seed/ variety, unavailability of required quantity of seed, unavailability of timely irrigation facility, unavailability of institutional credit facility, scarcity of labour during peak agricultural operations and low precipitation are some of the major factors which are responsible for the low yield as perceived by the farmers.

The results of the study show that there has been a wide extent of yield gap across regions of Tripura state where majority of the farmers are marginal and small. The study also reveals number of factors which are responsible for the yield gap as opined by the farmers. Thus, solving these problems may lead to bridge the gap and help the state in achieving food security of the state.