Organic Farming in Hill Ecosystems – Prospects and Practices

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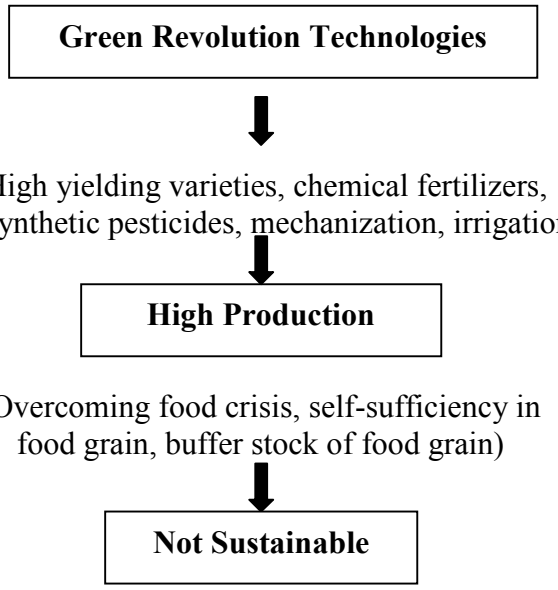
Organic farming is a system of production that relies on animal manures, organic wastes, crop rotations, legumes and aspects of biological pest control. It avoids (or legumes excludes) the use of synthetically produced fertilizers, pesticides, growth regulators and livestock additives. It is the ecological production management system that promotes and enhances biodiversity, biological cycles and biological activity of the soil. The essence of organic farming is to feed the soil rather than the crops to maintain optimum soil health with its vibrancy and resilience. Thus, making the soil capable of supplying all the essential nutrients to the crop for its proper growth and development. Organic farming aims at sustaining and increasing the productivity by improving the soil health and over all improvement of agro-ecosystem.

Organic crop production in the organic farming system is gradually gaining momentum worldwide. It is based on the minimal cost of the off-farm inputs and management practices that restore maintain and sustain ecological harmony. Organic crop production is not only a holistic approach of production system that gives quality "Organic food", but helps to restore soil fertility on long term basis. It is relatively independent production system compared to conventional agriculture, which depends mostly on synthetically produced inputs i.e., fertilizers, fungicides, insecticides, herbicides, growth regulators, etc. In the organic crop production system, it is observed that there is yield drop during the conversion period as it takes sometime for the soil and plants to reach equilibrium. Yield of crops rise again once management systems get established.

Plate 1. Rice on sunken beds and bhindi on raised beds under organic production systems at ICAR Research Complex, Umiam

Organic farming or the organic crop production is not a new concept to the farmers of the country. Indian farmers were all organic farmers before the advent of synthetic fertilizers, pesticides, mechanization, etc. It was mostly during the mid sixties and afterwards that farmers started using the synthetically produced inputs (fertilizers, pesticides, etc.), which brought about "Green revolution" in our country. Green revolution not only dramatically increased the productivity of many crops (wheat, rice, etc.) leading to self-sufficiency in food grain production in 1970's but also help build up buffer stock of food grains for the burgeoning population. No doubt that intensive chemical agriculture (or conventional agriculture) helped achieving dramatic increase in crop yield ensuring food security and commercialization of agriculture in our country, but at the same time, the intensive use of chemical fertilizers and pesticides led to gradual decline in soil health and ultimately the productivity of crops per unit of input application. Uncontrolled and unscientific use of chemical fertilizers without adding adequate quantities of organic manures has resulted in the deterioration of soil health and environment. Because of this, yield levels are falling and soils are becoming degraded in intensively cultivated agriculturally advanced areas. To sustain fertility and productivity of Indian tropical soils, there is an urgent need to promote liberal application of organic manures

by the farmers. The factor productivity has fallen. Micro-nutrient deficiencies are increasingly felt in most of the soils. Useful microbes that are helpful in maintaining soil health are also diminishing. The high input cost and low return in the conventional agriculture gradually becoming evident almost everywhere.



Moreover, conventional agriculture increased pest and disease outbreak causing despair to farmers forcing them to use synthetic pesticide indiscriminately. Apart from falling productivity of crops, there are inherent problems of environmental pollution, health hazards and ultimately the ecological unsustainability threatening the future prospects of mankind and other living being. Under the context of hill farmers, present day requirement of plant nutrients through chemical fertilizers or plant protection through the synthetic pesticides is neither desirable nor feasible. The high cost of chemical fertilizers, pesticides, the widening gap between supply and demand and the low purchasing power of small and marginal farmers (particularly in the hills of north eastern region) are at present major constraints in exploiting full potential of the crops. Moreover, the farmers of the north eastern region, in general and the hill farmers in particular are not very keen to use of fertilizers and pesticides for growing crops.

Advantages of organic farming

- Organic matter supplies all the essential macro and micro plant nutrients.
- Organic matter improves physico-chemical and biological properties of soil.
- Organic matter recycling is renewable and thus energy resources can be made available for organic production.
- Organic farming improves agro eco-system and helps stopping environmentally degradation.
- Organically grown crops are preferred most by people as it is believed to be more nutritious compared to the conventional ones.
- Organic produce fetches more prices in the national and international market.

Debated issues on organic agriculture

- **Can organic farming produce enough food for everybody?**

We should realize that our demand for food production is increasing and on the other hand the land resources are shrinking. Therefore, we can't effort to organic farming in all the ecosystems and areas. Rather, we should think rationally and select only those areas that remained organic due to wisdom and/or by default. Hill regions of the country can be easily converted to organic food production zone mainly to meet domestic and international demand and for higher farm income.

- **Is it possible to meet the nutrient requirement of crops entirely from organic sources?**

In intensive cropping areas it is not possible to meet the entire crop nutrient requirement through organic source. As high as 30 t FYM manure application are reported to be used to get equivalent yield of rice-wheat system after three years of conversion in IGP. However, contrast is the case for North Eastern Hill Zone. About 15 t FYM along with crop residue recycling is sufficient to get a yield similar to recommended NPK from second/third year onwards.

- **Are there any significant environmental benefits from organic farming?**

It can be very well established that there is significant environmental benefits from organic farming. In organic farming not only healthy foods are produced but also a lot of emphasis is given on ecosystem conservation and maintenance. The biomass, manure, animal excreta that has the potential to create pollution are composted and recycled in organic crop production.

- **Is the food produced by organic farming superior in quality?**

European Union funded project on Organic Farming (10 years) data revealed that revealed that there is 40 per cent more beneficial compounds in agricultural produce and 90 per cent more in milk compared to modern chemical based agriculture (TOI 2007). Organic produce are known to be richer in micronutrients, vitamins and other quality parameters.

- **Is organic farming economically feasible?**

Organic farming is economically feasible in areas where resources are available within the farm and least dependent on external resources. The areas like North Eastern region of India and other hilly areas, where a lot of biomass is available from forest, weeds, crops etc. organic farming would be more economical. Moreover, organic produce are expected to fetch premium price (at least 25per cent) and therefore should be economical to the poor farmers.

- **Is it possible to manage pest and disease in organic farming?**

Pest and disease management is so far the most difficult task in organic farming. However, with the experience and selection of resistant varieties, cultural practices, use of bioorganics, biopesticides etc. the problem of pest and disease can be managed to great extent. The farmer's knowledge on ITK should also be effectively used.

Status – world wide

Organic farming is no longer to be considered a niche market within developed countries but a pulsating agricultural production system, being practiced in more than 120 countries. World wide statistics for organic agriculture reveal that 30.42 m ha land, sharing 0.65 per cent of total agricultural land, is certified according to organic standards (Willer *et al.*

2008). Australia continues to account for the largest certified organic surface area, with 12.3 m ha followed by China (2.3 m ha), Argentina and USA (Table 1). The World organic market (2006) is estimated at over US $ 38.6 billion with global organic area of 30.4 million ha (Prasad and Gill, 2009). The value of organic market is expected to reach $ 70 billion by 2012. The leading organic products consumers are North America and Europe.

Table 1. Area under organic farming in different countries (as of 2006)

Country	Area (million ha)	Per cent of organic land to total land
Australia	12.3	2.8
China	2.3	0.4
USA (2005)	1.62	0.5
Uruguay	0.931	6.1
Italy	1.15	9.0
Argentina	2.22	1.7
Spain	0.93	3.7
Brazil	0.88	0.3
Germany	0.83	4.8
India	0.53 (cert + uncertified)	0.4

Mahapatra *et. a.l,* (2009)

Scope and opportunities of organic crop production in India with special reference to North Eastern Region

The certified organic area in India is 0.33 million ha (2006-07) with organic produce of about 585 thousand tone having export value of 3012 million rupees (Mahapatra *et al*. 2009). India has now become a leading supplier of organic herbs, organic spices, organic rice (basmati, joha etc.). The organic produce includes all varieties of food products (cereals, pulses, honey, tea, spices, coffee, oilseeds, fruits, vegetables and their value added products. Country also produces organic cotton fibres, garments, cosmetics, functional food products, body care products etc. India exported 35 items in 2007-08, with the total volume of about 19,456 t (Table 2). Though very nascent, the Indian organic sector is growing rapidly and has already made in roads into the world organic sectors. India has a great potential for export of organic products, if inspection and certification is streamlined and credibility in the international market is established. There are inbuilt organic practices already existing among the farmers of our country. Perhaps, there is no other country as India where almost all crops, both temperate and tropical, can be grown. Reasonable quantity of organic matter also can be sourced for plant nutrients. Several indigenous technologies knowledge of plant protection is available in this country. The Indian Council of Agricultural Research has already documented nearly 3000 indigenous technological knowledge. Many of these technologies would be useful for organic farming.

Table 2. Present status of organic products in India (as per 2006-07, www.apeda.com)

Total production (tone)	5,85,970
Total quantity exported (tone)	19,456
Value of total export (Million Rs)	3012.4
Total area under certified organic cultivation (ha)	3,39,113
Number of farmers	1,41,904

The Indian share of the world trade in spices is 45-50 per cent by volume and 25 per cent in value. The total Indian spice export by 2004-05 was estimated to be 3.35 lakh tonnes valued at US $ 490.6 million. Quantity wise, this is only about 15per cent of India's production envisaged. Among spices exported from India during 2004-05, chilli constituted 41.1per cent followed by seed spices 23.7per cent, ginger and turmeric 16.7per cent and black pepper 4.2per cent accounting to 25-35per cent of total global trade in spices in quantity. India has the largest area (0.874 lakh ha) and production (2.98 lakh tonnes) of ginger in 2003-04. India export was estimated to be 550 tonnes of small cardamom and 8.5 and 32.0 thousand tonnes of ginger and turmeric during 2002-03 valued at Rs. 37.6, 24.1 and 99.4 crores, respectively (Parthasarathy *et. al.,* 2007). Major export market for Indian organic producers are Australia, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Sweden, Singapore, South Africa, Saudi Arabia, UAE, UK, and USA. The current estimated share of organic foods in these countries is approximately 1 to 1.5 per cent. Organic pepper is produced and exported to these international markets by India, Indonesia and Sri Lanka. Since organic foods are free from chemical contaminants, the demand for these products should steadily increase in the coming years. Among the major organic foods produced in India (Table 3) tea and rice contributes around 24per cent each, fruits and vegetables together make 17per cent of organic produce (Garibay and Jyoti 2003).

Table 3. Major products produced in India by organic farming

Type of Product	Products
Commodity	Tea, coffee, rice, wheat
Spices	Cardamom, black pepper, white pepper, ginger, turmeric, vanilla, tamarind, clove, cinnamon, nutmeg, mace, chili
Pulses	Red gram, black gram
Fruits	Mango, banana, pineapple, passion fruit, sugarcane, orange, cashew nut, walnut
Vegetables	Okra, brinjal, Garlic, onion, tomato, potato
Oil seeds	Mustard, sesame, castor, sunflower
Others	Cotton, herbal extracts

Source: Garibay and Jyoti (2003)

The market for organic products is growing. The biggest hurdle to India for export of organic produce is the lack of processing, packing, storing and transport facilities of International Standards. Once these infrastructural facilities are developed, the country can look forward for the prosperous future for organic produce export. Most of the countries are now planning to produce organically. Therefore, it may not be wise to think of converting all crops to organic production with a view to export purpose only. On the other hand, there are areas where there is less competition and greater demand, like spices, medicinal and aromatic plants.

Initially, the North Eastern States were identified for promoting organic farming. These states were selected because the land is almost virgin and the crops are grown virtually organic. There is lot of scope for organic agriculture in the hills especially in the north eastern region of India. Firstly, the use of inorganic fertilizers and chemicals is meager in the region. The farmers of the region, in general and hill farmers in particular are having apathy towards use of agro-chemicals (Table 4). Secondly, the fruits of green revolution could not benefit the farmers of the hills as the system of production in the hills remained low input-low risk-low yield technology based and the average yield of most of the crop remained far behind. It is assumed that the difference in production gap due to adoption of organic agriculture is expected to be negligible; rather there is scope for enhancing productivity with good organic management, the

organic premiums would boost earning of the hill farmers. Thirdly, it is an added advantage that all the households are maintaining livestocks (pig, poultry, cattle, goats, etc.) producing sufficient quantity of on-farm manures, which could be efficiently used for organic agriculture. Moreover, the north eastern states being the one of the mega biodiversity receiving very high rainfall (2000 mm to 11000 mm per annum) leads to profuse production of biomass including weeds, shrubs and herbs. Some of these species could be efficiently used in organic production. Bujarbaruah (2004) reported that the region has a potential of about 47mt of organic manure including 37mt from animal excreta and 9 million tons from crop residues.

Table 4. State wise consumption of plant nutrients per unit of gross cropped area in the North Eastern Region

(kg/ha)

State	2000-01				2001-02			
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
Arunachal Pradesh	1.4	0.6	0.4	2.4	1.6	0.9	0.4	2.9
Assam	18.7	9.2	7.8	35.7	19.2	10.6	9.1	38.8
Manipur	85.2	10.6	6.2	102.0	86.5	12.0	6.4	105.0
Meghalaya	9.0	5.0	0.5	14.5	10.5	6.2	0.5	17.2
Mizoram	4.7	4.8	2.8	12.4	4.9	5.2	3.6	13.7
Nagaland	0.8	0.5	0.1	1.4	1.1	0.8	0.2	2.1
Sikkim	5.0	3.1	0.5	8.5	5.0	3.5	1.2	9.7
Tripura	15.5	4.0	1.2	20.7	16.5	8.6	5.3	30.5
All India	56.7	21.9	8.1	86.7	58.7	22.8	8.7	90.1

The strength of north eastern region for organic farming can be summarized as under:

- North Eastern Region (NER) is home to some niche crops like Assam lemon, Joha rice, medicinal rice and passion fruits which has high market demands.
- NER accounts for 45per cent of total pineapple production in India.
- Sikkim is the largest producer of large cardamom (54per cent share) in the world.
- NER is the fourth largest producer of oranges in India.
- One of the best quality ginger (low fiber content) produced in the North Eastern Region.
- Extent of chemical consumption in farming is far less than the national average.
- 18 lakh ha of land in NER can be classified as “Organic by Default”.
- Assam tea is known for its quality world wide
- Thin population density per square kilometer (13-340 compared to 324 at national level).
- Dependence of mid and high altitude farmers on within farm renewable resources.
- Time tested indigenous farming systems and use of indigenous technical knowledge in agriculture.
- Agri-Export Zone (AEZ) set up in Tripura for organic cultivation of pineapple.
- Another Agri-Export Zone (AEZ) established for ginger in Sikkim.
- Promotional schemes for agriculture and related industrial investments for NER.

The Challenges for Organic Farming in the North Eastern Region

The major challenges associated with promotion of organic farming in the region,listed by Bujarbaruah (2004) are :

- Benchmark survey of the region for identifying the potential areas for organic food production.
- Research, development and extension strategies for promotion of organic cultivation.
- Human resource development in production of organic inputs like biofertilizers, vermicompost, botanicals for pest management etc.
- Assistance to farmers in post harvest handling, processing and value addition
- Identifying certification agency within the region and reduction of certification cost
- Creation of infrastructure and mechanisms for marketing of organic produce.

Steps required for organic crop production

As organic cultivation has to adhere to well defined norms, procedures and practices for the preparation of land, application of inputs such as seeds, organic manure, etc. have to conform rigorous production guidelines. Then only the products will be accepted as organic. Some of the important steps required for organic production are given below:

Duration of conversion period

Organic crop production system and building up of soil fertility requires an interim period called the conversion period. It is the period in which the whole farm including the livestock is converted into organic. The beginning of the conversion period shall be calculated from the date of application for certification or the last date of application of unapproved farm inputs.

- Conversion period may take 1 – 3 years based on the number of years the land had been put under conventional agriculture, type of cultivation, etc. Feed produced in the first year of organic production may be classed as organic for the purpose of calculation for feeding the animals in the farm.
- In accordance with the norms laid in the National Standards for Organic Products (NSOP), the entire farm unit should be converted into organic in a phased manner.
- Community approach is suggested for a group of contiguous farms forming a large belt or zone.
- Converted land and animals shall not alternate between organic and conventional management.

Farm designing

Farm designing is important for optimizing the utilization of resources within the farm. Topography of the land and varieties of crops to be cultivated are the two basic factors in farm design. Border trees, bund, cattle shed, compost pits, storehouse, etc. should be suitably incorporated.

- The cattle shed, compost yard, storehouse and office could be at a comparatively higher elevation than the cropped area to prevent water logging. This will also help to utilize cattle shed washings to lower ridge cropped area, fishery, etc.
- Multipurpose border trees like neem, pongamia, erythrina, alder or any other local trees of importance are planted (8 – 10 m apart). These border trees will serve different purposes like wind brakes, green leaf manuring and composting, managing pests and diseases.
- In between the border trees, smaller shrubs like *glyricidia sp, subabul, erythrina, dhaincha,* fodder plants and any other legumes can also be planted.
- Farm diversification by maintaining subsidiary activities like apiculture, dairy farming, etc. to be incorporate.

- Fodder, grasses etc. should be planted on the field bunds to get an additional income to the farmers and prevents breaching of bunds.

Field preparation

The field is ploughed to get a good tilth. At the time field preparation well decomposed FYM @ 10 – 15 t/ha or vermi - compost @ 2.5 -5 t/ha should be uniformly incorporated into the soil.

Choice of crops and varieties

- Based on performance and demand of the region, particular crops should be selected. Joha rice, medicinal rice, pineapple, passion fruit, ginger, large cardamom, medicinal plants, etc. are in demand for organic production in the region.
- Location specific varieties need to be selected for organic production. All seeds and planting materials should be certified organic.
- Chemically untreated conventional seed and plant material can be used if certified organic materials are not available. Chemically treated seed and plant materials may be used with the approval of Certification Agency (CA) where no other alternatives are available.
- Crops/varieties should be naturally resistant to pests and diseases.
- Crop rotation including legumes and other green manuring to be practiced. Cover crops, catch crops and mulching should be done.
- Healthy, clean and high percentage germination seeds from authentic source should be selected.
- Seed treatment should be done by using Cowdung, Neem seed powder coating, Bio-fertilizers (*Azospirillium, Azotobacter*, Phosphorus solubilising bacteria) etc.
- Genetically engineered seeds, pollen, transgenic plants or planting materials should not be used.

Diversity in crop production

Rotation of crops with any leguminous crops to be practiced. Sufficient diversification should be obtained to take care of the pest and disease pressure and to improve soil fertility, microbial activity and general soil health.

Nutrient management

- Maintenance of soil fertility may be achieved through organic matter recycling, enrichment of compost, vermi-composting, animal manures, urine, farm yard manure, litter composting, use of botanicals, green manuring, etc.
- Use of bio-fertilizers like *Azolla, Azospirillium, Azotobacter, Rhizobium* culture, *PSB*, etc. to be used.
- Blood meal, bone meal and human excrement may be applied with the approval of the Certification Agency (CA).
- Saw dust from untreated wood, calcified seaweed, limestone, gypsum, chalk, magnesium rock and rock phosphate can be used.
- Various sprays like vermi wash and liquid manures etc. can be used in crops for nourishing the soil and plant.

Weed management

- Hand weeding is to be practiced. Rotary weeder etc. can also be used.
- Cultivation of cover crops, mulching to be practiced.
- Intercropping and crop rotations reduces weed problems.

- Use of all kinds of herbicides is prohibited.

Contamination control

- All relevant measures should be taken to minimize contamination from outside and within the farm.
- Accumulation of heavy metals (lead, cadmium, nickel, chromium, etc.) and other pollutants should be kept to the minimum.

Soil and water conservation

Soil and water resources should be handled in a suitable manner. Relevant/appropriate measures should be taken to prevent salination of soil and water.

- Excessive exploitation and depletion of water resources is not permitted.
- Pollution of surface and ground water is not allowed.
- Clearing of primary forest not permitted and burning of organic matters to clear land to the minimum level.
- Landscape and biodiversity improvement shall be taken up.

Soil and crop management in organic production system

Organic farming system encourages the use of mixed/inter cropping, crop rotation and manure to maintain soil fertility. The fertility of soil gets depleted by growing one single crop year after year. Moreover, growing the same crop in the same field invites attacks of particular insect pest and disease. Mixed/inter crops are advantageous in many ways when cereals/millets are mixed/inter cropped with legumes because the nodules in the roots of legumes fixed the atmospheric nitrogen and increase the soil fertility (Singh *et. al.,* 1994). This gives stability not only in production but also produce more economic return. Under such crop management, the whole of the energy from sunlight is fully used by the foliage by adoptions of suitable crop management. The rainfall is also carefully conserved. A large portion is received in the surface soil and excess is gently allowed to be absorbed in sub soil. Three tier cropping, an intensification of crops in time and space dimensions is ideal for sharing sunshine, nutrients and water level. The intercropping/crop rotation also helps in better utilization of profile moisture, nutrients extraction from various layers of soil and effective utilization of farmland. Karlen *et. a.,* (1994) have reviewed many of the advantages of crop rotation such as increase nitrogen supply, improvement in soil, water and nutrient availability, besides improvement in soil microbial activities and in weed control. They further reported that there was 10 – 20 percent increased in the corn yield when grown in two years rotation with soybean than mono culture of corn. The introduction of legumes in crop rotation helps to increase the soil fertility. Alley cropping is also a way of maintaining of soil productivity.

Although, organic manure forms a small part of mineral soil, it plays a vital role in productivity and conditioning the soil. It serves as food for soil bacteria and fungi, which are responsible for converting complex organic mineral into simple substance readily used by the plant. The intermediate products of decomposition of fresh organic matter help to improve the physical conditions of soil. To conserve the soil organic matter and biotic life, minimum tillage is adopted (Singh *et al.* 1994).

Million of microorganisms inhibit the soil, which keep the soil an alive media for agriculture purpose. In organic farming, the soil is treated as living creature and one important macro fauna i.e. earthworm is known as farmers friend. In different soil their number varies from 1-8 lakh/ha. Their number can be increased by making soil rich in organic carbon and by adoption of minimum tillage practices. The earthworm function in three main ways i.e. making burrows thereby facilitating the infiltration of air and water, it neutralizes soil by extracting calcium through its exertion and eats and digest soil mixed it with organic matter and through

it out in the form of casting (Pal 2001). Now there is a vast domain of tiny little creature, known as microorganisms.

There is strong link between micro fauna and microbes. Also they form an intricate community, each one, helping or depending on the others. These organisms are classified into two broad groups i.e. soil flora and soil fauna. Soil micro flora includes bacteria, fungi, actinomycetes, algae, etc. Of these groups, the bacteria are most abundant followed by actinomycetes, while fungi and algae are found under specific situation. The biomass and population of these microorganisms in soil have depicted in Table 3. The presence of these microorganisms makes the soil living and active. The most abundant species of soil bacteria are Pseudomonas, Bacillus *Arthobacter, Aerobacter and Agrobacterium*. Some most useful bacteria are *Beijernekia, Nitrobacter and Nitrosomonas*. The bacteria, which are beneficial, are being cultured and used as bio-fertilizer in crop production.

Biofertilzer either to fix the atmospheric nitrogen or solubilise the mineral nutrient like phosphorus besides releasing some growth hormones and vitamins. That is why the bio-fertilizer are being widely accepted as low cost supplement to chemical fertilizer, which do not have deleterious effect either on soil health or environment. The bio-fertilizer such as *Rhizobium, Azotobacter, Azospirillum* and Phosphobacteria have been developed and used in large scale (Verma, 1993). *Azolla*, which is an aquatic fern is capable of fixing atmospheric nitrogen and increase the yield of flooded rice (Munda *et. al*., 2001) under natural farming situation.

Some case studies at ICAR Research Complex for NEH Region, Umiam, Meghalaya

Various field experiments for standardizing package of practices for organic food production are being conducted in the ICAR Research Complex for NEH Region, Umiam, Meghalaya, since 2005. Results, obtained in the current year (2007-08) are discussed below-

Soil fertility management in important field crop based multiple cropping systems

Field experiment was conducted to evaluate the efficacy of various on- and off-farm produced organic sources of nutrients on productivity and soil health under various rice and maize based cropping systems. The five organic nutrient sources used were Farmyard Manure (FYM), vermicompost (VC), local compost (LC) made from composting of locally available weed biomass and crop residues, integrated nutrient sources (1/3rd each of FYM +VC+LC) and control. Nutrient sources were applied on N-equivalent basis. P requirement was adjusted by applying mussorie rock phosphate (MRP). The experiment was laid out in a split plot design with four cropping sequences in main plot viz., CS1: Rice + soybean (4:2) - mustard, CS2: Rice + soybean (4:2) - tomato, CS3: Maize + soybean (2:2) - groundnut, CS4: Maize + soybean (2:2) - Frenchbean and five nutrient sources in sub-plots.

Integrated application of organic manure proved to be best management practice followed by FYM application which was significantly higher than rest of the sole treatments for all the crops. However, maximum fruit yield of tomato was recorded in FYM application. Higher values of yield attributing characters contributed to higher yield in maize, soybean, and groundnut, French bean under integrated management practices irrespective of cropping system followed by FYM and vermicompost treatment.

The pH of the experimental soil increased form the initial value of 4.5 to 5.6 due to FYM application. Improvement in N, P, K content, soil physical and microbiological properties was also recorded due to application of organic nutrient sources which indicated the improvement in soil health. Soil Microbial Biomass Carbon (SMBC) content was recorded maximum (210 µg/g dry soil) under integrated management practices followed by FYM (204.2 µg/g dry soil) and vermicompost (182.6 µg/g dry soils) treatment. Maximum bacterial (208 x 10^4), fungal (62.0 x 10^4) and actinomycetes (40 x 10^4) counts in soil samples was recorded under the integrated nutrient application. At harvest, total soluble solids (4.2per cent), reducing

sugar (2.8 per cent) and lycopene (19.4 mg/100 g) content of tomato was recorded maximum in integrated management practice.

Soil fertility management in important vegetable crop based multiple cropping systems

Filed experiment was conducted to study the performance of vegetables under different cropping systems and to evaluate efficacy of various on- and off farm produced organic sources and their effect on productivity of vegetables and soil health. The organic sources of nutrient used were Farmyard Manure (FYM), Vermicompost (VC), integrated nutrient sources (½ of FYM+ ½ of VC) and compared with control. The experiment was laid out in split plot design with treatment combination consisted of three cropping sequences in main plot CS1: Maize + soybean (2:2) – Frenchbean - tomato, CS2: Maize + soybean (2:2) - radish- potato and CS3: Maize + soybean (2:2) – Frenchbean - carrot along with four nutrient management practices in sub-plots. Yield of vegetables were maximum under integrated management practices, however sole application of FYM produced comparable yield with that of integrated nutrient source.

Improvement of soil health was noticed as pH increased up to 5.27 from the initial value of 4.8 and organic carbon content increased to 2.6 per cent from the initial of 1.8 per cent because of application of organic inputs. Likewise, available nutrient (N, P & K) content also increased from the initial status. Maximum microbial population and SMBC were recorded with integrated nutrient management.

Effect of organic, inorganic and integrated management practices on soil health and crop productivity under various cropping systems

The comparative efficacy of organic, inorganic and integrated management practices on soil health and crop productivity was tested under rice based cropping system in raised and sunken bed method of cultivation. The fourth year results revealed that maximum yield of upland rice and vegetables were recorded in integrated management practices followed by 100per cent organic and inorganic management practices. Lowland rice varieties also registered higher yield in integrated management practices followed by organic management practice.

There was improvement in soil health in terms soil physico-chemical and biological properties. Porosity (per cent) and maximum water holding capacity was increased from the initial value due to application of organic manures. In general the improvement in this parameter was relatively higher in sunken beds compared to raise beds. pH of soil increased to 5.4 from initial value of 5.1 under raised bed situation, while OC increased above 3 per cent from initial value of 2.5per cent in the integrated management practice. SMBC (Table 5) and microbial counts (Fig 1) was also recorded significantly higher in integrated management practice, followed by organic and inorganic treatment.

Table 5. SMBC (µg/g dry soil) as influenced by various cropping systems and nutrient management practices in raised and sunken bed situation

Treatments	**SMBC (µg/g dry soil)**	
Cropping systems:	**Raised bed**	**Sunken bed**
CS1: Rice-potato	121.3	101.4
CS2: Rice-tomato	123.3	128.9
CS3: Rice-French bean	194.9	85.5
CS4: Rice-carrot	119.1	110.5
CD at 5per cent	**NS**	**4.2**
Nutrient sources:		

NS1: Organic	140.4	114.5
NS2: Inorganic	130.9	101.3
NS3: Integrated	170.5	128.2
NS4: Natural	116.9	82.2
CD at 5per cent	**7.7**	**8.7**

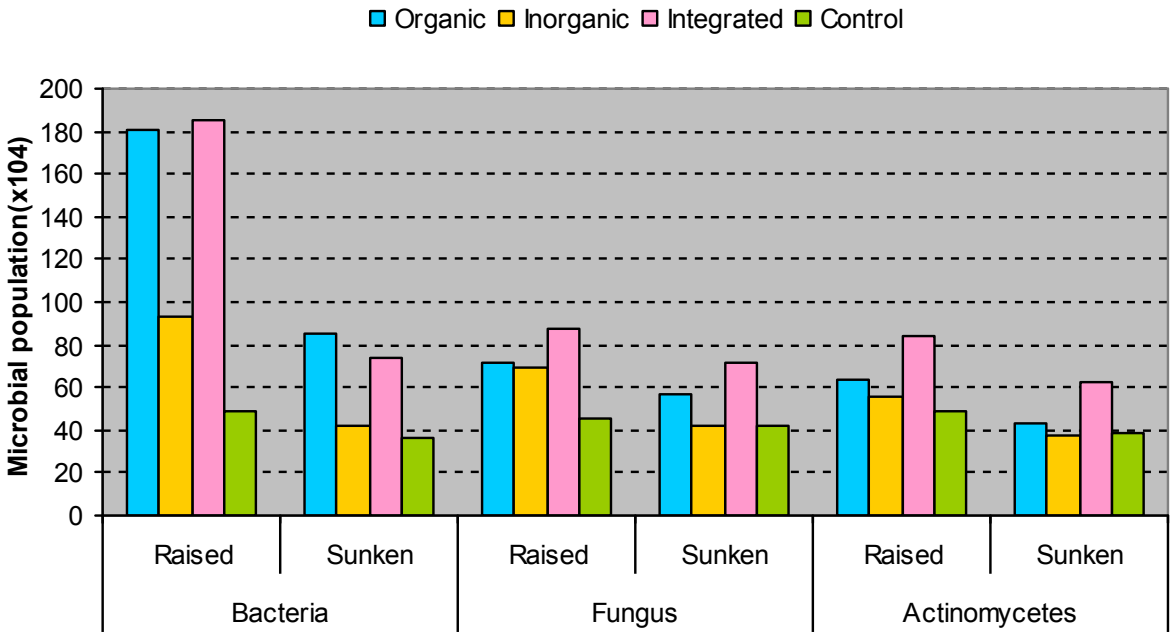


Fig 1. Microbial population as influenced by different nutrient sources under raised and sunken bed situation

Quality of tomato produced under various management practices was determined at maximum ripening stage. Fruits grown under integrated management practice and FYM application exhibited superior quality in terms of biochemical properties including TSS content, ascorbic acid, average juice volume, reducing sugars and lycopene content.

Organic Farming on rain fed dry terraces ginger and turmeric

Ginger and turmeric was grown in rainfed dry terraces following two methods of cultivation i.e. flat bed and bun (raised bed of 30cm height, 1 m. width) along with four organic nutrient management practices. Soybean as green manure crop was grown in the inter row spaces of ginger and turmeric and was incorporated during earthing up operation. Like previous year all the treatments were superimposed in the same plot to see the residual effect of treatments on soil health and crop performance. Experimental results revealed that integrated application of FYM & VC with soybean green manuring produced significantly

Plate 2. Green manuring in ginger under organic production

higher yield in ginger (12.4 t/ha) & turmeric (79.8 t/ha) compared to control (Table 6). Performance of FYM, vermicompost and integrated treatments with soybean green manuring were found at par with each other. No significant difference in yield under two method of cultivation was observed in both the crops.

Table 6. Yield of turmeric and ginger (t/ha) under different method of cultivation and organic management practices

Treatment	Turmeric		Ginger	
	Rhizome yield	Stover yield	Rhizome yield	Stover yield
Flat bed	27.8	5.0	6.2	0.13
Raised bed	30.5	5.3	10.0	0.24
CD at 5per cent	NS	0.71	2.2	0.024
FYM+ RP +soybean green manuring	29.0	5.2	8.2	0.14
VC + RP +soybean green manuring	27.2	4.8	7.0	0.16
FYM + VC+soybean green manuring	29.8	5.0	12.4	0.18
Farmer's practice	20.6	3.0	5.0	0.14
CD at 5per cent	2.79	0.50	1.56	0.13

Groundnut

Twelve organic nutrient management combinations were tested to find out suitable organic nutrient source for groundnut in mid hills of Meghalaya during *kharif*, 2008 (Table 7). Application of FYM (10 /ha) along with rock phosphate (150 g/ha) and neem cake (150 g/ha) produced maximum pod yield (35.5 q/ha) followed by FYM 10 t/ha + RP 150 kg/ha. Application of fresh biomass of *Indigofera*, *Ambrosia* and *Eupatorium* spp. with and without FYM/VC increased pod yield significantly over control.

Table 7. Groundnut productivity (q/ha) as affected by source of nutrient supply

Treatment	Pod yield (q/ha)
Control	20.8
FYM @ 10 t/ha	31.9
FYM 10 t/ha + RP 150 kg/ha	35.1
FYM 10 t/ha + RP + neem cake 150 kg/ha	35.5
Vermicompost @ 5 t/ha	25.1
Vermicompost @ 5 t/ha + RP 150 kg/ha	26.1
Vermicompost @ 5 t/ha + RP RP 150 kg/ha + neem cake 150 kg/ha	29.4
Ambrosia/Eupatorium green biomass @ 15 t/ha	28.4
Indigofera green biomass @ 15 t/ha	29.5
FYM @5 t/ha + *Indigofera* @10 t/ha	31.2
FYM @5 t/ha + *Ambrosia/Eupatorium* green biomass @ 10 t/ha	29.9
Bun with FYM @ 10 t/ha	31.8
CD at 5per cent	**3.11**

Weed management in maize-mustard cropping system

An experiment on weed management under organic farming in maize-mustard cropping systems was carried out during *kharif* seasons. It was observed that mulching with

fresh *Ambrosia/ Eupatorium* @ 10 /ha after earthing up and one hand weeding at 60 DAS was found effective in reducing weed growth and produced significantly higher seed yield (37.8 q/ha) compared to all other treatments except mulching with fresh *Ambrosia / Eupatorium* @ 10 /ha after earthing up without weeding. Mulching has also shown a positive effect on yield of succeeding mustard crop and registered maximum seed yield (14.9 q/ha) in the particular treatment which was found significantly higher than other treatments. Soybean green manure incorporation might have added some nutrients to the soil resulting significantly higher seed yield (10.1 q/ha) in mustard.

Summary

There is lot of scope for organic agriculture in the hills especially in the north eastern region of India. Firstly, the use of inorganic fertilizers and chemicals is meager in the region. The farmers of the region, in general and hill farmers in particular are having apathy towards use of agro-chemicals. Secondly, the fruits of green revolution could not benefit the farmers of the hills as the system of production in the hills remained low input-low risk-low yield technology and the average yield of most of the crop remained far behind. It is assumed that the difference in production gap due to adoption of organic agriculture is expected to be negligible; rather there is scope for enhancing productivity with good organic management, the organic premiums would boost earning of the hill farmers. Thirdly, it is an added advantage that all the households are maintaining livestocks (pig, poultry, cattle, goats, etc.) producing sufficient quantity of on-farm manures, which could be efficiently used for organic agriculture. Moreover, the north eastern states being the one of the mega biodiversity receiving very high rainfall (2000 mm to 11000 mm per annum) leads to profuse production of biomass including weeds, shrubs and herbs. Some of these species could be efficiently used in organic production. The North Eastern Region is home to some niche crops like Assam lemon, Joha rice, Medicinal rice and Passion fruits. The region is also known for good quality ginger, turmeric, large cardamom, tea, orange, pine apple etc. Organic is likely to have a very good demand in domestic and international market. The major challenges for promotion of organic farming in the region are benchmark survey for identifying the potential areas, research needs for development of appropriate technology, human resource development in organic input production, assistance to farmers in post harvest handling, processing and value addition, reduction of certification cost, creation of infrastructure and marketing of organic produce.

The results of different experiments indicated that the productivity of crops under organic farming either maintained or improved over the years. Thus, it can be very well established that there is lot of scope for sustaining productivity of crops by improving soil quality through organic farming especially in the areas like North Eastern Region of India. For successful organic farming the resources available should be effectively used and a holistic approach should be adopted. Green manuring, mulching, crop rotation, use of biological pesticides, indigenous knowledge should be used together in a proper balance for maintaining productivity and increasing farmer's income.

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