Salient achievements of Division of Plant Breeding

- Developed and released 12 varieties of rice for upland, mid-altitude lowland, valley land and high altitude ecology.
- A pea variety developed at the Tripura centre has been identified by the variety identification committee.
- RCM – 11, a genotype developed at Manipur centre passed AVT2 in AICRIP and will be considered by Variety Identification Committee for central release.
- Three genotypes RCPL1-18C, 1-62C and 1-63C are in large scale on farm testing for final yield evaluation.
- Validated performance of 6 high yielding fine grain genotypes. Three genotypes RCPL1-72, 1-75 and 1-160 were promising and recommended by IFAD in their Technology Advisory Note.
- Two upland genotypes RCPL1-115 and 1-116 (3.2 – 3.8 t/ha) were identified through participatory selection and proposed for release.
- Developed a weed competing upland genotype of rice (RCPL1-129 – 2.9 t/ha, 135 days). The genotype was recommended by IFAD in their Technology Advisory Note.
- Collected and deposited more than 3000 crop germplasm from North East India.
- Characterized 600 germplasm and developed catalogue with 40 characters for 400 germplasm.
- Physical and nutritional quality analysis of popular rice varieties and germplasm of NE region were taken up. Total 723 were analyzed.
- Identified one OPV maize genotype showing QPM character (tryptophan 0.86, lysine 3.87g/16gN)
- Two gene pools, white (74.25g/pl) and yellow kernel (81.2g/pl), created from the germplasm through selection.
- RCM1-1 & 1-3 revalidated and would be proposed for release this year
- Two FELS resistant soybean lines (RCS1 & RCS9) developed.
- A composite of toria developed from local germplasm and having yield potential better than M27 has been identified.
- Dwarf photo-insensitive Ricebean for Spring Season has been developed.
- Standardized protocol for genetic transformation of chickpea
- Standardized diversity analysis of rice of NE region
- Preliminary diversity analysis of king chili completed and 12 polymorphic markers identified.

- Standardized a population-based diversity analysis protocol and tested with ginger germplasm collection in collaboration with Horticulture division.

Raised and Sunken Bed Technology for Marshy Land

Area in NER	2.0 lac ha
Area in Meghalaya	1557 ha
No. of crops / year	2-3
Depth of marshy soil	0.5 – 1 m

A typical marshy land

Raised and sunken bed technology has been developed and validated by the Institute. Under this technology the soil from one area is cut and used for filling the nearby area. This helps in improving the soil physio-chemical condition and improves crop productivity. Depending upon the depth of marshy soil various land configurations are used. The land configuration may be permanent or temporary. The temporary raised beds are made after harvesting of lowland rice and used mainly for cultivation of vegetables. Under such land configurations the sunken areas is left unutilized, as a results about 20-40 % land is wasted. Whereas, permanent raised and sunken beds configuration are used for cent per cent land utilization. Here vegetables and other arable crops are grown on raised beds and rice, fish etc. are grown on sunken beds.

- A raised and sunken beds ratio of 40:60 with raised bed height of 40 cm found optimum for a marshy soil depth of more than 50 cm. In this case carrying of additional soil from outside the field is not required.
- Whereas, a 50:50 of ratio raised and sunken beds was found optimum for a soil depth upto 50 cm

Cabbage + Pea intercropping in raised beds **Broccoli + pea intercropping in raised beds**

50:50 ratio raised and sunken beds

Important crops to be grown in raised beds

Cereal	Rice and Maize
Oilseed	Rapeseed and Mustard and Linseed
Pulses	Greengram, Blackgram and Ricebean
Vegetables	Cauliflower, Cabbage, Broccoli, Carrot, Radish, Methi, Coriander, Pea etc.

Options for sunken beds

Rice : rice rice, rice - ratoon

Fish : common carp @ 6000 fingerlings/ha

Food grain security

At least 25% of the total marshy land (40 th ha) in NER can be brought for cultivation crop with raised and sunken bed technology

Additional land for cultivation	= 40,000 ha
Area under raised beds available for upland rice	= 16,000 ha
Rice production on raised beds @ 2.5 t/ha	**= 40,000 t**
Area under sunken beds available lowland rice	= 26,000 ha
Lowland rice production @ 3.0 t/ha	**= 78,000 t**
Total rice production form these waste land	**= 1,18,000 t**

The raised bed area of 16,000 ha will be utilized for production of rabi crops

Rabi crops Oilseeds in 8,000 ha raised bed area with a production @ 1 t/ha **= 8000 t**

Pulses in 8,000 ha raised bed area with production @ 1 t/ha **= 8000 t**

RICE

Technology options for improving rice productivity in the region are given below:

Variety: The identified suitable varieties of rice for the region are presented in Table 1.

Table 1. Varieties suitable for different locations of the NEH region

State	Variety	Salient features	Ecosystem
Meghalaya	Bhalum – 1	3.5 – 3.8	Main *kharif*, mid altitude upland, suitable for jhum land
	Bhalum – 2	3.0 – 3.5	- do -
Tripura	MTU 7029 (Swarna)	145-160 days, widely adaptable, 4-6 t/ha	Lowland
	Naveen	Less disease problem 100 days duration	Lowland

SRI method of rice cultivation

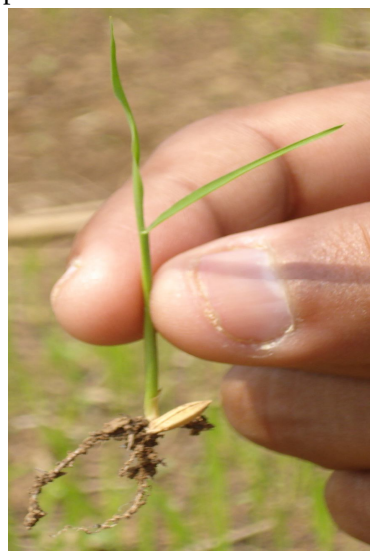
SRI method of rice cultivation developed in Madagascar not only produces 15 – 20 % higher yield than conventional method of rice cultivation, but also saves 35 – 40 % of water requirement crop also matures 15 – 16 days methods. SRI method of rice cultivation is highly suitable in low altitude area of Tripura, Garo hills of Meghalaya, Pasighat of Arunachal Pradesh and other low altitude areas of NEH region. During boro season, adoption of SRI method is very useful as it gives very high yield with less use of water. SRI method is also useful in mid altitude area.

SRI method

- Use 10 – 12 days old seedlings
- Plant spacing 25 cm x 25 cm
- Use one seedling per hill
- Use maximum organic manure
- Maintain very shallow depth of water

SRI and ICM Rice Culture

For SRI 10 days old seedling @ 1 seedling/hill with 25 x 25 cm spacing and for ICM 20 days old seedlings @ 2 seedlings/hill with a spacing of 20 x 20 cm spacing is given. Whereas, under conventional rice culture (CRC), 30 days old seedlings @ 3 seedlings/hill with a spacing of 20 x 15 cm spacing is in practiced. For SRI and ICM improved nursery practice i.e. MMN (modified mad nursery) is followed for getting robust healthy seedlings. A well leveled field with drainage channels after every 10 – 15 rows (2.5 – 3 m) is given for water management. A thin film of water is maintained instead of continuous flooding. Water is applied when ever hairy cracks appears in the field. A good amount of organic manure (10 – 15 t/ha) should be applied alongwith a low dose of NPK (40:30:20 kg/ha) for better result. Frequent (10 – 15 days interval) mechanical disturbance is given with conoweeder (or local weeder) for weed management, incorporation of weed biomass and better soil respiration



10 days old seedling ready for transplanting (SRI)

A good crop of rice under SRI at ICAR, Umiam

Advantages of SRI/ICM

- Save resources and increase resource use efficiency like fertilizers, water, labour etc.
- Requires only about 5-7 kg seeds (SRI), 15-20 kg (ICM) compared to about 50 kg under conventional transplanting.
- Matures about 15 days (SRI) and 7 days (ICM) earlier compared to CRC.
- Save upto 40 % water as alternate wetting and drying is practiced instead of continuous flooding.
- Gives on an average 15-20 % higher productivity under NE condition.
- Improves soil health and conserves ecosystems
- Good for seed production as single seedlings is transplanted under SRI.

Scope of SRI in North East

The rice productivity in the region (1.6 t/ha) is much lower than the national average (2 t/ha). The research results indicated that it is possible to increase rice productivity by 15- 20 % with SRI and ICM (integrated crop management- an intermediate practice between SRI and CRC) rice culture in the region. The five years research results at ICAR, Umiam also proved the same. The state of Tripura has made a significant progress in SRI and about 20 % rice area in the state is already brought under SRI/ICM. Garo hills in Meghalaya also has done some progress in this front and has the scope for further Development. Similarly, other state has initiated the work. Of late, ICM is gaining popularity, mainly because of less risk involved, easy to adopt and higher productivity.

SRI method of rice cultivation

SRI method of rice cultivation developed in Madagascar not only produces 15 – 20 % higher yield than conventional method of rice cultivation, but also saves 35 – 40 % of water requirement crop also matures 15 – 16 days methods. SRI method of rice cultivation is highly suitable in low altitude area of Tripura, Garo hills of Meghalaya, Pasighat of Arunachal Pradesh and other low altitude areas of NEH region. During boro season, adoption of SRI method is very useful as it gives very high yield with less use of water. SRI method is also useful in mid altitude area.

SRI method

- Use 10 – 12 days old seedlings
- Plant spacing 25 cm x 25 cm
- Use one seedling per hill
- Use maximum organic manure
- Maintain very shallow depth of water

ICM method of rice cultivation

ICM method of rice cultivation developed by IRRI, Philippines is also a better method of rice cultivation compared to conventional method. ICM also produces 15 – 20 % higher yield than conventional method of rice cultivation. ICM method of rice cultivation can be adopted under low altitude, mid altitude during *kharif* as well as in boro season.

ICM method

- Use 20 days old seedling
- Plant spacing 20 cm x 20 cm

- Use two seedlings per hill
- Use fertilizer and manure
- Maintain shallow depth of water

Conventional method

- Use 28 – 30 days old seedlings
- Plant spacing 20 cm x 15 cm
- Use three seedlings per hill
- Use maximum inorganic fertilizer
- Maintain ± 2.5 cm depth of water

Agri-horti system

A number of field crops such as turmeric, ginger, groundnut, soybean, taro were cultivated with fruit trees such as Assam lemon, Khasi Mandarin and Guava to develop a suitable agri-horti system in the region. Among the various tree-crop combination, Khasi mandarin – ginger was the best combination. Annual yield of Khasi mandarin with a population density of 400 tree per ha and ginger were 23 t ha^{-1} and 17 t ha^{-1}, respectively. This could generate net annual income of Rs 33,000 per ha per annum on the basis of 1990 price.

MPT based agroforestry system

Multipurpose tree species such as *Alnus nepalensis, Gmelina arborea*, *Michelia oblonga, Parkia roxburghii*, *Prunus cerasoides* and *Symingtonia populnia* were planted at a density of 416 trees per hectare. Cash crops such as ginger, turmeric, pineapple, soybean were cultivated with these tree species. In terms of economic productivity, *Perkia roxburghii* and Pineapple (var. Kew) was the best system. Wood volume productivity of *Perkia roxburghii* was about 70 m^3 ha^{-1} which could generate an annual return of Rs 30,000 ha^{-1}. Pineapple which was cultivated as an understorey crop with a plant population of 36,625 ha^{-1}, generated net annual return of Rs. 19000 ha^{-1}.

Development of alder-tea and alder-tea agroforestry system

To optimize resource utilization in vertical plane and enhance economic productivity tea and large cardamom were cultivated in association with alder. Yield of alder pruned biomass and foliage biomass were 8.5 q ha^{-1} and 24 q ha^{-1}, respectively. Yield of green tea buds and large cardamom were 59 q ha^{-1} and and climbers 6.4 q ha^{-1}, respectively.

Selection of Mulberry varieties suitable for the NEH region

Seven Mulberry varieties such as TR-4, TR-10, BC-259, S-1635, C-7635, Kanva-2 and Meghalaya local were screened for their growth and productivity. Silkworm NB-18- a bivoltine breed was reared to evaluate the palatability and cocoon productivity. Among these Mulberry varieties, TR-4 was produced highest green leaf (19 t ha^{-1} yr^{-1}), fuel wood (6.4 t ha^{-1} yr^{-1}) and cocoon (0.81 t ha^{-1} yr^{-1}). Performance of TR-4 and S-1635 were not unsatisfactory.

Development of sericulture based agroforestry system

The varieties of Mulberry TR-4, TR-10 and S-1635 were raised and sericulture was practiced on it. Combination of sericulture with field crops (French bean-groundnut-mustard/vegetables) for valley land, fruit crops (guava, pine apple) and grasses for mid hill situation and rice for low land were found suitable.

Intensive Integrated Farming System

Intensive integrated farming system (IIFS) is based on the concept that there is no waste and waste is only a misplaced resource which can become a valuable material for another product. It is a more refined and holistic approach of land use system through practices in which a number of production components are integrated with the primary objective of developing a self sustainable system. In IIFS all the components of agriculture like crop, fish, forestry, horticulture are integrated in a complementary way. Keeping in view the agro-ecological situation of the place and socio-economic condition of local people and farmers preference, six models in IIFS were developed. Size of each model was restricted to 1 ha so as to represent majority of the farming community in the region.

Land use system	Investment (Rs ha^{-1})	Output/ input ratio
➢ Poultry -crop- fish-duck-horticulture along with hedgerow on contour bunds	1,05,722	2.24
➢ Crop-fish-poultry-multipurpose trees	60,137	2.12
➢ Crop- fish-goat -multi purpose trees	59,442	2.40
➢ Crop- fish-pig – vermicompost bamboo-multipurpose trees hedgerow-broom	77,273	1.86
➢ Crop- fish-dairy – mushroom vermicompost - horticulture hedgerow	1,70,120	2.48
➢ Crop-fish without integration (control)	31,773	1.50

Soft wood grafting in Khasi mandarin

Soft wood grafting is used as an alternative method for raising the quality planting material of Khasi mandarin. Soft wood grafting should be done in July-August on 60 to 90 days old rootstock. Previous season's 3-4 months old shoot is ideal for this technique. Leaves are removed from the rootstocks leaving 2-3 leaves before grafting. Defoliated scion is inserted into prepared rootstock by simple wedge grafting and wrapped with polythene strip. It gave >80% graft success depending upon the rootstocks.

Khasi mandarin plants produce through soft wood grafting

Promising guava cultivars/ hybrids developed

Four promising guava varieties/hybrids have been developed at ICAR Research Complex for NEH Region, Umiam and are in multilocational trial in different parts of Meghalaya, Arunachal Pradesh and Assam.

RCGH-1: Hybrid of Sour type X Red fleshed local. Plant growth upright erect with dark green broad leaves. Yield 35 kg/tee, fruit medium (125-160 g) size, greenish yellow in colour with red dots at ripening, pulp white, sweet taste, less seed, TSS (11-11.2%), acidity (0.39-0.40%) and Ascorbic acid content (240-255mg). Fruiting one week earlier than other guava variety. Suitable for fresh consumption.

RCGH-7: Hybrid of Lucknow-49 X Pear shaped guava. Plant growth erect. Yield 30.5 kg/tree, medium size fruit (115-150 g) size, light green in colour at maturity, pulp white, sweet taste, less seed content, TSS (11.4-11.8%), acidity (0.31-0.35%) and Ascorbic acid content (210-225mg). Suitable for fresh consumption.

RCG-11: Seedling progeny selection from Meghalaya. Plant growth semi spreading type. Yield 32.5 kg/tree, medium size fruit (110-145 g) size, light green colour at maturity, pulp white, sweet taste, less seed, TSS (11.2-11.4%), acidity (0.36%) and Ascorbic acid content (205-215 mg). Suitable for fresh consumption.

RCGH-4: Hybrid of Red fleshed X Allahabad Safeda. Plant growth semi spreading type. Yield 28.5 kg/tree, fruit medium to big size (170–200 g), greenish yellow colour at maturity, pulp red, sweet taste, TSS (10-10.4%), acidity (0.45-0.58%) and Ascorbic acid content (200-215 mg), suitable for processing purpose.

Standardization of suitable time for grafting of guava

Wedge grafting should be done during February-March on pencil thickness one year old rootstock. The scion shoot 15 to 18 cm long of pencil thickness (0.5-1.0 cm) with 3-4 healthy buds is used for grafting. Rootstock is headed back about 15 cm above the ground level and then, the beheaded rootstock is split to about 3.5 to 4.0 cm deep through the center of stem with grafting knife. A wedge shaped cut, slanting from both the sides (3-4.0 cm long) is made on the lower side of the scion shoot. The scion stick then inserted into the split of the stock and pressed properly. The union is then tied with the help of 150 gauge polythene strip.

Standardization of propagation techniques for Sohiong (*Prunus nepalensis*)

The well ripens fully blackish/purplish coloured fruits were collected during September for seed extraction purpose. The seed were extracted from fruit by removing the pulp and then seeds were soaked in water for about 3-4 days for fermentation of pulp adhering on seed. After that seed were washed in water and put for drying under shade for 24 hours. The dried seeds were kept for 3-4 weeks in a pot under alternate layer of moist sand for stratification. The

rupture of seed coat was observed at 3 weeks of stratification and then these ruptured seed were sown in nursery about 5 cm deep during October. About 65 % seed was ruptured during stratification process and > 95% germination was occurred. The germination of sohiong seed may be increased up to 80% with seed treatment of GA3 @ 100 ppm..

Wedge and tongue methods of grafting were performed on one year old seedling of sohiong rootstock during IInd week of October. >80% Graft success was achieved under both the methods.

Standardization of Nutrient and spacing of strawberry

Among the different combinations of NPK dose and spacing, 100:60:120 kg NPK/ha at a spacing of 30x30cm recorded maximum growth and yield with best quality fruits

Technology standardization for runner production of strawberry

1.2 x 1.2m (plant to plant and row to row) is the optimum spacing for runner production. For greater survival and fast growth, the runners should be lifted in September and planted in poly bags (1 soil: 1 Sand: 2 FYM) for one month.

Off-season production of strawberry under low tunnels

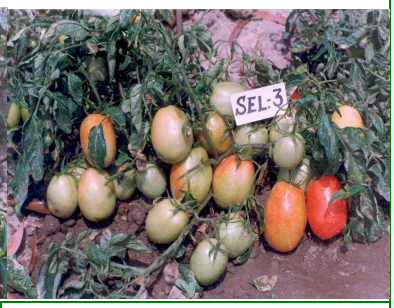
Planting of strawberry in low tunnels of 50% shade net in the month of July or August produces fruits 30-35 days earlier than normal planting. Fruit availability may be extended to 47 days by planting in the month of November under UVS polythene tunnels.

Effect of pruning time on early fruiting of peach

Peach cv. TA-170 was pruned on 30th October, 15th November and 30th November (normal pruning time). Earliest shoot emergence was recorded in 30th October pruned trees, which also produced flower (100%) and fruits 12-15 days earlier than normal pruning date.

TOMATO VARIETIES DEVELOPED

(Three varieties have been developed)

MANIKHAMNU (SEL-1)	MANILEIMA (SEL-2)	MANITHOIBI (SEL-3)
		
Yield: 533 q/ha	**Yield : 630 q/ha**	**Yield: 637 q/ha**

- Early maturing (85-90 days)
- Tolerance to fruit cracking and moisture stress
- Fruits are medium size, round and smooth with 2-3 locules
- Flesh is thick and juicy, suitable for processing and consumption purpose
- These varieties have been recommended for rice based cropping system during spring summer season
- These varieties have been released by State Variety Release Committee, Manipur in 2000
- AICRP on Vegetable Crops recommended Manileima (Sel-2) for zone III (entire Northeast and Andaman & Nicobar Island)

Varieties developed (to be released)

Megha Tomato-1

- Plants are semi-indeterminate with profuse branching
- Fruits are round, smooth and attractive in colour
- Tolerant to bacterial wilt and late blight diseases under field condition
- Average yield 500 q/ha

Megha Tomato-2

- Plants are semi-indeterminate and bear roundish oval fruits with shallow ridges on surface
- Suitable for cultivation during rainy season for blight and wilt susceptible areas
- Average yield 450 q/ha.

BRINJAL

Varieties developed (to be released)

RCMBL-3

- Moderately resistant to bacterial wilt
- Yields 400 q/ha in rainy season

RCMBL-2

- Fruits are 8-10 cm long and clustered
- Average yield 350 q/ha
- Moderately resistant to bacterial wilt

COLOCASIA

Varieties developed (to be released)

ML-1

- Corms are 10-12 cm in length and 5-6 cm in diameter with 6-7 small to medium sized cormels
- Moderately resistant to leaf blight of colocasia
- Average yield 27 t/ha

ML-9

- Average yield 22 t/ha
- Moderately resistant to leaf blight (*Phytophthora colocasae*)

Megha Turmeric-1

- Developed through clonal selection from the local genotype Lakadong.
- Tolerant to leaf blotch and leaf spot.
- Maturity: 300-315 days.
- Average yield: 27-30 t/ha.
- Curcumin content 6.8%.
- Dry matter content: 16.40 %

Dolichos bean *(Dolichos lablab)*

RCDL-10

- A photoinsensitive, bush type pure line selection
- Sown from April to September at a spacing of 80x 40 cm.
- Harvesting stats after 75 days of sowing
- Green pod yield 140-150 q / ha.
- Tolerant to aphids, leaf spot and powdery mildew

French bean *(Phaseolus vulgaris)*

RCFB-48

- A pole type selection from local material collected from Silchar
- Pods are flat and remain tender at harvesting
- Average yield 112 q/ha in August sowing

DISEASE PROTECTION TECHNOLOGIES

MUSHROOM

Management of mushroom pest:

- Application of Neem based pesticide Rakshak @ 0.15% and Neemark @ 0.03% results in low infestation (1.97%) of insect pest and 42% and 28% increase in yield respectively.
- Formalin @ 4% applied by cotton swab controls mould affected patches in oyster mushroom blocks /bags.

Improved production technology

- High yielding strains of oyster mushroom i.e. *Pleurotus sajor caju* PSC 04 has been identified for summer cultivation .This strain gives 972g/ kg of dry paddy straw.
- *P. flabellatus* (B) gives average yield of 890g / kg of dry paddy straw during Jan-Mar grown crops.
- Hot water treatment (80^0C for 20 min) and chemical sterilization technique (Formalin 500 ppm + Carbendazim 75 ppm soaking for 18 hrs.) were found equally effective for pretreatment of paddy straw.
- Paddy grain based spawn production technology standardized.

GROUNDNUT

- The variety ICGS-76 has been identified as tolerant to early leaf spot (ELS) disease and it gives 2958 kg/ha pods in unsprayed crops.
- Single spray of Dithane M-45 @ 2.6 g + Bavistin 1 g/lit at 40-55 days old crop controls ELS disease economically in high yielding susceptible variety JL-24.

RICE

Tricyclazole @ 0.05% fungicides for the control of blast disease and seed soaking with carbendazim for 12 hours. Sowing in April May for disease escape.

MAIZE

Genotypes DMR-1326, DMR-1327, DMR-1328, NECH-131, NECH-132, KAVERI-218, BH- 4062, BISCO-855, MCH-35, FH-3356, FH-3358 genotypes were identified as resistant to Turcicum leaf blight.

IPM TECHNOLOGIES

- IPM technology for the control of brinjal fruit and shoot borer (BFSB) was refined and validated.
- Indigenous technology for attraction of rice gundhi bug by using rotten crab on the stack was improved and validated
- Two species of entomopathogenic nematodes viz. *Steinernema carpocapsae Heterorhabditis indica* were isolated, multiplied and evaluated against brinjal fruit and shoot borer (BFSB)

- Standardization of doses of botanicals viz., anonin and karanjin against cob borer and stem borer of maize, aphids, diamond back moth, cabbage butterfly, blister beetle and red cotton bug
- Local strains of entomopathogenic fungi were isolated, multiplied and doses were standardized. *Beauveria bassiana* @ 3.5 g / litre against blister beetle and pod boring weevil, *Metarrhizium anisopliae* @ 2.5-3g / litre against white grub and *Verticillium lecanii* @ 3g / litre against white backed plant hopper proved effective.
- Potential bioagent viz., *Trichogramma japonicum* @ 50000/ha (5-6 releases from 30 DAT) against yellow stem borer of rice and *Coccinella septumpunctata* against mustard aphid were standardized for their use in IPM

B. bassiana for controlling pod weevil in pigeonpea

Improved crab trap for controlling gundhi bug in rice

M. anisopliae for controlling plant hopper in rice

Developed for Soil Health Management

- A Decision Support System on fertility management of soils has been developed to access block level detailed soil test database, district wise soil fertility map, acid soil amendment module besides e- package of practices for major crops and their nutrient recommendation module of Mizoram. This is a web based system and can be of immense help for the planners, researchers and primary stakeholders as it provides a number of information's at one platform.

- Soil Testing kit for acid soil
- Soil Test based fertilizer response to targeted yield of developed for rice, maize and soybean.
- From field trials, varieties of soybean (TS 80-1), Groundnut (ICGS-76) and Rajmas (Amber, Arkakomal and HUR-14) found comparatively tolerant to soil acidity.

- Application of 250-500 kg lime/ha in furrows to each crops in sequence can optimized the productivity of maize, soybean, groundnut and wheat, which are almost 15-20 times less the broadcast application of lime.

Effect of liming on maize

- The application of fertilizers can be reduced to 50% with application of FYM and lime in furrows to get the optimum yield of crops.
- A ready lime to achieve the target soil pH (5.5) has been developed taking into consideration of soil organic matter, clay content and pH, to be adopted by the soil testing laboratory for liming of acid soils.
- The leaf analysis of various mandarin orchards of the region indicated that the Nitrogen is the most limiting nutrient.

Table . Lime requirement of soils to achieve the pH 5.5 as affected by pH, organic matter and clay content of soils (t/ha)[*]

Soil	Organic matter, 2%				Organic matter, 4%				Organic matter, 6%				Organic matter, 8%			
pH	Clay (%)				Clay (%)				Clay (%)				Clay (%)			
	10	15	20	25	10	15	20	25	10	15	20	25	10	15	20	25
4.5	3.56	3.83	4.11	4.39	3.72	4.00	4.28	4.56	3.89	4.17	4.44	4.72	4.05	4.33	4.61	4.89
4.6	3.15	3.42	3.70	3.98	3.32	3.59	3.87	4.14	3.49	3.77	4.04	4.32	3.66	3.93	4.21	4.49
4.7	2.74	3.01	3.29	3.60	2.91	3.18	3.34	3.62	3.08	3.36	3.63	3.91	3.24	3.52	3.80	4.08
4.8	2.25	2.53	2.81	3.09	2.42	2.70	2.98	3.26	2.59	2.87	3.14	3.42	2.76	3.03	3.31	3.59
4.9	1.93	2.22	2.49	2.75	2.10	2.38	2.66	2.93	2.27	2.54	2.82	3.10	2.43	2.71	3.00	3.27
5.0	1.52	1.80	2.08	2.35	1.69	1.97	2.24	2.52	1.86	2.13	2.41	2.69	2.02	2.30	2.58	2.86
5.1	1.11	1.40	1.68	1.94	1.29	1.56	1.84	2.12	1.46	1.73	2.01	3.29	1.62	1.90	2.18	2.46
5.2	0.71	1.00	1.27	1.56	0.90	1.16	1.43	1.71	0.06	1.33	1.61	1.90	1.22	1.50	1.78	2.06
5.3	0.31	0.59	0.86	1.13	0.48	0.76	1.03	1.31	0.64	0.92	1.20	1.48	0.81	1.09	1.37	1.64
5.4		0.18	0.44	0.72	0.07	0.34	0.62	0.90	0.23	0.51	0.82	1.10	0.40	0.68	0.96	1.23

- Agricultural dolomitic limestone passed through 100-mesh sieve and average neutralizing power 90% equivalent to pure limestone.

Micro Rain Water Harvesting Structure for Hills - *Jalkund*

Water resource and constraints

Annual average rainfall of the region is 2450 mm accounting for 10% (42.0 Mha m) of the country's total water of 420 Mha m. In spite of its rich water resources base, the region has not progressed to the expected level.

It can till date utilize only less than 1% of water resource (0.88 Mha m of water). Remaining more than 41.0 Mha m water is lost annually due to its major portion being hilly. This also depletes the soil fertility and imbalance the ecology of the region.

The practice of rainwater harvesting in ponds and reusing the stored water for life saving irrigation of crops and also for domestic purpose is prevalent in India since ancient times. One can find efficient management of water in the region in traditional farming systems like 'Zabo system' of Nagaland and Bamboo drip irrigation of Meghalaya and rice + fish farming in *Apatani* valley of Arunachal Pradesh.

Inspite of its high rainfall, there is acute shortage of even drinking water during dry season ie, Nov to April in the region. Due to lack of irrigation facilities, a second crop is not possible in uplands, as a result cropping intensity is very low (120%) in the region. The problem is especially grim in hill tops.

A simple rain micro rain water harvesting structure - *Jalkund* has been developed and popularize by the ICAR Complex Umiam to solve the problem of water scarcity to a great extent.

***Jalkund* technology**

The Institute has developed the low cost, simple, polythene based micro rain water harvesting structure for hill top.

The capacity of a Jalkund is 30,000 litres at Rs. 6055. The cost of per litre harvested water was computed at Rs. 0.067 per litre considering 3 years life span of lining material.

Each *Jalkun*d can harvest approximately one and half times its original capacity considering replenishment of the pond by intermittent rains and consequent evaporation loss of about 10%.

Subsistent farmer investing in micro water harvesting structure like *Jalkund* and its recycling can increase productivity and diversify their homestead farming to growing remunerable crops and rearing cattle, pigs, poultry, etc.

From each Jalkund, the farmer can grow 250 tomato plants with 18,000 litres water and the remaining 12,000 litres can be used for rearing 3 piglets or 10 ducks and 100 fish or 50 poultry birds.

Jalkund* construction mechanism*:

- Excavation of the pit of the 4 x3 x 1on selected site (preferably at hill top/uplands) before the onset of monsoon.
- The bed and sides of the *kund* should be levelled by removing rocks, stones or other projections, which otherwise might damage the lining material.
- The inner walls, including the bottom of the *kund*, to be properly smoothened by plastering with a mixture of clay and cow dung in the ratio of 5 : 1
- After clay-plastering, about 3–5 cm thick cushioning should be done with locally and easily available dry pine leaf (@ 2–3 kg/sq. m) on the walls and bottom, to avoid any kind of damage to the lining material from any sharp or conical gravel, etc.
- This should be followed by laying down of 250 mm LDPE black agri-film or Silpauline sheet. The agri-film sheet should be laid down in the *kund* in such a way that it touches the bottom and walls loosely and uniformly, and stretches out to a width of about 50 cm all around the length and width of the *kund*. A 25 x 25 cm trench should be dug out all around the *kund* and 25 cm outer edge of agri-film may be buried in the soil, so that the film is tightly bound from all around. At the same time, side channels all along the periphery of

the *kund*, helps to divert the surface run-off and drain out excess rainwater flow. This is to minimize siltation effect in the *kund* by allowing only direct precipitation. Silpaulin sheet (250 GSM) can be also used for longer duration in place of LDPE black agri-film.

- *Jalkund* is covered with thatch (5-8 cm thick) made of locally available bamboo and grass. Neem oil (10ml/sq.m.) is also advocated to reduce evaporation in off season.

***Jalkund* with silapaulin lining**

Demonstration in farmers field

Silapaulin lined *Jalkund* filled with rain water

The *Jalkund* technology has been demonstrated in 111 farmers' fields of four NEH states namely, Manipur, Meghalaya, Nagaland and Tripura (71 units through Farmers Participating Action Research Programme, Ministry of Water Resources and 40 units through NABARD). A strawberry farmer of Umroi Madan village of Ribhoi District, Meghalaya could earn more than Rs.50,000/- in a year using water from *Jalkund*

***Jalkund* filled with rain water**

Strawberry cultivation in Umroi Madan

Cono Weeder

Cono weeder is manually operated weeding equipment with long handle. The blades are fitted on two set of cones to perform weeding operation in between the paddy rows without bending the posture of the operator thus reducing drudgery of work. It performs well in standing water condition.

Specification-

Dimensions	: 1.74m ×0.20m × 0.94m
Weight	: 6.7 kg
Number of persons required	: 1
Width of coverage	: 140 mm
Field capacity:	: 0.36 ha/h
Price	: Rs. 900/-

Sustainable Farming System Models Developed by ICAR on Micro Watershed Basis;

Since establishment of the ICAR Research Complex for NEH Region in Barapani, Meghalaya work on two major research project on (i) "Alternative Farming System to replace Jhuming" at Byrnihat in 1975 and (ii) "Micro-watershed based land use planning for Hills" in 1983 at Umiam (Barapani) known as Farming System Research Project (FSRP) were under taken. Eight different micro-watershed based farming systems were established and evaluated for last two decades under this FSRP. The suitable farming system models have been developed on micro watersheds which are economically viable and sustainable. The agronomic and mechanical conservation measures were employed to reduce the soil and water loss from the cultivated field. Among them promising and most suitable systems are like Agro-pastoral farming system, Agri-horti-silvipastoral farming system, Livestock based farming system, Horticultural based land use system, Horti-silvi farming system which are established with integration of livestock system in most of the cases and details of package and practices crops, vegetables on the upland terrace and other integrated component of animals (cows, pigs, goats, fish), fodders, etc. are formulated out. Agroforestry systems like, agri-horti-silvi-pastoral

View of the Farming System research Project (FSRP) at Umiam

system performed better over shifting cultivation and other traditional cultivation practices. The agroforestry intervention with suitable soil conservation technique is most viable alternative for natural resource management and could sustain long-term soil productivity in highly degraded soils.

Some selective models have been tried on Multi-location trial at the farmers field namely at Mawlankhar, Nongpoh etc. apart from model created under NWDPRA at Umroi, Mawpun, Mawthei, Umdohbyrthih at Meghalaya, at Peren – Jalukie in Nagaland and at Sajung in Sikkim.

Integrated farming system models at Mawlangkhar and Nongpoh

Salient features of Watershed Planning and Development

- **Delineation of watershed:** Survey of India topographical maps are used. Now-a-days satellite sensed imageries are extensively used for demarcation of watershed. Remote sensing technique and Geographic Information System (GIS) tools provide ways for rapid collection of field data and prompt data processing.
- **Identification of critical areas within the watershed:** Assumes significant importance for its effective treatment to reduce the sediment and pollutant load at the outlet of the watershed. Only a few critical areas within the watershed are responsible for disproportionate amount of the pollution.
- **Watershed planning:** To provide technological options for optimum utilization of available rainfall through improved water, soil and crop management and to create awareness among the farmers about better dry farming technology through adoption of a package of scientific agricultural practices.
- **Constitution of Planning team:** Includes specialists in agricultural engineering, soil and water conservation engineering, agronomy, hydrology, geology, horticulture, forestry, socio economics, livestock, financial analysis and micro-credit management.

- **Project components:** Land use planning, Moisture/soil conservation measures, water harvesting and drainage structures,Improved cropping systems and suitable agronomic practices rainfall analysis for over 35 years, Use of improved implements, Tree planting including horticulture and social forestry, and pasture development in community lands, Livestock development (dairy, poultry, piggery etc.), Non-farm activities, Small scale industries/cottage industries, Self helps groups, Women empowerment, Livelihood improvement activities, Credit, Marketing, Access roads, and Establishment of a project implementation cell etc.
- **Watershed development-** developing it completely within a reasonable period of 3-5 years. (i) Conservation, upgradation and utilization of natural resources or endowments like land, water, plant, animal and human resources in a harmonious and integrated manner, (ii) Protect and enhance water resources, moderate floods, reduce silting up of tanks and water bodies, increase irrigation, promote *in-situ* rainwater conservation and thus mitigate droughts (iii) Utilization of the natural and local resources for improving agriculture and allied occupation or industries, so as to improve the socio-economic condition of local residents, Employment generation etc.
- **Farmer participatory approach in watershed based planning for sustainable development:** Passive participation, Participation in information giving, Participation by consultation, Participation for material incentives, Functional participation, Interactive participation and Self-mobilization.
- **Community organizations in watershed management programme:** Participatory Rural Appraisal (PRA) tools can be effectively employed for ensuring people's participation in various stages of planning and implementation of watershed based programmes. Organizing the community into various groups termed as Self Help Groups (SHGs), User Groups (UGs), Watershed Association (WA), Watershed Committees (WC) and the like. Also role of Panchayati Raj Institutions.
- **Watershed treatment technologies for resource conservation:** (i) Agronomic/Biological measures: Land use *v/s* land capability, Crop rotation, Soil conserving crops, Soil building crops, Conservation tillage, Stubble–mulching, Cover crops, Green manuring, Contour farming, Strip cropping-contour strip cropping, field strip cropping, buffer strip cropping, Role of grasses, Afforestation, Agroforestry Contour hedgerows: Stylosanthus guyamensis, Shameta, thin napier and Seteria, Geojute technology, Multi-storied cropping system, Integrated farming or mixed farming. (ii) Engineering Measures : Contour bund-,Side bunds, Lateral bunds, Supplemental bunds, Marginal bunds , Bench terracing, Level bench terraces, Inwardly slopping bench terraces, Puertorican or California type of terraces, Half-

moon terraces, Contour trenching, Grassed waterways, Diversion drains, Crescent platforms/bunds, Check dams/Gully plugs and Ponds

- **Sustainable Farming System Models Developed by ICAR on Micro Watershed Basis:** Agro-pastoral farming system, Agri-horti-silvipastoral farming system, Livestock based farming system,Horticultural based land use system
- **Hydrological evaluation of land use systems:** Silvipastoral system and agri-horti-silvipastoral system showing the effectiveness of suitable soil conservation and appropriate land use system on hill slopes
- ***In –situ* moisture conservation in watershed areas:** Paddy straw, transparent polyethylene, sugarcane trash ,leaf mulching, maize stalk mulching etc. Live mulching consists of growing crops having dense foliage in between two rows of other crops to control evaporation as well as weeds. Generally fast growing leguminous crops such as sunnhemp are grown before or simultaneously with seasonal grain crops such as rice/maize and incorporated into the soil to act as mulch, which after decomposition supplies nutrients to the main crop as well.
- ***In-situ* green manuring and mulching:** Growing of sunnhemp (*Crotalaria* spp.) fixed nitrogen through the root nodules.
- **Rainwater harvesting technologies:** The rainwater can be collected in large plastic lined ponds. Generally big ponds are constructed and subsequently lined with plastic sheets like silpaulin, nylon or High Density Polyethylene (HDPE). Small quantity of rainwater/roof water can be harvested in closed plastic, ferro-cement or masonary tanks for potable purposes.
- **Roof water harvesting for ground water recharge:** Collecting and storing rainwater from rooftops, mostly in tanks. In domestic systems, rainwater from the house roof is collected in a storage vessel for scarcity periods. Excess roof top rainwater is diverted to existing open/bore well after filtration. Also rainwater available in open spaces around the building may be recharged into the ground through percolation pits (small houses) or recharge trench (big houses/apartments). Generally these pits are filled with pebbles or brick pieces to avoid water stagnation.
- **Watershed development with livelihood perspective:** does not confine itself to land-based development issues. The project positively encourages the flexibility required for local people to prioritize interventions to include viable non-agrarian activities Excess roof top rainwater can be diverted to the existing open/bore well after filtration. Along with this, rainwater available in open spaces around the building may be recharged into the ground through the simple effective methods such as percolation pits (small houses) or recharge

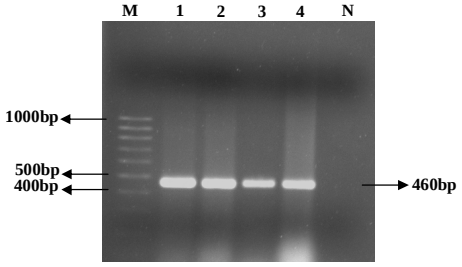
trench (big houses/apartments). Generally these pits are filled with pebbles or brick pieces to avoid water stagnation.

Molecular Disease Diagnosis

Molecular based methods for rapid diagnosis of important livestock and zoonotic diseases are standardized and employed. PCR based method for detection of *Brucella abortus, B. melitensis, B. suis* (brucellosis), *Pasteurella multocida* (swine pneumonia**),** *Clostridium perfringens* (enteric & myonecrotic diseases), *Salmonella* spp (salmonellosis), *E. coli, L. monocytogenes,* mesophilic *Aeromonas,* thermophilic *Campylobacter* spp and *Yersinia enterocolitica* (food-borne pathogens) are standardized. These methods are used for rapid diagnosis of bacterial diseases in animals and livestock. PCR methods for RAPD profiling are standardized and used for analysis. Plasmid profiles of the isolated bacteria are also analyzed and studied for their roles in diseases in animals and livestock.

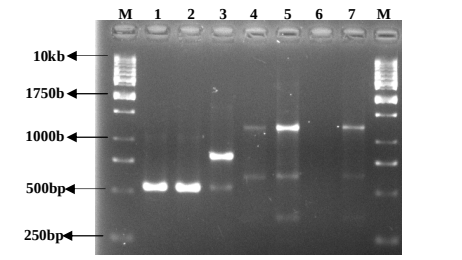
Salient features

- Development and use of comprehensive nucleic acid based & Ag-Ab diagnostic protocols for rapid, accurate and prompt diagnosis of livestock and poultry diseases in the region.



PCR based detection of *Pasteurella multocida* isolated from pig using *Pasteurella multocida*-specific PCR (PM-PCR, 460 bp). M- Marker, Lane (1-4) test organisms, Lane N-Negative

Reverse Transcriptase PCR (RT_PCR) was standardized and carried out for the detection of group A Rotavirus from the faecal samples. A Classical Swine fever virus **(**CSFV) specific Reverse Transcriptase PCR (RT_PCR) using primers specific for E2 gene of CSFV was standardized and carried out for screening clinical samples from pigs suffering CSF. PCR based detection of Glycoprotein C gene of BHV-1, the causative agent of infectious bovine rhinotracheitis (IBR) was standardized and used for screening of semen samples in cattle.



RAPD profile of *Aeromonas hydrophila* isolates with primer OPH-1. Lane M: 1kb DNA Marker, Lanes 1-7: *A. hydrophila* isolates from fish.

Artificial Insemination Technology in pigs for dissemination of superior germplasm

Pig is the most preferred and important livestock species in the north-eastern hill region. In spite of considerable pig population and interest of people to rear pig, the pork production in the region is inadequate to meet the demand. This is mainly due to poor productive and reproductive ability of local pigs and non-availability of quality germ plasm. In this context, upgrading of local pigs with superior germ plasm is an urgent need to improve the present status. However, supply of superior breeding male to every village is very costly affair and also requires intensive managemental practices. Therefore, artificial insemination is the suitable and viable option. ICAR Research complex has standardized the Artificial Insemination (AI) technology including semen collection, evaluation and preservation methods, and successfully carrying out insemination in pigs in farm as well as field condition. A total of 68 pigs were inseminated in different villages and pregnancy was diagnosed by Doppler method using trans-abdominal probe after 50-60 days at farmer's field. Pregnancy rate of 79.4% and farrowing rate of 77.8% with average litter size of 8.2 was observed. The beneficiaries could save on mating cost of Rs1000-1500 and transport cost of females to boar pen (Rs 300). The adopted farmers also got additional litter size (2-3 piglets); thus enhancing their income of Rs 3,000-4,000 through sale of piglets. Besides this, they also saved on maintenance of boar (approx. Rs 5000) including manpower. The obtained piglets were superior germplasm through AI, which has higher body weight gain and high feed conversion efficiency, higher litter size and high economic returns. Therefore, 80% of tribal farmers adopted the artificial insemination technology in pigs in selected villages.

AI at farmer's field

Nondescript sow with improved piglets after AI

- Standardized semen collection, semen evaluation preservation and insemination methodology
- Achieved 79.4% pregnancy rate and farrowing rate of 77.8% with average litter size of 8.2 under filed conditions.

- The beneficiaries saved the mating cost of Rs1000-1500 and transport cost of females to boar pen (Rs 300) and additional litter size (2-3 piglets); thus enhancing their income of Rs 3,000-4,000 through sale of piglets
- 80% of farmers adopted the AI technology and farmers highly satisfied and benefited in several ways

Development of upgraded pig Varity to improve the productivity

Pig husbandry is a major and important integral component of farming systems practiced in the North Eastern Hill region. In spite of considerable pig population (28% of country's population)) the pork ction in the region is lower than the requirement. This is mainly due to poor productive and reproductive ability of non-descriptive local pigs. Therefore, the Animal production of the institute developed upgraded pig through crossing Khasi local with exotic Hampshire pig. The upgraded pig variety was evaluated for productive and reproductive preference in farm as well as farmer's field and recommended 75 and 87.5% Hampshire inheritance with Khasi local upgraded varity in the region.

The productive and reproductive performance and diseases incidence were studied under low input production at farmer's field. The

Upgraded pig

productive and reproductive performance of upgraded pig is shown in the table 3. The upgraded pigs has higher body weight gain, feed conversion efficiency and litter

Table 3. The productive and reproductive performance of upgraded pig under

Parameters	Mean ± SE
Body weight at (kg)	
3 months	13.65±1.52
4 months	19.67± 2.54
5 months	24.34 ± 3.23
6 months	33.73 ± 3.78
7 months	40.12 ± 4.67
8 months	50.32 ± 6.89
Age at puberty (days)	276.66 ± 11.19
Age at first conception (days)	328.00 ± 31.14
Age at first farrowing (days)	442.17 ± 31.2
Inter farrowing interval	208.40 ± 18.74
Litter size at birth	8.53 ± 0.15
Ind. litter wt at birth	0.87 ± 0.28
Litter size at weaning	7.38 ± 0.23
Ind. litter wt at weaning	8.46 ± 0.47
Weaning percentage	87.41 ± 4.66

size at birth as well as at weaning as compared to local pigs. The adult upgraded pigs were sold by the fattener farmers @ Rs 6000 –7000/pig as compared the earlier local adult pig @ Rs 3000-4000/pig. While, the breeding farmers harvested 2-3 extra piglets per litter than earlier system and farmers sold each piglet @Rs1400/. The beneficiaries got Rs 9000-10000/unit through selling the piglet/ farrowing which is significantly higher and Rs 3000-4000/ extra per unit. Therefore, the farmers were highly satisfied with the upgraded pigs.

- The upgraded pig varity has higher feed conservation efficiency and faster growth
- upgraded pig varity attain double the body weigh gain than local
- Higher litter size
- Higher economic return/pig/year

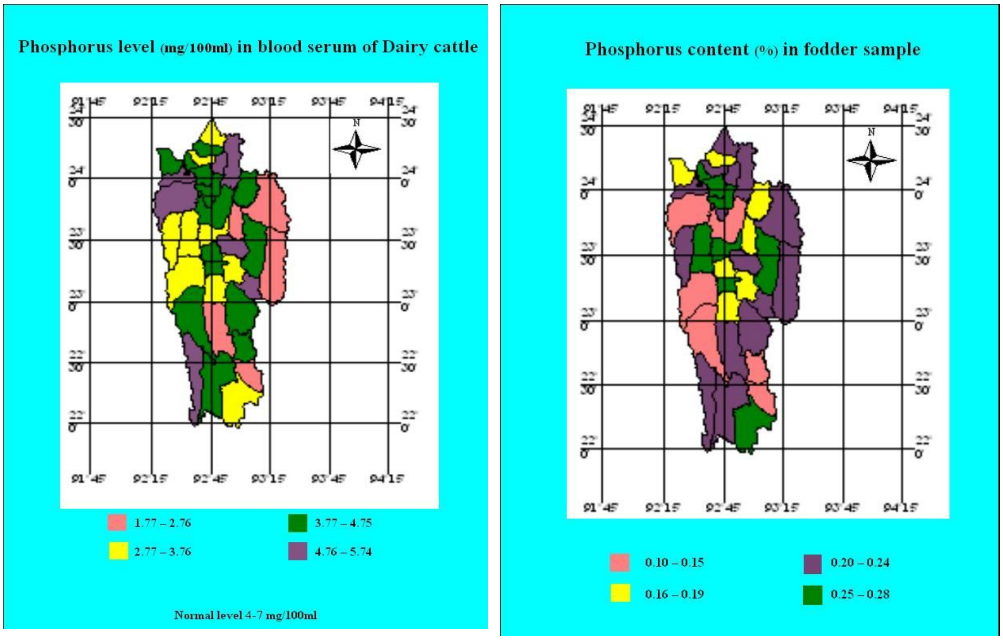
Soil – Plant – Animal Continuum in Relation to Mineral Status and Fertility in Dairy Cattle in Mizoram

The purpose of the present study was to estimate the macro and micro mineral content of soil, fodder and serum of dairy cattle and to establish the soil-plant-animal continuum in subtropical hilly areas of Mizoram, a hilly state of northeast India. Soil (n=96), fodder (n=96) and blood serum samples from dairy cattle (n=120) were collected from randomly selected smallholder dairy farms in all the eight districts of the state.

Significant correlation values were obtained between soil and fodder for Ca, Cu and Fe. The correlation values between fodder and cattle were significant for all the minerals studied except for P and K. The correlation value between fodder and cattle was highly significant ($P<0.01$) for Ca (0.878), Mg (0.88), Cu (0.885) and Zn (0.928). However, such correlations were not observed between the mineral levels in cattle and mineral levels in soil except for Ca (0.782). An attempt was made to predict the mineral content in cattle keeping the soil and fodder mineral content as independent variables. Prediction equations that could fairly predict the mineral content in cattle based on the mineral content in soil and fodder have been developed. Equations developed for prediction of Ca (R^2=0.797), Mg (R^2=0.777), Zn (R^2=0.937), Fe(R^2=0.861) and Cu (R^2=0.794) had significant R^2 values.

- Based on the results, for the first time, a region specific mineral mixture formula was evolved for Mizoram
- For the first time, GIS based mineral mapping of Mizoram soil, fodder and dairy cattle was carried out.

Inventorization of the mineral status in fodder and animal in an area would give a deep insight in developing location specific technologies and to evolve strategies for fodder as well as animal production. It is in this context, as a preliminary database has been developed with the basic information regarding the macro and micro nutrient status soil, fodder and blood serum of dairy cattle in Mizoram. Soil fertility status, mineral content in fodder and blood serum of dairy cattle has been assessed and the strategies to reduce the mineral deficiency so as to improve the productivity in a sustainable manner were also evolved. GIS based maps have also been prepared, most probably for the first time, for Mizoram state using the data generated on mineral content in soil, fodder and blood serum, which is expected to serve as a key to open several locks impeding the crop and animal productivity.



GIS based mineral mapping

Our results revealed that most of the cattle were deficient in Ca, P, K, Mg, Co, Cu, Mn and Zn. The extent of deficiency was very high in case of Zn. The correlation values between fodder and cattle were significant for all the minerals studied except for P and K. The correlation value between fodder and cattle was highly significant ($P<0.01$) for Ca (0.878), Mg (0.88), Cu (0.885) and Zn (0.928). However, such correlations were not observed between the mineral levels in cattle and mineral levels in soil except for Ca (0.782). Equations developed in the present study for prediction of Ca (R^2=0.797), Mg (R^2=0.777), Zn (R^2=0.937), Fe (R^2=0.861) and Cu (R^2=0.794) had significant R^2 values. Based on the results, an area specific mineral mixture formula was evolved.

Sweet potato tuber based feeding technology for pig production

Sweet potato cultivars (Pusa safed, Kokrajhar red and Sankar) are coming well in acidic soil and having good production potential and nutritive value for swine feeding.

Table. Yield potential and characteristics of different sweet potato cultivars

Particulars	Pusa safed	Kokrajhar red	Sankar
Characteristics	Cylindrical in shape, with white skin & white flesh	Cylindrical in shape, with red skin & white flesh	Cylindrical to oval in shape, with red skin & orange flesh
Fresh tuber yield (t/ha)	18-20	30-32	30-34
Dry Matter (%)	31-32	29-30	30-31
CP (% DM basis)	5.87	3.79	5.65

Utilization: Boiled sweet potato tuber could be incorporated to the level of 50% (DM basis) in concentrate mash ration of crossbred pigs at post weaning (10-20 kg BW), grower (20-45 kg BW) and finisher stages of growth for obtaining economic growth rate of 235, 465 and 600 g/d, respectively.

Legume forage based feeding technology for rabbit production

- Feeding of green legumes fodder (groundnut, stylosanthes, soybean and rice bean) can safely reduce 50% of commercial concentrate feed in growing rabbits without any adverse effect on growth and production. However, sole feeding of soybean fodder works as

Soybean (Glycine Max Merr.)

Perennial groundnut (Arachis pintoi)

Stall feeding of rabbit

maintenance ration for adult rabbits since it contain almost 18-20% crude protein on DM basis.

- Fodder can be fed in the morning hours in cut and carry system and concentrate mash feed in the evening.

Round the year fodder production and conservation for dairy farming

- Fodders which thrive well (Perennial improved grasses like Setaria, Congosignal and Guinea, legumes like soybean, rice bean and perennial groundnut during rainy season and broom and oat during winter season) under acidic soil in hot, humid and high rainfall conditions were identified and their cultivation practices developed for making fodder available for feeding to dairy animals through out the year under cut and carry system. The forages yield recorded in between 80-100 t/ha/year for improved grasses and 20-25 t/ha for legumes. Surplus green fodder available can be ensiled to get excellent quality silage to feed to dairy cattle during scarcity period when there is shortage of green fodder in the NEH region. During the months from May to November, around 90% of the roughage DM was met through perennial grasses and legumes in cut and carry system.
- Two ha area can be produced approximately 140 tone forage that will meet roughage (60% of total DM intake) requirement of 10 crossbred HF dairy cattle for one year.
- The average milk yield in crossbred HF cattle was recorded 3400 liter per lactation (390 days lactation length).

Feeding of perennial grasses in cut and carry system to dairy cow

Feeding strategy for maximization of growth rate in crossbred HF calves

- Keeping in view of excellent climatic conditions available in this part of the country for rearing of crossbred dairy animals, feeding strategy has been evolved to maximize growth rate in the later part of the growth period by offering feedlot finishing rations. An ADG of more than

A well grown HF calf

750g/day could be attained by offering good quality concentrate with 18% CP and 60-70% TDN @ 1.75% of body weight and increasing it gradually to 2.25% as the calves grew in weight along with locally available forages.

DOT-ELISA based diagnostic kit for detection of antibody against *Oesophagostomum* sp. and *Bunostomum* sp.

The Division of Veterinary Parasitology continuously monitored the GI parasitic infection in animals for several years using standard faecal sample examination through microscope. Though it is till now the only recommended standard method for monitoring of GI parasitic load in animals but the method has some limitation regarding the sensitivity and specificity. Due to close morphological resemblance between the eggs of different GI parasites, experience and expertise is required for accurate identification. Since floatation and centrifugation of faecal sample using concentrated salt solution is required for isolation of parasitic egg, it is very difficult to isolate the eggs in low level of GI parasitic infection in animals. To overcome this limitation, division has evolved serological based alternate method for accurate identification of different GI parasitic egg in farmers' filed. This method is based on identification of specific antibody in the sera of infected animal using specific antigen purified in the laboratory. The antigen purified for this purpose is specific for each GI parasites. The purified antigen is able to identify in low level of specific infection in animals. The antigen used for this purpose purified using different immunological and biochemical techniques. Using this purified antigen a DOT ELISA based diagnostic kit has been developed for monitoring the antibody level of GI parasites in naturally infected animals. The kit is being used for diagnosis of *Oesophagostomum* sp. and *Bunostomum* sp. infection from serum of suspected animal.

DOT-ELISA based diagnostic kit for detection of antibody against *Oesophagostomum* sp. and *Bunostomum* sp.