

वार्षिक प्रतिवेदन

ANNUAL REPORT  
2004-2005



उत्तर पूर्वी पर्वतीय कृषि अनुसंधान परिसर  
(भारतीय कृषि अनुसंधान परिषद)  
उमियम-७९३ १०३, मेघालय

ICAR Research Complex for N.E.H. Region  
(Indian Council of Agricultural Research)  
Umiam - 793 103  
Meghalaya

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**ICAR Research Complex for NEH Region**  
**Umroi Road, Umiam-793 103**  
**Telephone : 0364-2570257**  
**Fax : 0364-2570363**  
**Gram : Agricomplex**  
**E-mail : director@icarneh.ren.nic.in**

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**Scientific Publication of ICAR**

**Planning and idea:**

**Dr. K. M. Bujarbaruah**

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**Director**  
**ICAR Research Complex for NEH Region**  
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## PREFACE

Annual report is the mirror of an organization through which its status of health in the year that has just gone by is known. However, for an organization that strives to provide technology backstopping in agriculture and allied sector in a holistic manner, compilation of the report covering all tits and bits is a difficult task. I compliment the Editorial Board for painstakingly trying to reflect the major activities that ICAR Research Complex for North Eastern Hills Region with its six regional centers was engaged in during the year 2004 – 05.

The Institute, I am happy to mention, worked with a rejuvenated zeal for finding solutions to problems faced by the resource poor, topographically disadvantageous, structurally divided, economically handicapped group of tribal farmers – be it the problem of resource conservation and utilization, crop – animal – fish varieties suitable for macro and micro environment, drudgery reduction through energy efficient implements, increasing cropping intensity, awareness building through technology demonstration and training etc. Through these unstinted efforts the institute could add one more rice variety to its existing lists of eleven rice varieties. Farmers of lowland ecosystems of the region are getting a yield of 6.0 t/ha from this variety – a significant contribution towards productivity increase. Area under horticultural crops could also be increased due to the production and supply of quality planting materials by the institute. Technology assessment programme at farmers' field in a participatory mode with the concept of learn and earn while doing brought much acclaim to the Institute- thanks to the scientific and technical staff who worked hand in hand with the farmers as a team. The support extended by the Animal Science and Fishery group tremendously helped in output maximization. Technology generation process for organic farming was in line with the wishes of the Government and farmers of the region.

The Institute also arranged a number of seminars/workshops / meetings etc. on upcoming areas of interest to both scientific and farming community besides feeding the Doodarshan and print media with weather forecasting reports.

All these were possible due to the constant support and encouragement received from our sagacious and concerned Director General and Secretary, DARE, Govt. of India, Dr. Mangala Rai and the ever persuasive and committed Dy. Director General, Natural Resources Management, Dr. J.S. Samra in addition to the internal support from all my colleagues in the Institute. It would be our collective endeavor to ensure that the present pace of research and development sustains.



(K.M. BUJARBARUAH)  
DIRECTOR.



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## 1. EXECUTIVE SUMMARY

With a total scientific strength of 136, the Institute handled 206 research projects, 40 NATP and 9 Adhoc, including AICRP projects during the year besides taking up technology validation projects on Farming Systems at as many as 18 projects at farmers' fields.

Crop wise achievements, irrespective of the study location are presented together with a weather picture of the location.

In crop sector research, a rice variety, RCM-10 a derivative of Prasad X IR 24 with a yield potential of 6 t/ha was released from Manipur centre for low land ecosystem. The variety which is resistant to blast has been giving 6 t/ha yield at farmers field under FLD programme. Suitable varieties screened under different centres were also recommended to respective state government together with agronomical packages. In Tripura centre the advance generation of upland crosses (F-5) was raised besides evaluating successfully a cross, TRC-2000-36-1-1, between TRC 87-25 X Vandana variety. In addition, 14 local jhum lines and 5 aromatic lines were also evaluated besides purifying local aromatic line – Kalikhasa. At Barapani, Meghalaya, 16 out of 42 advance generation lines for upland ecosystem were selected for further screening under jhum areas. Similarly, DH18 DH239 anther culture lines were selected for on farm evaluation. For lowland condition, 11 genotypes were tested besides analysing the nutritional qualities of 38 local cultivars for Manipur and Nagaland.

All the 4 transgenic lines developed at Barapani with cry/A(c) gene contained a single copy of active gene. Protocols for *in vitro* conservation of the clones of wild rice for long duration were also developed. Highly promising result (185 and 225% root growth) were obtained when rice seed was treated with 2% concentration of two bio organics developed from local weeds. Better grain yield (26.5 q/ha) was also obtained in upland rice (RCPL 1-29) when FYM was applied in split doses with NPK.

Irrespective of the application of inorganic fertilizer, the use of microbial enriched compost (paddy straw and pine needle) increased nutrient uptake and residual soil fertility. Soil samples collected from rice fields indicated highly acidic nature, low phosphorus and zinc content, medium potassium and high organic matter contents.

Achievements made for managing rice diseases and pests both through chemical and biopesticide have been reported for developing complete package of rice production.

Identification of suitable strains/varieties of maize which is the second most important cereal was also taken up for popularising the best varieties of both kharif and rabi seasons. Developed lines of baby corn (RCBC), popcorn (RCPC) and sweet corn (RCSC) were further evaluated and demonstrated. Trials were conducted on the feasibility of round the year maize production with 7 entries sown on 5<sup>th</sup> day of solar month. FLDs on maize production were taken up at farmers' fields with pest/disease management package. Agronomical package like sowing maize seed on 15<sup>th</sup> of April was found to have completely managed cob borer infestation. Application of Zn @ 6 kg/ha with FYM and lime gave highest grains yield of 33 q/ha.

In pulses sector, 4 crosses between earlier identified photo insensitive and photosensitive lines were evaluated for flowering response in prekharif. Two promising genotypes of rice beans were also identified.

Under pulses bio-technology, attempts were made to transform shoot buds and cotyledon-derived calli of chickpea using agro bacterium mediated transformation method. Diversity analysis of rice bean germplasm was attempted with 50 core genotypes under DNA fingerprinting and diversity analysis programme. Attempts were made to isolate micro satellite containing sequence from rice bean genomes. Similar programmes taken up at different centres on black gram, green gram, french bean and cow pea are reported.



Under germplasm evaluation programme for oilseeds, 10 genotypes out of 167 germplasm lines of soybean screened were found promising. 3 chemicals, 2 botanicals and one bio-control agent were tested against soybean rust disease. Observation on pod blight disease was also recorded. Similarly, 43 bunch type and 35 spreading type germplasm of groundnut were evaluated.

The effect of organic sources of plant nutrients on Toria was observed and maximum yield (12.7 q/ha) was recorded with the application of NPK with Azolla compost @ 2.5 t/ha. Studies on INM, efficacy of biofertilizers, pest and disease management, varietal screening of various oilseed crops were also taken up in all the research stations. Screening of mustard varieties for acid soil tolerance was also carried out and it was observed that application of lime in furrows was beneficial to mustard cultivation. In addition, bio-efficacy of insecticides and botanicals against mustard aphid was also evaluated.

In horticulture, research was carried out on important fruits viz. khasi mandarin, lemon, guava, peach, passion fruit etc. Out of eleven provenances of khasi mandarin CRS-3 and CRS-5 exhibited maximum plant height and stem diameter. Soft Wood grafting proved most successful under polyhouse conditions. *C. jambhiri*, *Naity Jamir* and *C. latipes* proved to be the best root stock for khasi mandarin and the success varied from 85 to 92%. The efficiency of crude pheromone extracted from female genitalia proved effective both in laboratory (60%) and field (40%) in attracting the male beetles. Growth performance of different lemons was also compared. All the centres concentrated on varietal screening and agro-technique development of location specific fruit crops ranging from kiwi to banana.

In Mizoram, fertiliser and manure doses along with bio agents like *Azospirillum* and phosphorus solubilizing microbes were standardised for different fruits like banana, passion fruit, guava and pineapple. Planting density and planting material for quality fruit production of pineapple was standardised in Tripura centre.

Under vegetable improvement programme, generation advancement of 20 long type and five round type brinjal and 4 promising tomato varieties resistant to bacterial wilt was taken up. IPM

technology for management of brinjal fruit and shoot borer was successfully demonstrated in farmers field in Meghalaya and Tripura.

One French bean line (Sel-35), of the twelve promising lines of Indian bean, RCDL-115 and one line of cowpea (RCCP-1) suitable to the region were put under multi location testing under AICRP vegetables.

In animal husbandry research, physical and chemical parameters affecting the viability of spermatozoa during cryopreservation of boar semen were found out. Comet assay was used to assess the DNA integrity of boar spermatozoa during preservation. On farm trials on pig and rabbit production technology supported with health care and nutritional aspects like corn-soy based and sweet potato based system for pigs and buckwheat-soy based ration or soybean fodder as a sole feed were carried out and productive and reproductive performance was recorded at Institute as well as in the farmers' field. Work on resource based feeding system showed corn – soy based diet to be economical for post weaning and grower stage of pigs. Supplementation of corn-soy with DL-methionine, and DRP-soy with probiotics was beneficial. In case of Kuroiler chicks, corn soy based feeding system needed to be fortified with major minerals and trace elements. After successful adoption of Vanaraja breed, birds were given to the farmers to study their performance under backyard system. The herbal and non-herbal liver stimulants enhanced the performance of Vanaraja chicken.

Molecular techniques like RT-PCR for diagnosis of classical swine fever and rotavirus infection, PCR for detection of virulence genes in *Escherichia coli* and *Salmonella*, molecular typing and subtyping of *Clostridium perfringens* and *Bordetella bronchiseptica* and genotyping of mesophilic *Aeromonas*, isolation and identification of immunogenic fraction of *Oesophagostomum* and *Bunostomum* parasites by SDS-PAGE and western blotting and Dot ELISA for detection of these parasites were standardized and used.

In fishery sector, a total of 71 ornamental fish species belonging to 38 genera under 17 families and 4 orders were recorded from Nagaland. Captive breeding and larval rearing trials of chocolate mahseer were successfully conducted. The studies showed that body length, body weight and ovary

weight contributed about 91% for the fecundity variable of *Zebra danio*. The duck droppings used as manure for mixed culture of plankton were found to be an important feed for the fishes. The duck excreta were comparatively better than other livestock excreta to feed Red Tilapia. *G. parviflora* was found to be an excellent feed for grass carp among 4 evaluated weeds. Carp culture technology was disseminated to 24 fish farmers in 7 villages of Meghalaya where a good performance was recorded in fishes growth.

Six different Intensive Integrated farming Systems (IIFS) models have been developed by judicious combination of agrihorti crops-fish-animals. Compared to mono cropping, crop productivity was 10 fold higher in IIFS, which offered unique opportunities to achieve food and nutritional security at household level. All the systems have been found ecologically and economically viable. Crop-fish-dairy-mushroom-vermiculture unit of IIFS showed highest monetary return (1:1.76), followed by chicken-crop-fish-duck-horticulture (1:1.58). All the crop residue, crop

by products and weeds were recycled into the system through vermi composting keeping intact the organic base of the IIFS.

Integrated farming system models have also been designed in farmers' fields at Nongpoh (Meghalaya) and Jhaluki (Nagaland). Crop, fish animals and horticultural crops were integrated in a complimentary way. The fish productivity was recorded to be 30.0 q/ha when integrated with pig. Vanaraja, goat, rabbit, duck and dairy cattle are the other livestock component being reared in farmers' fields. The institute developed upland paddy varieties have performed extremely well in farmers' fields with a production potential of 30.0q/ha in IIFS.

In addition to the above activities, the institute arranged a number of seminars, symposia/workshops at national and regional levels besides arranging training programmes for both the in-service personals and farmers. Interface meetings with the state departments of all the states of the region were also arranged for priority identification.



## 2. INTRODUCTION

ICAR Research Complex for NEH, a premier Institute in the field of agriculture and allied sector research, development and extension in the tribal and backward areas has completed 30 years of its services not only to the tribal farmers but also to the development departments, NGOs and other stake holders. The Institute was set up in 1975 at Shillong, Meghalaya under the aegis of ICAR, an apex body for agricultural and allied sector research in the country.

ICAR Research Complex encompasses all the disciplines of agriculture and allied sciences like crop science, horticulture, animal science, farming systems research, Agroforestry, fisheries and agricultural engineering for overall growth of agriculture in the region. The Complex has one centre each in every hill state of the region located at Lembucherra (Tripura), Kolasib (Mizoram), Imphal (Manipur), Basar (Arunachal Pradesh) and Tadong (Sikkim) with its headquarters at Umiam (Meghalaya). One KVK is also attached to every centre except Mizoram to disseminate the technology generated through research undertaken by the Complex.

Headquarters of the Complex is located at Umiam, about 22 kilometers from Shillong covering an area of about 101 hectare with a mild to steep slope and flat valleys. At present, the area under cultivation is around 70 hectare. Research work is carried out through 15 disciplines viz. Plant Breeding, Agronomy, Soil Science, Plant Pathology,

Entomology, Agroforestry, Agricultural Economics & Statistics, Agricultural Engineering, Agricultural Extension, Animal Health, Veterinary Parasitology, Animal Nutrition, Animal Production and Fisheries.

### Budget

The Budget for the year 2004-05 is detailed below

Budget (Rs in lakhs)	Allotted	Expenditure
Plan	800.00	795.72
Non-Plan	2089.95	1963.44

### Human Resources

The staff position during the period under report was as under

#### Main Institute

Category	Sanctioned	Filled	Vacant
R.M.P.	8	7	1
Scientific	190	136	54
Technical	303	281	22
Administrative	133	129	4
Supporting	124	122	2

#### KVK

Category	Sanctioned	Filled	Vacant
Technical	77	51	26
Administrative	14	7	7
Supporting	14	11	3

### Thrust Areas

- To evolve sustainable integrated farming systems to replace jhum cultivation for increased productivity.
- Restoration of degraded/jhum fallow lands through tree based farming.
- Development of feed and fodder resources including locally available fodder for livestock.
- Improvement of citrus plantation to rejuvenate the citrus industry.
- To increase the overall productivity of different crops through research in cereals, pulses, oilseeds, horticultural crops, fisheries and other economical crops.
- Animal health coverage and improvement of livestock production system.

### Mandate

- To undertake basic and applied research for delivering technologies based on sustainable farming system for different agroclimatic and socio-economic condition.
- To improve the productivity of crops, livestock and fishery.
- To act as a repository of information on natural resources, different farming and land use systems.
- To impart training in research methodology and application of improved technologies for enhancing agricultural productivity.
- To collaborate with the State Departments for agricultural development in the region and testing and promotion of improved farming and land use systems.
- To collaborate with National and International agencies.
- To provide consultancy.

### Library

Nature of Journal	No. of copies Available
Books and reports	18188
Back issues	11016
Foreign journals	62
Indian journals	160
Hindi books	1867

### Computer facilities

Computer facilities are available as per the need and requirements of various divisions. The institute has a rich computer database of library resources. It also provides computerized database on environmental degradation and meteorological data. A website has been developed giving details of every activity of the institute.

### Linkages

To provide advisory services to the line departments of Central and State Government, Public sector undertakings and NGOs the institute remains in touch with these departments and meetings/trainings are regularly organized. Biennial interface meetings are held at the institute to discuss various problems of agriculture and related matters for research and development with the departments of Agriculture, Horticulture and Animal Husbandry and Fisheries of the respective State Governments of the region. The information generated through research is disseminated to farmers through line

departments, off farm research, Kissan Melas, Field Days and Front Line Demonstrations.

### IMPORTANT EVENTS

A High Power Committee headed by Dr. J.B. Chaudhury and Dr. I.V. Subba Rao visited the Institute on 5<sup>th</sup> April 2004 and held a meeting with the Director of the Institute to evaluate the worth of the research work being carried out by the various ICAR Institutes.

A workshop on farm mechanisation in the North Eastern Hill Region was organised at ICAR Research Complex, Umiam from 24<sup>th</sup> to 27<sup>th</sup> May 2004 with a view to enhance the use of modern agricultural machinery in the region.



**Dr. K.M. Bujarbaruah, Director, ICAR Research Complex addressing the participants of the workshop on Farm Mechanisation in NEH Region held from 24 to 27 May 2004 at the Institute (HQ)**

Officials of the Department of Agriculture, Horticulture and other State Government establishments of various North Eastern States participated in the four day workshop.



A DBT sponsored short term training programme on Molecular Technique in Animal Disease Diagnosis in NE Region was organised at the institute (HQ) from 16<sup>th</sup> June 2004.

Interface meeting on “Experimental Agromet Advisory Services” held on 22<sup>nd</sup> July 2004 at the Institute (HQ).



Interface meeting on “Experimental Agromet Advisory Services” held on 22<sup>nd</sup> July 2004 at the Institute (HQ).

ICAR Research Complex organised a 21 day Summer School on Organic Food Production from 5<sup>th</sup> to 25<sup>th</sup> August 2004. Scientists from 13 different states of the country participated in the Summer School.



Valedictory session of the Summer School organised by the institute (HQ) from 5<sup>th</sup> to 25<sup>th</sup> August 2004

“Sadbhavana Diwas” was celebrated for a fortnight from 20<sup>th</sup> August to 5<sup>th</sup> September 2004 in the Institute as well as its centres. Seven different programmes were organised as part of celebration of the programme giving due representation to minorities, backward classes, women folk and communal harmony through different programmes.

‘Hindi Week’ was celebrated in the Institute as well as its centres from 14<sup>th</sup> to 21<sup>st</sup> September 2004. Essay, extempore speech, song competitions etc. were held in the institute and its centres during the ‘Hindi Week’.

A Field Day at Nongthymmai village in Ri-Bhoi District of Meghalaya was organised for farmers to make them aware of the benefits of improved production technologies. Meghalaya Legislator, Shri S.W. Rymbai addressing the farmers lauded the role played by ICAR Research Complex in bringing about a change in the agricultural scenario of the State.



Shri.S.W. Rymbai, Hon'ble Minister for Forestry, Govt. of Meghalaya addressing the farmers during Kisan Mela held on 29<sup>th</sup> October 2004 at the institute (HQ)

A two-day regional consultation on Farmer's Issues and Mission 2007: Towards Hunger Free India was held at ICAR Research Complex for the NE Hill Region, Umiam on November 3-4 2004. Organized by the National Commission on Farmers (NCF) in association with M. S. Swaminathan Research Foundation (MSSRF) and the United Nations World Food Programme (UNWFP), the meeting was held to understand farmers' issues in the region, the food security situation in the States and the steps needed to address the same. There were presentations from the State Governments of Meghalaya, Assam, West Bengal, Bihar, Arunachal Pradesh, Manipur, Nagaland and Tripura. The event was inaugurated by the Hon'ble Chief Minister of Meghalaya, Dr. D D Lapang and there was ministerial level participation from three States, viz.



Dr D.D. Lapang, Hon'ble Chief Minister, Govt. of Meghalaya addressing the meeting on “Farmers Issues of Eastern India” held on 3-4 November 2004 at the institute (HQ), Umiam.



Mr. W A Chowdhary, Minister for Agriculture, Government of Assam, Dr. Surya Kanti Mishra, Minister for Panchayats, Government of West Bengal and Mr. Tapan Chakraborty, Minister for Agriculture, Government of Tripura. Secretaries and Directors of Agriculture from the different States were among the participants.

A two-day workshop on “Rice Heritage of the Northeast: Challenges, Opportunities and Strategies for the Future” organized by the M S Swaminathan Research Foundation, Chennai and ICAR Research Complex for Northeast Hill Region on 5-6 November 2004 at the ICAR Complex in Umiam. The eminent agricultural scientist Professor M S Swaminathan presided over the inaugural session of the meeting.



**Dr.M.S. Swaminathan giving his presidential address**

Shri P J Bazeley, Chief Secretary, Government of Meghalaya, was the Chief Guest and delivered the inaugural address and Dr.S.S.Baghel, Vice Chancellor, Central Agricultural University gave a special address. Dr. D N Borthakur, the first Director of the ICAR Research Complex and former Vice Chancellor of Assam Agricultural University, delivered the Keynote address.

17th meeting of the ICAR Regional Committee No. III comprising the states of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and Andaman & Nicobar Islands was held in Gangtok, Sikkim from 25th to 26th November 2004.

Shri Thenucho, Honb’le Minister of Animal Husbandry, Veterinary Health and Family Welfare, Government of Nagaland was the chief guest during the Inaugural Session. In addition, the following dignitaries and distinguished personalities also graced the inaugural session with their august presence.

1. Shri Tsering Gyurme, Honb’le Minister of Agriculture, Horticulture, Animal Husbandry & Veterinary, Govt. of Aruanachal Pradesh as guest of Honour.

2. Smt. Kalawati Subba, Honb’le Minister for Animal Husbandry & Veterinary Services, Livestock & Fisheries, Government of Sikkim, as Special Guest.

3. Shri Somnath Poudyal, Honb’le Minister for Food Security and Agricultural Development, Government of Sikkim, as Distinguished Guest.

4. Sri Sher Bahadur Subedi, Honb’le Minister for Forest and Environment, Government of Sikkim, as Special Invitee.

5. Sri Menlom Lepcha, Honb’le Minister of Transport, Motor Vehicle and PHE, Government of Sikkim, as Special Invitee.

6. Dr. Mangala Rai, Secretary, DARE, Government of India and Director General, ICAR, Chairman of the Regional Committee No. III.



**Dr. Mangala Rai, Secretary DARE, Govt. of India & Director General, ICAR delivering the introductory remarks**





**Dr. K. M. Bujarbaruah, Director, ICAR Research Complex and Member Secretary Regional Committee NO. III welcoming the delegates**

7. Dr. J. C. Katyal, DDG (Education and National Director NATP), as in-charge Regional Committee No. III.

8. Dr. K. M. Bujarbaruah, Director, ICAR Research Complex and Member Secretary, Regional Committee No. III

A Farmers Field Day was organised by ICAR, Sikkim Centre at Namcheypong village on 27th November, 2004. Dr. Mangala Rai, Hon'ble DG, ICAR & Secretary DARE and Dr. J. S. Samra DDG(NRM) addressed the farmers and distributed seed of improved varieties to the farmers.



**Smt. Radha Singh, Secretary, Agriculture, Govt. of India interacting with the scientists at the Institute's HQ on 14th February 2005**

An Interface meeting with officials of the State Government and scientists from Animal Science discipline was held on 24<sup>th</sup> February 2005 at the Institute (HQ) to work out research priorities of the region.



**A view of the Farmers' Field Day**



**Pu H. Rammawi, Hon'ble Minister for Agriculture, Govt. of Mizoram on his visit to Mizoram Centre on 8th December 2004**



**A view of Interface meeting**

### 3. RESEARCH ACHIEVEMENTS

#### WEATHER

Air temperature, relative humidity and rainfall recorded in the seven states of North Eastern Hill States are given in **Table 1**.

In addition, sun shine hours and evaporation losses recorded in Meghalaya, Sikkim and Tripura centres varied from 1.9 to 7.8; 1.32 to 5.04 and 3.16 to 8.31 hrs/day and 1.8 to 3.7; 0.24 to 0.31 and 97.4 and 158.8 mm/day respectively. Evaporation loss at Nagaland ranged between 0.4 and 8.0 mm/day. Similarly, soil temperature recorded at Mizoram, Nagaland and Tripura centres varied from 26.57 to 28.68; 31.22 to 33.1 and 33.24 to 34.5°C at 5 cm, 10 cm and 20 cm respectively. Mean monthly maximum and minimum temperatures recorded

during morning and evening hours ranged from 5.1 to 18.0°C and 11.0 to 24.0°C at 5 cm and 3.0 to 16.0°C and 10.0 to 24.0°C at 10 cm depth of soil, respectively. It ranged from 15.7 to 27.7 at 5 cm; 16.6 to 28.8 at 10 cm and 17.6 to 28.8°C at 20 cm depths of soil. However, during evening hours, it varied from 25.6 to 37.3; 23.6 to 35.0 and 21.8 to 30.4°C at the corresponding depths of soil.

Wind velocity, wind direction and cloud cover recorded in Manipur and Tripura ranged between 0.16 and 11.27; 1.4 and 8.3 km/hr; 146.1 and 243.6; 172 and 335 degrees; 1.07 and 7.23 and 3 and 6 Okta, respectively.

Total number of rainy days recorded in Arunachal Pradesh and Tripura were 128 and 116 days respectively.

**Table 1: Variation of air temperature, relative humidity and rainfall in the seven states of North East.**

Centres	Air Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Max	Min	8 hrs.	14 hrs	
Meghalaya	19.2-29.0 (24.82)	7.2-20.5 (15.09)	73.0-89.8 (82.1)	43.7-79.4 (64.23)	2953.0
Arunachal Pradesh	16.5-30.7 (25.53)	5.7-20.6 (14.43)	68.0-79.9 (73.74)	41.8-63.1 (53.96)	2284.3
Manipur	20.2-28.5 (25.22)	5.56-22.10 (15.83)	84.16-97.68 (90.71)	41.79-76.80 (60.69)	2158.0
Mizoram	20.08-30.94 (26.06)	14.80-24.62 (21.13)	52.21-80.10 (66.66)	65.54-87.48 (78.37)	3443.0
Nagaland	20.4-31.3 (27.05)	10.0-30.0 (22.63)	70.0-85.0 (79.58)	42.0-84.0 (60.08)	1955.6
Sikkim	16.53-27.75 (23.08)	7.14-20.04 (14.71)	80.9-91.8 (86.47)	42.3-68.8 (56.60)	955.4
Tripura	23.6-33.9 (29.9)	11.3-25.3 (21.05)	38.0-87.0 (74.16)	54.0-73.0 (68.0)	3156.0

Figures in parenthesis are the annual mean values



## I. CROP PRODUCTION AND PROTECTION

### RICE

#### Breeding for upland ecosystem:

Four yield evaluation trials were conducted under upland condition. In the All India Coordinated trials, two medium maturity genotypes viz. RCPL 1-46 produced highest (3.96 t/ha) followed by RCPL 1-45 (3.51 t/ha). Both genotypes showed more than 5% yield advantage over checks Bhalum 1 and Bhalum 2. Among the early maturing types VL 3959 and VL 4045 (both from IVT recording 3.1 t/ha and 3.0 t/ha) were promising. In the station trial for upland genotypes, IR 71524 – 44 – 1 – 1 (3.89 t/ha) and IR 72777-35-1-1 (3.59 t/ha) were promising. In the International Observatory Nursery IR 68321-15-1-3 was most promising. Details of best line from each trial are given in Table 1. Forty two advanced generation lines were evaluated and 16 lines were selected for further evaluation under jhum conditions. Nine anther culture lines were evaluated for the 3<sup>rd</sup> year. Line 239 and 18 were selected for on-farm yield evaluation.

#### Breeding for lowland ecosystem:

Six yield evaluation trials and four observational nursery trials were laid out. In the non-aromatic group 11 genotypes were tested and BM9820 yielded 5.2 t/ha but was not significantly superior to Shalsarang1 or Lampnah1 (checks). In the aromatic group AR5 and AR6 recorded 3.8 and 3.9 t/ha yield. Both genotypes were tested for 3 consecutive years and recorded average yield of 3.8 t/ha with high stability (*bi* value 0.92). In the aromatic very fine grain group Mahisugandha yielded 2.7 t/ha and in the non-aromatic very fine grain group IET 17294 recorded 3.24 t/ha yield. In the international observational nurseries C5252-B-1-1-1-1 recorded highest yield and was significantly superior to all checks. Forty two F<sub>4</sub> populations derived from 13 crosses were evaluated and selected genotypes advanced to next generation. Details of best line from each trial are given in Table 1.

**Table 1: Details of best genotypes in different evaluation trials/observational nurseries of rice.**

Trial	Genotype	Yield (t/ha)	Maturity (days)	CV% of the trial
<b>Upland Rice</b>				
AVT1	RCPL1-46	3.96	122	9.8
IVT	VL3959	3.10	104	11.2
Station Trial	IR71524-44-1-1	3.89	130	7.3
Int. Obs. Nurs.	IR68321-15-1-3	3.92	103	14.6
<b>Lowland Rice</b>				
Non aromatic (ST)	BM9820	5.20	135	8.8
Aromatic (ST)	AR6	3.90	142	5.9
Aromatic very fine (ST)	Mahisugandha	2.70	144	12.3
Non-aromatic fine grain (ST)	IET17294	3.24	153	9.3
Int. Obs. Nurs.	C5252-B-1-1-1-1	5.9	135	15.2
<b>Highaltitude rice</b>				
Station Trial	RCPL1-63C	4.0	155	12.5

#### High altitude lowland :

Two yield evaluation and two germplasm evaluation trials were conducted at Upper Shillong. RCPL1-63C recorded highest yield (4.0 t/ha) followed by RCPL 1-62C (3.4 t/ha) Table 1. In the germplasm evaluation trials, 96 germplasm were evaluated for the second year. Ryllo Red-4, Ryllo White, Tomiwikari and GGAF-BYEO were consistently promising and showed fertility above 85%.

Eight trials were conducted in farmers' fields. Average yield of RCPL 1-10C was 3.0 t/ha (average of 4 years with CV-15.8%) while average yield of RCPL1-18C was 3.3 t/ha with cv. 9.8%. It was observed that RCPL1-10C met all quality standards for export besides being medium in yield potential.

#### Biotechnology:

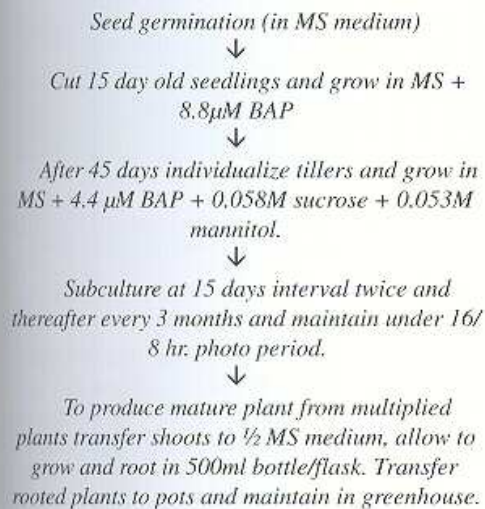
Four transgenic homozygous lines with *cryIA(c)* gene were developed. All lines contained a single copy of active gene. Qualitative and quantitative expressions of the gene were tested.

A clonal multiplication and slow growth based *in vitro* conservation protocol for *Oryza rufipogon*, *O. officinalis*, *O. minuta* and *O. granulate* was developed (Fig 1).



Fig. 1. Clonally propagated shoots of *O. rufipogon* (left) and *O. officinalis* (right) in long-term culture.

Protocol for long-term *in vitro* maintenance of *O. rufipogon* and *O. officinalis* developed by the institute is summarized below:



Using this protocol, clones of wild rice could be maintained in long-term cultures with subcultures every 60 days. Relative efficiency of gelling agents sugars and sugar alcohols was also established. (Fig 2a, 2b & 3). Two cryopreservation protocols – i) for calli and ii) for shoot meristems of wild and cultivated rice were standardized. Viability of calli at different intervals was tested using FDA staining (Fig. 4). In case of shoots

regrowth percentage was calculated from the number of surviving shoots. Plasmolysis treatment for 4 hours before cryopreservation was found most effective for shoots and produced highest number of surviving shoots. Re-established plants are being maintained for checking their fertility status.

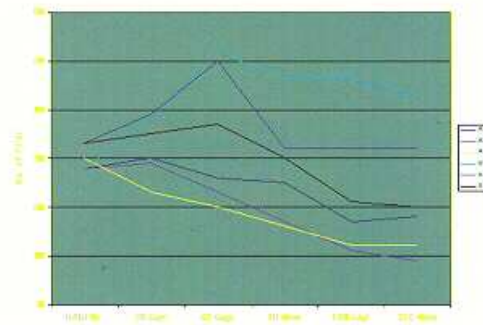


Fig 2a . Efficiency of different combinations of mannitol, sucrose and BAP for long-term maintenance of shoots of *O. rufipogon*

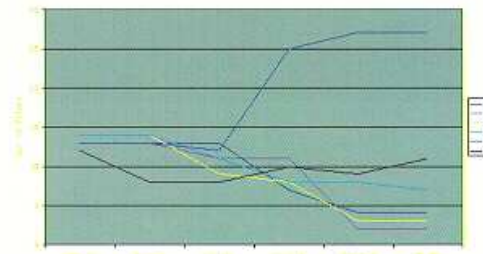


Fig. 2b. Efficiency of different combinations of mannitol, sucrose and BAP for long-term maintenance of shoots of *O. officinalis*.

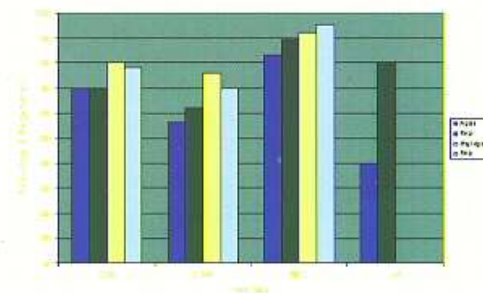


Fig. 3. Relative efficiency of medium-hormone-gelling agent combinations



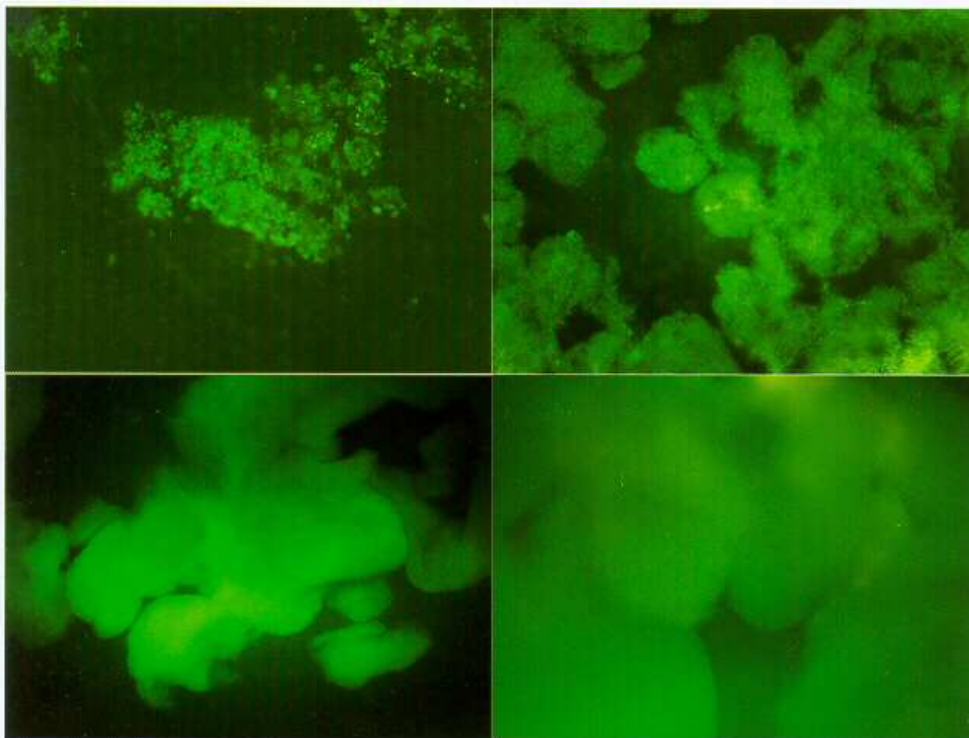


Fig 4. Viability testing of rice calli at different intervals after cryopreservation : A. First day after cryopreservation. B. Third day after cryopreservation. C. Seventh day after cryopreservation. D. Fifteenth day after cryopreservation.

#### Rice quality analysis:

Nutritional qualities analysis was done for 38 varieties from Nagaland and Manipur. Total crude protein content ranged from 4.99% to 12.07%. Nayanap, Phouibi (from Manipur), Kereilha and Naga Special (from Nagaland) contained more than 10% protein and were classified as high protein rice. Amylose content ranged from 32.8% to 81.9%. Out of the 38 varieties 32 had aroma. Among these 8 have strong, 6 medium and 18 mild aroma intensity.

Hulling, milling and grain type studies were done for 45 varieties for the Region. Hulling percentage ranged from 61.67% to 77.08%. Milling percentage ranged from 51.3 to 83.7% against the national standard of 65% minimum. Head rice recovery ranged from 16.45% to 72.86% against standard value of 45% minimum. Length of the rice

kernels ranged from 3mm to 8.7mm, breadth ranged from 1.2mm to 2mm. Kernel colors were various. Black, black and red striated and light green kernels were observed apart from standard white and red grains.

#### Agronomy

##### Effect of different establishment methods on the performance of transplanted rice

Studies on different establishment methods on two rice varieties viz., Shah Sarang and Krishna Hamsha revealed maximum yield of 32.20 q/ha when 30 days old seedlings were transplanted at 20 x 10 cm (3-4 /hill) followed by integrated crop management practices (15-20 day old seedlings at 20 X 20cm ). The system of rice intensification

recorded the lowest yield (19.06 q/ha) when 8-12 day old seedlings were transplanted at 20 x 20 cm.

#### **Effect of cultural management practices for enhancing grain yield of rainfed upland rice.**

The experiment consisted of 2 varieties viz., RCPL 1-29 and Vandana with 5 cultural management practices viz., Farmers practice of broadcasting (100kg/ha) + FYM 5t/ha, line sowing (60 kg/ ha) + FYM 5t/ha + recommended NPK (60:60:40 Kg/ha), Line sowing + FYM 5t/ha + 50% NPK, line sowing + green manuring (2:1) + 50% NPK and line sowing + FYM 5 t/ha (15 days before sowing) + recommended NPK (3 splits- 1<sup>st</sup> in 15 DAS, 2<sup>nd</sup> at tillering and 3<sup>rd</sup> at P.I). Result revealed that RCPL 1-29 produced significantly higher grain yield (25.66 q/ha) compared to vandana (15.53 q/ha). Integrated application of FYM and recommended NPK with split application of N gave highest grain yield of upland rice (26.27 q/ha).

#### **Crop intensification in lowland/marshy land areas:**

##### **Production Potential of rice based cropping system in lowland area**

The experiment was designed to find out suitable cropping sequence for lowland area. The data revealed that vegetable based cropping sequences were promising as compared to maize grown for grain purpose. The maximum rice equivalent yield (REY) of 253.20 q/ha was recorded with rice-capsicum followed by rice-tomato (210.73 q/ha) and rice-potato (192.59 q/ha) crop sequence. It was also observed that when maize was grown for green cobs, it not only increased the productivity (105.93 q/ha REY) but also provided 278.54 q/ha green fodder and increased system productivity (141.64 q/ha).

##### **Evaluation of rice-based cropping system on permanent raised beds in marshy land areas.**

The experiment designed to find out suitable cropping system for raised beds in marshy land area. Eleven rice-based cropping sequences were tested. Results revealed that adoption of raised bed system could increase the cropping intensity by 150% as compared to 100% in check. It was also observed that vegetable based cropping sequence markedly

increased the productivity by registering 419 q/REY/ha with rice-capsicum followed by rice-tomato 301 q/ha. Among the 200% cropping intensity lowest productivity of 44.27 and 56.48 and REY/ha was recorded with rice-toria and rice-mustard, respectively, which were however 1.59 and 2.03 percent higher over rice fallow cropping system.

##### **Determination of bed size for Raised and Sunken bed system (Rice + Maize + French bean).**

To find out optimum size of raised and sunken beds for various crop production systems. Beds of different sizes were prepared. Rice was cultivated in sunken beds whereas maize and frenchbean were grown in raised beds. The results (Table 2) showed that rice yield increased with the increase in size of sunken bed recording maximum yield potential of 17.34 q/ha with 3:1 ratio of sunken: raised bed and lowest (2.42q/ha) was with 1: 3 land allotment ratio. The system productivity increased with the increase in area under raised beds achieving maximum productivity (115.12 q/ha) with 1: 4, followed by 2: 4 (100.4q/ha) and 3: 4 (91.1q/ha) of sunken: raised bed area. This indicates that area under vegetables and maize decided the rice equivalent productivity because of the higher commercial value of frenchbean grown on raised beds.

##### **Raised and sunken bed system of cultivation.**

A field experiment was conducted to study the performance of pre-kharif and kharif rice in sunken beds under raised and sunken bed systems of cultivation (Fig.5). The treatment consisted of six varieties of rice in pre-kharif and five varieties in



**Fig.5. Crops under raised and sunken bed system**



**Table 2: Determination of optimum land ratio for sunken and raised bed in marshy land (Rice + Maize – Frenchbean)**

Sunken : raised bed ratio	Rice yield in sunken bed (q)	Crop yield on raised beds(q)		Rice equivalent yield on raised bed (q)		Productivity on raised bed (q)	System productivity (REY q/ha)
		Maize	Frenchbean	Maize	Frenchbean		
1:1	6.38	11.12	32.71	15.88	46.72	62.60	68.98
1:2	3.53	16.33	45.58	23.32	65.11	88.43	91.96
1:3	2.42	20.10	52.80	28.71	75.42	104.13	106.55
1:4	2.08	22.05	57.08	31.50	81.54	113.04	115.12
2:1	12.96	7.72	20.12	11.02	28.74	39.76	52.72
2:2	9.21	12.90	32.71	18.42	46.72	65.14	74.35
2:3	7.32	16.74	41.82	23.91	59.74	83.65	90.97
2:4	6.24	19.16	46.76	27.37	66.80	94.17	100.41
3:1	17.34	5.03	16.64	7.18	23.77	30.99	48.33
3:2	13.45	9.84	28.26	14.05	40.37	54.42	67.87
3:3	10.87	12.90	34.20	18.042	48.85	67.27	78.14
3:4	9.46	15.97	41.37	22.52	59.10	81.62	91.08
Flat land							37.50
LSD (0.05)							10.54

*kharif* season grown in sunken beds and other crops (maize & vegetables) on the raised beds. The crops were grown in plots receiving washings of adjacent rabbit farm of the complex. Results revealed that all the rice varieties took longer duration for their maturity and produced higher number of tillers/plant in pre-*kharif* season compared to main *kharif* season. Significantly higher ripening ratio and grain yield was recorded in IR 64 (64%, 35.5 q/ha) followed by Krishna Hamsha (62.8%, 27.3 q/ha). Among the crops grown on raised bed, coriander, carrot and French bean (pole type) in pre-*kharif* season and french bean (pole type) in *kharif* season was found remunerative (Table 3).

Vegetables were grown in raised beds in both during pre *kharif* and *kharif* seasons. The yields per hectare recorded in pre *kharif* were Tomato (163 q), coriander green leaf 103q Carrot 259q maize green cob (67875 numbers) where as French beans were cultivated in both pre *kharif* and *kharif* season. The yield recorded in both the seasons in pole type (219q 231q), bush type (102q 105q) are promising. Cucumber was cultivated only in *kharif* with a yield of 96.5 q.

**Table 3: Performance of pre-*kharif* and *kharif* rice under raised and sunken bed systems.**

Rice Varieties	Grain yield (q/ha)	
	Prekharif	Kharif
IR 64	35.50	—
RCM 8	09.50	—
IET 17212	17.10	—
Krishna Hamsha	27.30	16.80
Vivek Dhan 82	18.10	37.18
Bhalum-1	24.40	21.84
V L Dhan 61	—	28.95
Shah Sarang	—	25.33
SEd ±	2.44	1.05
C.D. (0.05)	5.44	2.29

**Effect of Mineral Amendments and Microbial Inocula on Nutritional status of compost prepared from crop Residue (Paddy straw):**

An experiment on the compost preparation with mineral and microbial enrichment was conducted to evaluate the nutritional status of the enriched compost. Chopped and un chopped paddy straw (3q/pit) was used as substrate. For mineral enrichment, substrate was mixed with cow dung slurry (made

by using 40kg cow dung + 40 kg dry soil +20kg compost in 35 Lts of water per pit of 6m<sup>3</sup> size ), Mussoorie rock phosphate (10 kg/pit) and urea(4kg/pit) in a pit. The microbial compost was prepared using consortium of beneficial microbial inocula viz. *Bacillus polymyxa*, (500g /lt) *Aspergillus awamori* and *Azotobacter chroococum*. (10<sup>7</sup> cells per ml @ 50ml/kg on dry weight basis) The C: N ratio at different stages i.e. 30, 60 and 90 days of decomposition were recorded. The chemical analysis of the composts revealed a considerable boost in the nutritional status of the compost.. The microbial compost was found better than mineral enriched compost with respect to total N, P, NH<sub>4</sub>-

N, NO<sub>3</sub>-N, water soluble P and citrate soluble P (Table 4).

#### Effect of Microbial enriched compost on growth and yield of *kharif* rice:

The efficiency of microbial enriched compost and ordinary compost with different fertilizer doses was tested in rice cv. SHAH SARANG for growth and yield.. The analysis of data revealed that the significantly higher grain yield of rice (72.99q/ ha) was observed under microbial enriched compost + 100% recommended dose of NPK followed by mineral enriched compost+ 75% recommended dose (70.18q/ ha) (Table 5). Microbial enriched

**Table 4: Nutritional status of microbial and mineral enriched compost as well as C:N ratio at different stages of decomposition**

Treatments	Total N (%)	Total P (%)	NH <sub>4</sub> -N (mg/ kg)	NO <sub>3</sub> -N (mg/ kg)	Water soluble P (%)	Citrate soluble P (%)	C: N ratio Days after decomposition (DAD)		
							30 DAD*	60 DAD	90 DAD
T1-Chopped straw (CS)	0.83	0.30	24	15	0.028	0.224	79:1	66: 1	49: 1
T2-CS + Slurry + Mussoorie rock phosphate (MRP) + Urea	1.51	3.36	63	322	0.066	0.411	45:1	26:1	17:1
T3-CS + Slurry + MRP + Urea + microbial inoculum	2.13	4.15	92	365	0.146	0.511	34:1	16: 1	12:1
T4-Unchopped straw (UCS)	0.82	0.28	19	13	0.019	0.209	82:1	68: 1	55:1
T5-UCS + Slurry + MRP + Urea	1.42	3.11	42	298	0.062	0.408	47: 1	29: 1	20:1
T6-UCS + Slurry + MRP + Urea + Microbial inoculum	1.92	3.82	87	353	0.139	0.497	36: 1	19: 1	15:1
CD at P <sub>(0.05)</sub>	<b>0.032</b>	<b>0.029</b>	<b>0.741</b>	<b>2.041</b>	<b>0.002</b>	<b>0.004</b>	Unde-composed paddy straw	<b>87: 1</b>	

**Table 5: Effect of microbial enriched compost and mineral fertilizer on growth and yield parameters of *kharif* rice**

Treatments	Plant height (cm)	Tiller No.	Panicle length (cm)	Grains per panicle	Grain yield (q/ ha)
T1: No compost, No fertilizer	111.2	6	22.3	123	41.16
T2: Ordinary compost (OC)	117.6	12	26.3	139	45.38
T3: OC + 100:80: 60kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	133.4	22	32.6	155	62.64
T4: OC+ 75:60:45 kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	130.8	19	28.9	147	57.14
T5: OC + 50:40:30kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	130.5	16	26.3	139	53.34
T6: Microbial enriched compost (MEC)	145.9	22	35.0	167	68.07
T7: MEC + 100:80: 60kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	147.1	30	39.5	180	72.99
T8: MEC+ 75:60:45 kg N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O/ ha	147.8	28	38.2	172	70.18
T9: MEC + 50:40:30kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	146.3	24	36.4	167	66.92
T10: 100:80: 60kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	131.0	20	28.3	167	55.53
T11: 75:60:45 kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	126.9	17	27.7	143	52.10
T12: 50:40:30kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	123.3	12	26.8	140	47.56
CD at P= 0.05	<b>1.03</b>	<b>1.42</b>	<b>0.562</b>	<b>2.37</b>	<b>1.047</b>



compost alone recorded 68.07q/ ha which was 22.7q higher than ordinary compost and recommended for getting higher yield of rice without the use of fertilizers.

Nutrient uptake of whole plant was analyzed at crop maturity stage and residual soil fertility was determined after harvesting by following standard nutrient analysis methods (Table 6). The uptake

#### Effect of pine litter enriched compost on growth and yield of rice.

In an attempt to utilize forest litter a study was carried out to find out the effect of pine litter(chopped and un chopped) enriched compost with mineral and microbial supplements on rice yield of (Shah Sarang.) and was compared with the graded doses of N P K.

**Table 6: Nutrient uptake by *kharif* rice and residual soil fertility due to application of different types of compost**

Treatments	Nutrient uptake (kg/ ha)			Residual soil fertility (kg/ ha)		
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
T1: No compost/ fertilizer	93.14	16.24	86.25	311.54	15.66	123.36
T2: Ordinary compost (OC)	96.22	27.36	102.20	334.92	22.36	174.52
T3: OC + 100:80: 60kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	126.74	39.48	116.35	422.86	29.16	182.95
T4: OC + 75:60: 45kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	121.46	34.36	111.46	408.11	25.32	179.33
T5: OC + 50:40:30kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	118.26	31.46	108.24	376.4	21.74	177.54
T6: Microbial enriched compost (MEC)	154.18	56.25	143.37	446.72	36.78	186.77
T7: MEC + 100:80: 60kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	182.20	78.88	171.19	486.87	43.24	199.32
T8: MEC + 75:60: 45kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	174.76	69.15	162.66	472.39	40.22	191.57
T9: MEC + 50:40:30kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	165.17	62.79	151.22	456.28	38.19	188.94
T10: 100:80: 60kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	112.35	37.29	107.18	38.24	26.89	162.00
T11: 75:60:45 kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	103.28	28.82	101.45	362.84	22.46	139.52
T12: 50:40:30kg N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O/ ha	98.17	24.36	98.26	332.66	19.84	136.78
<b>CD at P=0.05</b>	<b>1.302</b>	<b>0.683</b>	<b>2.247</b>	<b>2.029</b>	<b>0.794</b>	<b>0.884</b>

values of NPK and residual soil fertility status were higher with microbial enriched compost treatments with or without mineral fertilizer. However, uptake values and residual fertility status of soil decreased with reduced doses of NPK with microbial enriched compost.

#### Effect of mineral amendments and microbial inocula on nutritional status of pine litter compost.

An experiment was conducted to prepare the microbial enriched compost with pine litter, a locally available forest waste. The protocol developed for microbial enriched compost was also applied in pine litter composting. Results (Table 7) revealed that microbial inoculum not only enhanced nutrient values but also reduced the lignin and cellulose content of the pine needles.

**Table 7: Nutritional status of microbial enriched compost prepared from pine litter**

Treatments	Total N (%)	Total P (%)	Total K (%)	Lignin (%)	Cellulose (%)
T1: Chopped pine litter (CPL)	0.45	0.12	0.48	18.22	17.12
T2: CPL+ Slurry+ MRP + Urea	1.16	0.92	0.51	17.64	15.46
T3: CPL+ Slurry+ MRP + Urea+ Microbial inoculum	1.48	1.23	0.55	15.55	12.19
T4: Unchopped pine litter (UPL)	0.43	0.10	0.42	19.24	18.65
T5: UPL+ Slurry+ MRP + Urea	1.02	0.87	0.50	18.16	16.82
T6: UPL+ Slurry+ MRP + Urea+ microbial inoculum	1.29	1.01	0.52	15.88	14.55
<b>CD at P<sub>0.05</sub></b>	<b>0.033</b>	<b>0.022</b>	<b>0.017</b>	<b>0.107</b>	<b>0.076</b>

The perusal of data revealed that microbial inocula along with mineral enrichment recorded highest yield both in chopped (54.6 q/ha) and unchopped (52.4 q/ha) pine litter followed by mineral enrichment chopped (49.3 q/ha) and unchopped (46.63 q/ha) which in turn was also higher than the unfortified compost. The recommended dose of fertilizers and the mineralized compost were at par in yields (Table 8)

It was also recorded from the study that nutrient uptake values of N and P was higher in chopped mineral and microbial enriched compost as compared to 100% recommended dose of N and P. But in case of K<sub>2</sub>O, higher uptake was observed under chemical fertilizer application. Uptake of NPK was higher under chopped pine litter compost in comparison to unchopped pine litter compost. However, both chopped and unchopped compost proved better when enriched with mineral or microbes as compared to unfortified compost. As regards residual soil fertility, the soil under chopped pine litter compost irrespective of enrichment showed higher residual soil fertility as compared to unchopped pine litter compost but higher residual fertility was noticed in microbe enriched pine litter compost plots followed by mineral enriched pine litter compost plots. The residual fertility status of soils was lower as compared to enriched compost plots.

#### Bioorganic for rice seed treatment

Three hundred and twelve bioorganic preparation made in the laboratory were tested in

rice for their growth promoting ability. The extracts were tested in petridish (0.5- 4% concentration). Nine extracts, namely, RCHE 374L, RCHE 355L, RCHE 84L, RCHE 84R, RCHE 377L, RCHE441L, RCHE 378L and RCHE71L resulted in increasing higher root and shoot growth. Rice seed treated with 2% concentration of two promising preparations (RCHE 84L and 84R) (Fig. 6) resulted in 185% and 221% more root growth, whereas, shoot elongation was 180% and 200% more over control.

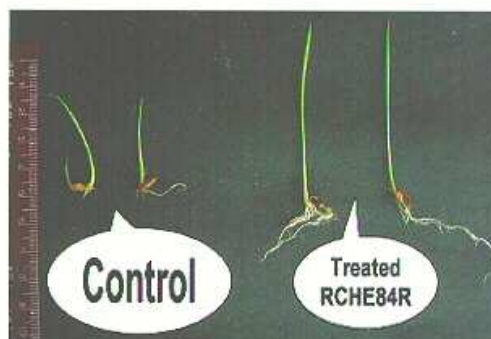


Fig. 6. Growth promoting ability of bio-organics

#### Natural Farming in low land rice

A field experiment was undertaken to evaluate the production potential and physiological activities of rice cultivars under in-situ fertility management with and without weeding. No external input including fertilizer, pesticides etc. were applied except fresh *Azolla* biomass @ 250 g m<sup>-2</sup> which was released 7 days after transplanting. Highest grain yield was recorded in SHAH SARANG (37.0

Table 8: Influence of pine litter enriched compost on growth and yield attributes of rice (kharif)

Treatments	Plant height (cm)	Tiller No.	Panicle length (cm)	Grains per panicle	Grain yield (q/ ha)
Control	106.3	8	21.5	123	38.46
Chopped pine litter (CPL)	111.5	11	25.6	139	43.54
CPL+ Slurry+ MRP+ Urea	128.8	15	28.2	145	49.28
CPL+ Slurry+ MRP+ Urea+ Microbial inoculum (MI)	132.4	21	30.7	151	54.62
Unchopped pine litter (UPL)	109.2	9	23.8	136	41.27
UPL+ Slurry+ MRP+ Urea	127.9	13	27.8	143	46.63
UPL+ Slurry+ MRP+ Urea+ MI	131.6	18	29.4	148	52.38
100:80:60kg N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O/ ha	126.5	17	28.7	142	48.76
75:60:45 kg N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O/ ha	122.3	14	26.2	138	44.45
50:40:30kg N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O/ ha	117.6	12	24.3	132	42.36
CD at P <sub>0.05</sub>	0.975	1.230	0.809	2.035	0.782



q/ha) followed by Vivek Dhan 82 (32.0 q/ha) and Mendri (30.9 q/ha) which was significantly superior to Manipuri (26.6 q/ha) and RCM 9 (8.6 q/ha). The increase in grain yield due to one hand weeding at 30 DAT was maximum in variety Vivek Dhan 82 (52.8 %) followed by Mendri (49.4 %), Manipuri (48.3 %) and SHAH SARANG (45.2 %). Chlorophyll 'a', 'b' and 'total' content was found significantly higher in Vivek Dhan 82 compared to all other varieties. Highest photosynthesis rate ( $28.2 \mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ ), stomatal conductance ( $552.2 \text{ m mol m}^{-2} \text{ s}^{-1}$ ), transpiration rate ( $8.16 \text{ m mol m}^{-2} \text{ s}^{-1}$ ), WUE (3.5) and Leaf temperature depression ( $3.3^\circ\text{C}$ ) was also observed in Vivek Dhan 82. Whereas, SHAH SARANG recorded a photosynthesis rate, stomatal conductance and WUE of  $22.5 \mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$ ,  $484.0 \text{ m mol m}^{-2} \text{ s}^{-1}$ , and 2.9, respectively. However, cultivar Vivek Dhan 82 suffered from lodging resulting in reduction in grain yield. Vivek Dhan-82 was found suitable for cultivation under natural fertility management in mid hills of Meghalaya because of early maturity by 12-15 days followed by SHAH SARANG.

#### Integrated nutrient management.

An experiment was carried out to compare two methods of *Azolla* application with five levels of N P.K doses under low land condition with cv SHAH SARANG. The data revealed that, rice + *Azolla* dual cropping performed better (42.8 q/ha) as compared to incorporation of *Azolla* in the soil (39.5 q/ha). Rice + *Azolla* dual cropping in combination with recommended NPK (80:60:40 kg/ha) recorded highest of grain yield (45.6 q/ha) followed by its combination with 50% NPK (44.6 q/ha).

Effect of various organic manures on low land rice (SHAH SARANG). The yield data revealed that maximum yield (47.9 q/ha) was recorded in the recommended NPK dose (80:60:40 kg/ha) but remained at par with application of paddy straw enriched compost @ 5 t/ha (46.1q/ha) and *Azolla* compost 5t/ha (42.6 q/ha). Addition of different doses of composts Viz. *Azolla*, pig manure and paddy straw enriched compost @ 2.5 and 5 tons /ha, remained almost equal in registering their effect on yield. All these doses were found superior to Ekta organic manure. Thus any of the compost @ 2.5 t/ha will be very economical.

A study was conducted to assess the optimum dose of organic nutrients sources equivalent NPK dose of 80:60:40. It was observed that organic input @ 20 t/ha was the optimal dose for supplementing nutrient requirement of Shah Sarang in low land ecosystem.

#### On farm research

Effect of *Azolla* dual cropping and line transplanting were evaluated in seven farmers fields in Mawlasnai village. It was observed that line transplanting of seedlings with *Azolla* dual cropping recorded higher yield of rice 28.6 to 36.8q/ha as compared to farmers practices 18.0 to 23.7 q/ha in all the seven sites. The percent increase in yield in line transplanting with *Azolla* dual cropping varied from 46 to 72.0 as compared to farmer's practices.

#### SOIL

##### Nitrogen availability indices and micronutrient status in rice soils of Meghalaya

A total of 57 bulk soil samples (0-30 cm depth) collected from rice fields last year from different districts of Meghalaya. Soil reaction (pH 4.27-5.56), organic carbon (0.61-5.28 %), were reported in the previous year. This year the soils were analyzed for total N (0.084-0.501 %), available N ( $182-603 \text{ kg ha}^{-1}$ ), available P ( $5.26-27.78 \text{ kg ha}^{-1}$ ) and available K ( $70.6-403.2 \text{ kg ha}^{-1}$ ). Exchangeable Ca and Mg varied from 0.8-9.6 and 0.4-5.6 c mol ( $\text{p}^+$ )  $\text{kg}^{-1}$ , respectively, however, the exch. Al ranged from 0.8-4.8 c mol ( $\text{p}^+$ )  $\text{kg}^{-1}$  (Table 9).

Experiments conducted in simulated puddled condition showed that among the three major nutrients, the yield response in terms of dry matter yield was in the order: P (55.9%) > K (49.7%) > N (46.0%).

The soils were also analyzed for available (DTPA -  $\text{CaCl}_2$ -TEA extractable) and total ( $\text{HNO}_3$ : $\text{H}_2\text{SO}_4$ : $\text{HClO}_4$  extract) micronutrient status. Available Fe, Mn, Zn and Cu ranged from 48.7-336, 2.0 - 183.2, 0.4 - 5.58 and 0.68 - 3.54 ppm, respectively in different districts. Available Zn in some soils was below critical limit. Total Fe, Mn, Cu and Zn ranged from 1.06-6.26%, 37 - 880.6 ppm, 9.6 - 884.4 ppm and 6.2 - 160.8 ppm, respectively.



**Table 9: Physico-chemical properties of rice soils of Meghalaya**

Location/ District (No. of soils)	pH	Org. C (%)	Total N (%)	Available nutrient (kg/ha)		
				N	P	K
Ri-Bhoi (25)	4.27-5.12	0.63-2.77	0.160-0.370	188-521	5.94-20.16	104-286
Jaintia Hills (6)	4.39-4.77	1.72-4.30	0.344-0.501	414-603	7.39-24.75	279-392
East Khasi Hills (8)	4.36-4.81	1.55-5.28	0.339-0.496	301-583	12.8-27.8	125-403
West Khasi Hills (6)	4.35-4.85	1.65-3.15	0.210-0.378	289-564	7.22-13.22	115-370
West Garo Hills (7)	4.73-5.42	0.67-1.80	0.084-0.238	220-295	5.26-12.54	76-211
South Garo Hills (5)	4.34-5.56	0.61-1.17	0.091-0.140	182-383	5.82-14.78	71-198
Mean	4.70	1.80	0.2724	346.94	11.79	202.54

**Acidity parameters of rice soils of Meghalaya**

Different forms of acidity in rice soils of six districts of Meghalaya (presented in table 1) were assessed for developing improvement strategies. The per cent contribution of pH dependent acidity towards the total acidity ranged from 90.8-95.5 in the soils of Jaintia Hills followed by West Khasi Hills (87.3-92.4 %) and East Khasi Hills (87.2-91.5 %). It is evident from the results that the soils from East Khasi Hills contain higher pH dependent acidity, while it was lowest in the soils of Garo hills. The percent contribution of exchangeable acidity towards the total acidity ranged from 5.7-17.4 in the soils of Ri-Bhoi followed by East Khasi Hills

(8.5-12.8 %). The exchangeable Al was highest in the soils of Ri-Bhoi followed by East Khasi Hills and west Khasi Hills. However, the exchangeable Ca & Mg were highest in the soils of Jaintia Hills followed by West Garo Hills and Ri-Bhoi (Table 10).

**PROTECTION**

**Uniform Blast nursery trial**

Total 772 entries were screened for blast resistance. Four varieties NSN 1 ( IAHS 200-11, CR 874-59, CR 874-24-2, NSN 2 (RR 373-21-1)

**Table 10: Different forms of acidity in rice soils of Meghalaya**

District and number of soils	Total potential acidity	pH dependent acidity	Exch. acidity	Exch. Al	Exch. H	Exch. Ca	Exch. Mg
Ri-Bhoi (25)	12.6-33.2 (22.9)	10.4-27.8 (20.2)	1.2-5.4 (2.68)	0.8-4.8 (2.2)	0.2-1.0 (0.46)	0.9-4.3 (1.99)	0.5-2.2 (1.38)
Jaintia Hills (6)	24.4-31.0 (26.5)	22.8-29.6 (24.7)	1.4-2.4 (1.7)	1.0-1.4 (1.2)	0.2-1.0 (0.53)	4.5-9.6 (6.78)	1.6-5.6 (2.92)
East Khasi Hills (8)	23.4-36.0 (29.3)	20.4-32.2 (26.2)	2.4-3.8 (3.0)	1.6-3.4 (2.3)	0.4-1.2 (0.78)	1.6-2.4 (2.30)	0.6-2.1 (1.09)
West Khasi Hills (6)	23.8-30.6 (25.9)	20.2-27.4 (23.3)	1.8-3.2 (2.7)	1.6-2.2 (2.0)	0.2-1.2 (0.67)	1.5-1.9 (1.80)	1.0-1.5 (1.23)
West Garo Hills (7)	12.4-20.6 (16.5)	10.4-26.8 (15.6)	1.0-3.2 (2.1)	1.0-3.0 (1.7)	0.2-1.0 (0.40)	1.6-6.0 (3.10)	0.9-3.8 (2.19)
South Garo Hills (5)	10.2-14.2 (11.9)	8.6-11.2 (9.6)	1.0-3.0 (2.2)	0.8-2.8 (2.0)	0.2-0.4 (0.24)	1.0-2.9 (1.90)	0.7-2.0 (1.28)

Parentheses indicate the mean values

were found to be resistant None of the other entries from NSNH (56 no.), NHSN ( 87 no.) and DSN (31 no.) showed resistant reaction.

#### **Blast management**

Under upland rice ecosystem two experiments were conducted. In first experiment, four botanicals were tested for their efficacy against leaf and neck blast with variety DR 92 and compared with established fungicides and unsprayed check. Amongst botanicals fresh Turmeric, dry Turmeric powder and Tricure were effective in significantly reducing the disease and were at par with Kitazin and Bavistin. In second experiment sticker (Antron AE) was used to find out increased efficacy of Hinosan in managing leaf and neck blast with rice variety, HR 12. The use of sticker (Antron AE) has shown increased blast management efficiency of Hinosan , decreasing the leaf blast by 25.6%.

Under lowland transplanted ecosystem experiment was conducted with two new formulations for blast management in RCPL 1-3 rice variety and compared with fungicides and unsprayed check. Sivic 75 WP was found best in managing the disease recording low leaf blast (0.45) and neck blast (1.77) and followed by Kasu B 0.65 and 0.54 in comparison to un sprayed check (1.76 and 7.82 leaf and neck blast rating respectively. Amongst new formulations Amistar 25 SC (1ml/l) was better in reducing the leaf (0.45) and neck blast (3.45). In another experiment on the efficacy of two stickers (APSA 80 and Antron AE ) used with Bavistin and Hinosan for the management of blast. Bavistin in combination with Apsa was found better followed by Bavistin +Antron. Both Hinosan and Bavistin performed better when used with stickers). Third experiment was conducted on var HR-12 to test the efficacy of different fungicides in blast management. In case of leaf blast RIL 011 was best followed by Kasu B.

#### **Epidemiology**

Rice varieties HR 12 and RCPL 1-3 were sown at 10 days interval starting from 28<sup>th</sup> April 04 to 21st June in upland condition. Observations were recorded at 30 and 60 DAS.

Leaf blast was first observed on 20<sup>th</sup> June. Severity slowly increased with time. Disease severity was higher during July-August. Crop sown upto 1<sup>st</sup> week of May escaped the disease.

#### **Modification of indigenous gundhi bug trap for higher efficiency**

The efficiency of the ITK improvised gundhi bug trap was evaluated on different rice varieties. The number of gundhi bugs trapped on five different rice varieties viz., RCM-8, Vivek Dhan 82, RCPL-1-29, Krishna Hamsa and IET 17212 varies from 1-24. Average daily catch was the highest 11 bugs/ trap in the variety RCM-8 and the lowest 3 bugs/ trap on IET 17212. For effective gundhi bug management number of traps per hectare has to be standardized.

#### **Local *Trichogramma* species**

Local *Trichogramma* species were collected by placing UV ray sterilized *Corcyra cephalonica* egg cards attached to rice plants in fields where no chemical pesticides were applied. After 48 hours of exposure corcyra cards were collected and kept in glass tube to observe the parasitization by local *Trichogramma* spp.. The infectivity of the local strain was studied in comparison with the other four species normally used in management of stem borer in field conditions. Though local strain was found to be at par with the other species but was found to have a better searching ability even during the monsoon period. Mass production techniques for the local species were standardized.

### **ARUNACHAL PRADESH CENTRE**

#### **Performance of wetland paddy:**

Eleven varieties of lowland / wet land paddy were evaluated. The highest grain yield of 44.0 q/ha was produced by the variety TOX 3241-221-2-2-3 followed by VL Dhan 61 (40.7 q/ha), RCPL 1-230 (39.0 q/ha), TOX 3093-10-1-2-32(37.0 q/ha), PSR 88090-1-2-4(35.0 q/ha) and ITA 222(32.0 q/ha). The lowest grain yield of 15.0 q/ha was recorded in c.v. Pooja

#### **Evaluation of upland rice varieties:**

Out of 7 varieties of upland rice tested , IR 6008-32 gave the highest grain yield of 31.7 q/ha followed by VL 206 (30.5 q/ha), VL 82 (25.0 q/ha) and IET 17655 (24.0 q/ha).

The varieties Vandana and IR 6008-32 produced 27.0 and 30.1 q/ha grains respectively. Line sowing



with 60 kg seed/ha, application of 40:30:30 kg NPK/ha along with 5 t FYM /ha produced highest grain yield (39.7 q/ha), which was at par with line sowing (60 kg seed/ha) with 80:60:60 kg NPK/ha (SSP incubated with FYM for 72 hours in 2:1 ratio).

The hybrid rice JKRH 401 produced maximum grain yield (20.87 q/ha) (Table 11) with application of 160 kg N, 80 kg P<sub>2</sub>O<sub>5</sub> and 80 kg K<sub>2</sub>O/ha which was at par with 140 kg N, 70 kg P<sub>2</sub>O<sub>5</sub> and 80 kg K<sub>2</sub>O/ha. The low yield of hybrid rice is due to prevailing cool and humid weather during ripening stage of the crop.

**Table 11: Response of hybrid rice JKRH 401 to different levels of NPK**

Treatments	Grain yield (q/ha)
100:50:50 kg NPK/ha	12.50
120:60:60 kg NPK/ha	13.00
140:70:70 kg NPK/ha	18.50
160:80:80 kg NPK/ha	20.87
SEM ±	1.18
CD (P=0.05)	3.77

## NAGALAND CENTRE

### Development and standardization of improved agronomic practices

#### Intercropping in Paddy based cropping system

Naga local variety was taken as main crop with intercrops of maize, mungbean, soybean, finger millet, groundnut and okra. Maximum Land Equivalent Ratio (LER) and yield was recorded (Table 12) with paddy + finger millet, followed by paddy+ maize, which was at par with paddy+ okra.

#### Yield evaluation trials of rice

The yield evaluation trials of paddy was conducted with 15 numbers of genotypes under foothill conditions. Among 15 genotypes, Dwarf Moosurie produced higher grain yield (52.56 q/ha) followed by Kushal (52.20 q/ha)

#### Seasonal incidence of major paddy pests

Seasonal incidence of yellow stem borer (*Scipophaga incertulas*), leaf folder (*Cnaphalocrosis medinalis*) and gundhi bug

**Table 12. Yield performance of different intercrops with paddy**

Inter crop combination	Yield (q/ha)			LER
	Paddy	Intercrop in sole conditions	Intercrop	
Sole paddy	30.00	-	-	-
Paddy+mungbean	26.50	15.00	8.00	1.43
Paddy+urldbean	25.90	14.20	7.50	1.38
Paddy+soybean	27.00	20.10	8.50	1.32
Paddy+groundnut	25.89	16.58	10.20	1.48
Paddy+finger millet	25.50	16.21	15.20	1.80
Paddy+ maize	24.85	25.00	13.52	1.37
Paddy+okra	26.10	20.00	14.10	1.41

(*Leptocorisa acuta*) was studied on Ranjit variety . The initial adult activity of stem borer was observed in the first week of June and assumed its peak in the first week of August (9 dead hearts/m<sup>2</sup>) and thereafter gradually declined and again assumed its peak in the first week of October (7 white ears/m<sup>2</sup>). Maximum incidence of leaf folder was observed in the first week of September (16 leaf folds/m<sup>2</sup>) and reached its minimum by second week of October (2 leaf folds/m<sup>2</sup>). In case of gundhi bug, maximum incidence was observed in the first week of October (15 adults/m<sup>2</sup>).

## SIKKIM CENTRE

### Studies on organic nutrition of rice

An experiment was conducted with three improved rice varieties VL Dhan-61, Pusa Sugandh II, Pant Dhan-10 and one local check "Attey" under two organic sources of nutrition (mixed compost and neem cake) to evaluate their performance in terms of yield, yield attributes and N-use efficiency in comparison with 3-split urea application. 30 day-old seedlings were transplanted with 20 x 15 cm spacing between rows and hills, in plots of 10m<sup>2</sup>. Nitrogen was applied through urea @ 80 kg ha<sup>-1</sup> through a combination of mixed compost and neem cake. Phosphorus and potassium were basally applied before sowing through SSP and MOP @ 40 and 30 kg ha<sup>-1</sup>, respectively. Grain yield with mixed compost as source of nutrition the rice grain yield ranged from 15.0 (Attey) to 24.0 q ha<sup>-1</sup> (Pant

Dhan-10). Grain yield in neem cake + mixed compost ranged from 20.0 (Attey) to 31.0 q ha-1 (PD-10) while the 3-split urea produced the highest grain yield in all the varieties 28.0 (Attey) to 46.0 q ha-1 (PD-10).

## TRIPURA CENTRE

### Breeding rice for increased productivity and resistance/ tolerance for prevailing biotic/ abiotic stresses.

- F5 generation developed from upland crosses was raised and TRC-2000-36-1-1, a cross developed from TRC 87-251 × Vandana was found to be promising.
- 14 local jhum lines and 6 improved varieties were evaluated under this program for maintenance. Maximum plant height (160 cm) and no of panicles/ m<sup>2</sup> (230) was recorded in Garomalati. Highest yield was recorded in Mykasak (3.5 t/ha).
- TRC 02-1-1 (RCPL 1-87-4/Pyzum), TRC 02-2-1 (RCPL 1-87-4 × Pyzum), TRC 02-3-1 (Basmati 370 × Pyzum), TRC- 02-4-1 (Basmati 370 × RCPL 1-87-4) and TRC 02-5-1 (Pyzum × Binni) were the five lines under generation advancement of aromatic lines. Another promising indigenous aromatic non-basmati line 'Kali khasa' was grown for purification at 4<sup>th</sup> cycle with an objective to release that variety through pure line selection method..
- Seven low land local lines (Pyzum red, Kasha, Pyzum white, Nogba, Binni, Kali kasha and Beti), 18 improved varieties of low land and 2 improved lines (TRC 229 F-41 & TRC 87-251) were maintained.

### Front Line Demonstration- Paddy

Five Front line Demonstrations of paddy in kharif and 10 in boro seasons were conducted in West Tripura (District).

### Integrated Plant Nutrition

Results obtained from a field trial on upland rice (var. TRC-87-251) are presented in **Table 13** revealed that maximum grain yield of 35.75q/ha

was recorded by plots treated with cowdung @ 10 t/ha, NPK recommended dose and PSB but best economical yields were recorded by combination of cowdung @ 5t /ha plus recommended dose of NPK (30.47q/ha). Comparison of two doses of cowdung also revealed that 10 t/ha was significantly better than check at 5t/ha.

**Table 13: Effect of biofertilizer on yield of upland rice**

Treatment	Grain Straw		Percent increase over control	
	(q/ha)	(q/ha)	Grain	Straw
Control	20.19	27.71	—	—
Cow dung 5t/ha	20.61	28.79	2.1	3.9
Cow dung 10t/ha	26.04	31.56	28.9	13.9
NPK 60:30:30	24.75	31.37	22.6	13.2
PSB	23.25	31.23	15.2	12.7
NPK + PSB	31.61	39.73	56.6	43.3
Cow dung 5t/ha + NPK	30.47	36.52	50.9	30.9
Cow dung 10t/ha + NPK	30.74	37.63	52.3	35.8
Cow dung 5t/ha + PSB	24.53	32.21	21.5	16.1
Cow dung 10t/ha + PSB	24.56	29.91	21.6	7.9
Cow dung 5t/ha + NPK + PSB	24.27	34.57	20.2	21.2
Cow dung 10t/ha + NPK + PSB	35.75	38.89	77.1	40.3
CD (5 %)	3.2	4.6	—	—

### Crop – Alley Cropping in upland rice

Upland rice was grown in alley cropping systems with subabul/ arhar/ gliricidia in terrace riser and the results are presented in **Table 14**.

**Table 14: Productivity of upland rice ( q/ha) in alley cropping systems**

Treatment	Subabul		Arhar		Gliricidia	
	Grain	Straw	Grain	Straw	Grain	Straw
100 % NPK	20.6	28.0	22.6	26.0	23.8	29.0
OM + 75 % NPK	23.0	29.5	24.0	27.0	25.0	30.0
OM +50 % NPK	15.0	21.5	23.2	25.0	23.0	29.0

The application of green leaf (5 MT/ha) in combination with 75 % NPK could produce a rise of 3.6, 2.6 and 2.8 q/ha grain of upland rice over control in subabul, arhar and gliricidia based alley systems, respectively.



## MANIPUR CENTRE

### Release of RCM-10 for Manipur

A high yielding culture RCM-10, derivative of Prasad x IR-24 was released by State Seed Sub-Committee on 21 February 2005 for cultivation in low land valley areas of Manipur as *Lungnilaphou*. This variety was tested for more than four consecutive years under farmers' conditions and it gave consistently good yield of 60.01 q/ha. It is tolerant to blast as well as sheath blight. This variety is very popular among the farmers and in great demand because of its high yield potential coupled with soft cooking quality and good taste. Arrangements are being made to multiply the seed to meet the farmers demand.

### High yielding, disease resistant rice for main kharif (June to Nov)

(a) Eleven advanced lines developed by Manipur Centre from the crosses viz., Prasad/IR-24, BR-1/Leimaphou (MC-33), along with three checks were evaluated in lowland. Lines MC-17-30-5-17, BR-1x Leimaphou, MC-17-19-1 and MC-17-30-6-12 gave 75.66, 62.33, 62.00, and 61.00 q/ha yield, respectively. Maturity duration ranged from 130 to 142 days.

(b) Eighteen quality rice lines developed from the different crosses viz., Prasad/IR-24, Napnang mumei/Basmati-370, BR-1/Basmati-370, Napnang mumei/KD-2-6-3, BR-1/RCM-7, IRAT-109/Basmati-370 and Konlong/ Basmati-370 were evaluated at lowland under transplanted conditions. Out of these lines viz., MC-17-30-6-2-11, MC-17-50-1, MC-17-8-2-1-1, MC-30-1-5-6 and MC-17-50-3-1-1 were found to be high yielding and gave 82.0, 77.33, 77.0, 74.0 and 73.66 q/ha yield, respectively.

### Cold tolerant and short duration rice genotypes suitable for pre-kharif season.

(a) One hundred eighty  $F_4$  generation selections were raised under transplanted lowland conditions for selection for different maturity duration 261 outstanding plants with different maturity durations ranging from 90 to 140 days were selected for further

selection. Eight advanced lines of short duration were also maintained.

### Regional Co-ordinated trials

(a) Among fifteen entries including four from Manipur (RCM-9, RCM-10, RCM-11 and RCM-12) and local check, KD-2-6-3 evaluated RCPL-1-179-3P, ITA-222, DR-92, RCPL-1-2-30 and TOX-3093-10-2-3-2 were found to be high yielding with the yield potential of 78.0, 75.5, 73.66, 72.33 and 69.0 q/ha, respectively.

(b) Research Complex Regional Trial on Aromatic Rice (RCRT-AR) comprising nine entries conducted under transplanted valley conditions, IET-16309, Pusa Basmati, IET-16310, IET-16313 and IET-16339 were found to be promising with 61.33, 58.66, 58.33, 57.33 and 53.33 q/ha yield, respectively with a maturity duration ranging from 130-140 days.

### All India Co-ordinated trials

Sixty-five entries including checks received from DRR, Hyderabad namely Advanced Variety Trial 1-Irrigated Mid Early (14 entries), Advanced Variety Trial 1-Irrigated Mid Early (11 entries), Initial Variety Trial-Very Early (21), Advanced Variety Trial-Very Early (10 entries) and Advanced Variety Trial 2-Upland Hills (9 entries) were evaluated under Manipur conditions during kharif-2004. Three entries of AVT1-IME viz., HRI-148, NDR 2072 and OR 2179-21 performed well and recorded 97.5, 75.8 and 74.5 q/ha yield respectively and one entry in AVT2-IME namely EXPH 209 (hybrid) gave 63.6 q/ha yield.

### Frontline demonstrations

40 FLDs with RC Maniphou-6, RC Maniphou-7 and RCM-10 (*Lungnilaphou*) were conducted successfully in different districts of Manipur to demonstrate the performance of these varieties under farmers fields..

### Breeder seed production

2250 kg of breeder seed of three varieties namely RC Maniphou-5, 6, 7 and RCM-10 (*Lungnilaphou*), was produced. In addition, breeder seed of the RC Maniphou-4, Bhalum-1, and Bhalum-2 was also produced in small quantities.



#### Maintenance of indigenous rice germplasm

More than 300 local rice germplasm were collected and maintained.

#### Studies on phosphorus management in rice based intercropping systems and residual effect on toria

The highest grain yield in terms of rice-equivalent yield (59.62 q/ha) was obtained in rice + groundnut – toria followed by rice + red gram – toria (56.19 q/ha) and rice + soybean – toria (51.08 q/ha) cropping systems (Table 15). Inclusion of groundnut as an intercrop with rice increased the REY of the rice - toria cropping system by 29.24 per cent. It was also observed that in kharif season, highest REY was recorded in rice + red gram (52.34 q/ha) followed by rice + groundnut intercropping system (40.93 q/ha).

The grain yield of rice as well as different intercrops increased with increase in phosphorus levels though there was marginal increase at 90 kg over 60 kg P<sub>2</sub>O<sub>5</sub>/ha. The highest rice equivalent yield was obtained at 90 kg P<sub>2</sub>O<sub>5</sub>/ha (58.11 q/ha). It was observed that the yield of rice was increased in sole as well as in intercropping system except rice + red gram intercropping and yield of all the intercrops increased with increase in phosphorus levels.

#### Integrated weed management in rice based cropping system

Five weed control measures (Unweeded check, Manual weeding at 3 and 6 weeks, Butachlor as pre and post emergence spray, Butachlor as pre emergence spray + manual weeding at 3 weeks and Butachlor as pre emergence + 2, 4-D spray as post emergence) in rice followed by four rabi crops (Toria, Field pea, Bengal gram and French bean)

gave maximum grain yield in terms of rice equivalent yield (39.91 q/ha) with pre emergence spraying of Butachlor @ 2.0 l/ha + one manual weeding at 3 weeks after transplanting of rice.

#### Effect of zinc and boron interaction on lowland paddy-tomato cropping system

RC Maniphou 7 released from this centre. The grain (52.9 q/ha) and straw yield (53.9 q/ha) increased significantly with 2.5 kg Zn/ha level over control and then decreased significantly with the higher doses. Application of B showed significant decrease in the grain and straw yield beyond the dose of 2 kg/ha (54.6 & 54.4 q/ha). Zn and B interaction was found significant.

Neck blast incidence in paddy was observed highest (38.24%) with no zinc and 5g boron combination and lowest (15.69%) with 10g zinc + 2g boron combination respectively. Maximum grain (60.0q/ha) and straw yield (60.4q/ha) was recorded with 5kg Zn/ha without any B application.

#### Efficacy of botanicals against neck blast diseases of paddy

For comparing the efficacy of four botanicals viz. *Lantana camera*, *Ganoderma lucidum*, *Acmelia sp.* and *Artemisia milagirica* on the neck and leaf blast (*Pyricularia oryzae*) disease of rice. Paddy variety RCM-9 was taken as the test crop. The results revealed that all the four tested botanicals were effective to control the blast disease.

#### Economics on yield performance and profitability

The average yield of HYV rice was 5.5 t/ha while that of local rice was 3.13 t/ha. Thus, it emerges that the yield realized by HYV rice growers was higher by 75.72 per cent compared with local

Table 15: Performance of various Rice based cropping systems

Intercropping systems	Rice yield (q/ha)	Pulse yield (q/ha)	REY of pulses (q/ha)	Total REY (q/ha)	Toria yield (q/ha)	REY of Toria (q/h)	Total REY of the system (q/ha)
Rice (Sole) - Toria	33.15	-	-	33.15	5.77	12.98	46.13
Rice + Groundnut- Toria	35.00	3.96	5.93	40.93	5.95	13.39	59.62
Rice + Soybean- Toria	30.18	3.07	7.69	37.87	5.87	13.21	51.08
Rice + Green gram- Toria	29.26	1.55	4.65	33.91	5.63	12.67	46.59
Rice + Red gram- Toria	8.33	17.60	44.01	52.34	1.71	3.85	56.19



rice growers in Manipur. The average cost of production of HYV rice worked out to be Rs.27317.36 while for local rice it was Rs 22080.40 per hectare. Among the components of total cost, expenditure on labour formed the single largest item and accounted for 43.82 per cent and 41.53 per cent of the total cost of HYV and local varieties respectively. The cost incurred on rent was the next important item (20-25 per cent of the total cost in both the cases). Manures and fertilizers accounted for 11.53 per cent of the total cost in HYV rice while it was 5.80 per cent in local variety. The farmers growing HYV rice realized a gross return of Rs.37,250 against Rs.23879.50 from local varieties. Thus, the gross return is 55.99 per cent higher in HYV rice cultivation. The profit (net return) realized in HYV rice production was higher by 452.09 per cent. Consequently, the benefit-cost ratio was also higher in HYV rice cultivation.

## MIZORAM CENTRE

### Varietal evaluation trial for yield potential in upland

Eighteen rice varieties were evaluated in upland. Maximum grain yield (52.70 q/ha) was recorded in variety Bahlum-1 followed by IURON-305 (50.70 q/ha). were maximum Grains /panicles (143.66) in IURON-312 while highest test weight of 32.01 g. variety IURON 414 was (Fig. 7) recorded



Fig. 7. Healthy crop of upland rice

### Standardization of date of sowing

To determine the suitable date of sowing of rice variety IURON-514 was sown at 15 days interval from 1<sup>st</sup> May to 30<sup>th</sup> June with 20 x 10 cm spacing.

June 16 was observed to be the suitable date with respect to number of effective tillers, number of grains/panicle and grain yield (Table 16)

**Table 16: Effect of different date of sowing on growth and yield of in upland rice**

Dates of sowing	Plant height (cm)	Effective tillers/ sq.m	No. of grains/ panicle	Grain yield (q/ha)
1 <sup>st</sup> May	86.00	237.00	85.00	46.37
16 <sup>th</sup> May	87.50	251.00	99.25	50.50
1 <sup>st</sup> June	83.00	285.00	99.00	51.66
16 <sup>th</sup> June	80.00	302.00	103.25	56.00
30 <sup>th</sup> June	78.75	287.00	96.75	52.00
CD (P=0.05)	5.21	21.96	9.61	4.15

### Varietal evaluation

- Out of 17 varieties under uniform dose of fertilizers RCPL 1-87-4 recorded maximum grain yield (52.70 q/ha) followed by ITA-222 (50.70 q/ha)
- Nine varieties of aromatic rice were evaluated. Variety AR-4 recorded maximum grain yield (32.40 q/ha), closely followed by variety AR-3 (31.80 q/ha). Maximum test weight of 25.32 g was recorded with variety AR-4 followed by variety AR-1 (22.18 g).
- Thirteen varieties of early duration were evaluated for their production potential. Variety AVT-308 recorded maximum grain yield (59.9 q/ha) followed by variety AVT-305 (53.7 q/ha).

### Standardization of nitrogen levels in lowland rice

Maximum grain yield (52.3 q/ha) was recorded with N @ 125 kg/ha, followed by nitrogen @ 100 kg/ha (50.66q/ha).

## MAIZE

### KHARIF MAIZE

#### Varietal Adaptability Evaluation

Four hundred and seventy two strains were evaluated to identified high yielding, disease resistant strains of medium, early and extra early maturity under rainfed conditions. Superior strains identified from observations of different trails are

listed in Table 1. These trails included 87 RC strains (14 composites and 62 hybrids) developed at the institute. In addition, specially strains in baby corn (RC BC), Pop Corn (RC PC) and sweet corn (RC SC) were evaluated and promising strains were identified.

**Table 1: Promising entries of maize (different maturity groups) at Umiam.**

Trial	Strain	Yield (t/ha)	Trial Mean yield (t/ha)
67E	DMR-326	6.24	2.23
61HET-FSM	DMR-644	6.13	2.90
67AEM	DMR-704	5.99	3.99
ZT103EEE	ZR-208	5.86	3.65
RCPC (Popcorn)	RCPC-12	3.45	2.02
RCBC (Baby corn)	RCBC-26	1.65*	1.29
RCSB (Sweet corn)	RCSC-18	5.94	4.89

\*Baby corn yield

### RABI MAIZE

Two trails were conducted to evaluate 48 strains including Rabi strains to identify high yielding, disease resistant strains for early maturity, cold tolerance and cob yield in winter season/pre-rabi maize season. Superior strains from the trials were DMR 219 (5.8 t/ha), DMR 216 (5.5 t/ha) and DMR 192 (5.7 t/ha).

**Table 2: Data on yield attributes, GDI, CHU etc.**

Rank	January	Feb.	March	April	May	June	July	August	Sept.
I	Hemant	Hemant	RCM 1-1	Vijaya comp	Vijaya comp	Vijaya comp	RCM 1-1	Hemant	Hemant
II	MLY	MLY	MLY	MLY	RCM 1-1	RCM 1-1	Vijaya comp	RCM 1-1	RCM 1-1
III	RCM 1-1	RCM 1-1	MLW	RCM 1-1	MLY	MLY	MLW	MLY	MLY
GDD	162	135	120	124	107	94	87	120	150
CHU	3097	3179	3163	3461	3140	2750	2725	3117	3055

**Table 3: Effect of lime and fertilizers on Maize Yield at Farmer's field (q/ha)**

Treatment	Locations										
	1	2	3	4	5	6	7	8	9	10	11
Farmers' practice	10.2	15.2	9.8	13.6	21.3	13.9	11.5	21.5	18.2	12.6	13.9
100% NPK (R.D)	18.3	21.3	16.7	21.8	38.5	28.7	19.5	35.6	27.6	18.5	25.7
50% NPK + lime (1/10LR)	24.6	28.2	22.3	26.7	35.6	30.1	28.6	37.5	31.2	28.7	30.8
50% NPK + lime (1/10LR) +5t FYM	32.5	30.7	27.8	30.1	43.9	38.7	37.6	42.8	35.8	32.3	35.6

CD at 0.05= 1.58

### Evaluation and Identification of Suitable cultivars for Round the Year Production of Maize

A trial was constituted with seven entries viz. RCM 1-1, RCM 1-2, RCM 1-3, MLY, MLW, Hemant and Vijaya Composite (Table 2). Sowing was done on every 5<sup>th</sup> day of the solar month. Data in addition to yield attributes were collected for growing degree (GDI) and crop health units (CHU) available at Barapani. Based on the performance of yield and yield attributes for each month a new high yielding elite pooled population was developed which will be evaluated in the subsequent seasons.

### Evaluation of maize-based cropping sequence in raised beds in marshy land

Out of 12 cropping sequences evaluated for productivity as expressed in terms of maize equivalent yield, maize - pea crop sequence recorded maximum productivity (116q/ha) followed by maize- French bean - radish (89.5q/ha).

### Response of lime and FYM at farmers' fields

Four treatments (Table 3) were evaluated at 11 locations in the Nongthymai (Kyrdem) and Mawpun villages of East Khasi hills district on soils having wide variation in soil reaction and lime requirements. In both villages the application of 50%



recommended dose of NPK+ lime (1/10<sup>th</sup> LR) in furrows + 5t FYM/ha gave the maximum grain yield of maize (35.2 q/ha). Application of 100% NPK (100:60:50 NPK) without lime could not enhance the efficiency of fertilizer to increase the productivity level as the soils of Kyrdem village were highly acidic.

#### Maize-Mustard cropping sequence:

#### Integrated nutrient management:

The effect of integrated nutrient management on the productivity of maize - mustard cropping sequence and soil properties was studied for the 4<sup>th</sup> year. The treatments consisted of 0, 50, 75 and 100 % of recommended dose of NPK with lime (500 kg/ha), FYM (5t/ha) and bio fertilizers (*Azotobacter and phosphatica*). Grain yield of maize increased significantly over control by all the NPK treatments integrated with lime and /or FYM along with biofertilizers. Highest maize yield (44.2 q/ha) was obtained in Lime + FYM + Bio + 100% NPK treatment combination over control (6.1 q/ha). Mustard yield also followed almost similar trend and maximum yield of mustard grain (9.3 q/ha) was recorded with full dose of NPK applied with Lime + FYM + Bio, followed by Lime + FYM + Bio + 75% NPK ( 8.45 q/ha) over the control yield of 0.02 q/ha. N, P and K uptake by both the crops was highest in the treatment Lime + FYM + Bio + 100% NPK. Use of only NPK fertilizers in any test dose without any amendments did not support the plant growth to the desired level.

There was a decline in soil pH in different treatments. Maximum decline in pH was recorded with only 100%NPK. Application of Lime and/or FYM with biofertilizers showed slight increase in

soil pH (0.1- 0.3 units). The increase in soil pH in rhizosphere zone of maize crop was by 0.75- 1.0 unit. Exchangeable acidity decreased and exchangeable Ca + Mg and organic carbon increased in the lime, FYM and biofertilizers treated plots.

#### Effect of Zn levels, FYM and lime on yield

Application of 6 kg Zn+ FYM+ lime recorded highest grain yield (33 q/ha) and straw yield (79 q/ ha) of maize, highest leaf Zn content (136 ppm), highest Zn uptake by grain (257 g/ha) and by straw (506 g/ha). Maximum increase in soil pH, organic C and available Zn (0.73 ppm) were also noticed in this treatment. Application of only Zn @ 3 or 6 kg/ha did not significantly influence the yield of maize. In case of mustard, the yields with application of 3 kg Zn + FYM + lime and 6 kg Zn + FYM + lime were at par.

#### Disease management

Seven varieties of maize (RCM 1-1, 1-2, 1-3, Hemant, Vijay Composite, MLY and MLW) were sown at monthly intervals. Observations on Turicum leaf blight (0-5 scale) were taken at dry silk stage under natural disease pressure. Disease was first recorded in March and increased subsequently, attaining maximum intensity in July. The correlation with weather parameters (Table 4) revealed that PDI was significantly positively correlated with maximum, minimum temperature, R.H. and total rainfall.

#### IPM in Maize

An experiment was conducted during the kharif season to study on bioefficacy of different insecticides against the maize cob borer and stem

Table 4: Correlation coefficients (r values) between disease index and weather parameters

Variety	Max Temp	Min Temp	RH	Total rainfall (mm)	Rainy days	Mean BSSH	WS
V.Composite	.688**	.726**	.571*	.548*	.723**	-.516*	-.199
RCM 1-1	.706**	.731**	.605*	.777**	.815**	-.747**	-.583*
RCM 1-3	.651**	.808**	.852*	.616**	.689**	-.600**	-.208
Hemant	.667**	.674**	.546*	.674**	.804**	-.686**	-.411
MLW	.678**	.761**	.750*	.434	.656**	-.532*	-.319
MLY	.695**	.727**	.540*	.728**	.854**	-.796**	-.510*
RCM 1-2	.595**	.752**	.848*	.638**	.690**	-.543*	-.325

\*\*Correlation is significant at 0.05 level (2-tailed)



borer. The cob borer damage ranged from 0-17.2% and the stem borer damage ranged between 0-14.7%. Carbofuran 3 G, when applied at whorl stage was found to be the most effective treatment with a maximum cob yield (27.8 q/ha) against the control (7.8 q/ha). Root zone application of Carbofuran 3 G, gave yield of 15.5 q/ha followed by cypermethrin 10 EC (14.5 q/ha), dimethoate (rogor 30 EC) (13.5 q/ha) and metasystox 36 EC (12.5 q/ha). Quinalphos treated plots gave only 9.0 q/ha yield and remained at par with control.

## NAGALAND CENTRE

### Intercropping under maize based cropping system

The best combination of intercropping was maize + groundnut (additive) with highest LER of 1.62 followed by maize + groundnut (skip) of LER of 1.50 respectively.

**Table 5: Yield performance of maize + groundnut intercropping**

S. No.	Intercrop combination	Yield (q/ha)		LER
		Maize	Groundnut	
1	Sole maize	28.50	—	-
2	Sole groundnut	—	17.50	-
	Maize + groundnut (additive)	22.00	15.00	1.62
3	Maize + groundnut (replacement)	20.0	10.00	1.27
4	Maize + groundnut ( skip row)	24.10	17.20	1.50
5	Maize + groundnut (1:2)	19.20	16.00	1.58
6	Maize + groundnut (2:1)	23.10	11.02	1.44
7	Maize + groundnut (mixed)	18.10	10.00	1.21
	CD at 5%	1.90	1.10	

### Effect of date of sowing on the incidence of maize stem borer

Three dates of sowing viz. 5<sup>th</sup> March, 5<sup>th</sup> April and 5<sup>th</sup> May were evaluated to find the effect of sowing time on maize stem borer incidence in Maize hybrid (900 M). Least incidence was observed on March sown crop (18%) delayed sown crop was found severely infested (28%-50%).

## Management of maize stem borer

Comparison of different soil application with carbofuran 3g and whorl application showed that combination of soil application @ 1kg a.i/ha along with whorl application 30 days after germination was found effective in management of the pest.

## SIKKIM CENTRE

### Maize Improvement Project

Three forms of Sikkim primitive maize differing in kernel colour (yellow, white and dark orange) were collected. Female prolificacy was found high (4 to 5 ear /plant) in these genotypes. High altitude genotypes from upper Dzongu were also collected. In order to assess the kind of varieties suitable for organic farming in Sikkim comparative evaluation of F<sub>1</sub> hybrids, composites and OPVs (local genotype) were undertaken. The trial was conducted without application of inorganic inputs including fertilizers. FYM was applied @ 5 tones/ha. Seed yield of open pollinated varieties ranged from 12.1 to 18.9 q/ha whereas the yield of composites ranged from 15.4 to 20 q/ha. Seed yield of hybrids were at par with composites.

### Eco friendly management of insect pest of maize

Various treatment included were Achook 15 EC (Azhadirachtin) @500 ml/ha, Nimbicidine 0.03 EC (Azhadirachtin) @500 ml/ha, Pestoneem (Azhadirachtin) @1000 ml/ha, Dimilin 25%WP (Diflubenzuron) @400 g/ha, Dipel (*Bacillus thuringiensis*) @500 ml/ha, Delfin WG (*Bacillus thuringiensis*) @500 ml/ha, Priority (*Paecilomyces fumosoroseus*) @1000g/ha, Biopower (*Beauveria bassiana*) @1000g/ha, Wah (*Beauveria bassiana*) @1000g/ha, Lumphos 36% EC (Monocrotophos) @750 ml/ha, Furadon 3G (carbofuran) @ 33.3 kg /ha and untreated check against Defoliator (*Plusia signata*) Armyworm (*Mythimna separata*) and Stem borer (*Chilo partillus*) on maize. Among all the treatments monocrotophos @0.05% was found to be an effective control over Defoliator (*Plusia signata*) and carbofuran @ 1.00 kg ai / ha provided good control over Armyworm (*Mythimna separata*) and Stem borer (*Chilo partillus*). Among



the eco friendly insecticides Pestoneem 0.5EC @1000 ml /ha effectively checked the population of Armyworm (*Mythimna separata*) and Defoliator (*Plusia signata*) whereas Dipel 8 L @500 ml /ha provided effective control of Stem borer (*Chilo partellus*).

## TRIPURA CENTRE

### Breeding maize for increased productivity in Tripura State.

Improvement of Jhum lines: Thirteen populations (TRM-1to13) developed from inter-varietal crosses from two Jhum maize lines with three composites and a hybrid were advanced to F<sub>6</sub> generation. Data were recorded for cob length, cob size and selections were done within the populations.

### Varietal adaptive trial

The existing parental lines and varieties were raised for germplasm maintenance for future breeding programs. "Amber popcorn" a newly introduced variety in Tripura recorded plant height of 194.5 cm and yield of 425-kg/ha.

### Sheath Blight in Maize

Twenty genotypes of maize were screened for sheath blight disease reaction during Kharif season. Genotypes, 'DRLT-180-IC 32 4207', 'GRS-7', 'M-2', 'M-5' and 'M-8', were moderately resistant with disease scores ranging between > 2 and 3 in 1-5 point scale. The rest of the genotypes were either moderately susceptible or highly susceptible as in RKD 113 IC 309153.

## MANIPUR CENTRE

### Use of biofertilizer along with organic manures and intercropping in maize based cropping systems of Manipur hills.

Intercropping with soybean increased the grain yield of maize significantly by 22.3 per cent over control. The grain yield increased significantly with

FYM @ 5 t/ha + A (*Azotobacter* and *Azospirillum*) by 33.5 percent and then further increased by 14.3 and 29.6 per cent when coupled with ½ NPK and full NPK respectively. Maximum significant grain yield (41.5 q/ha) was obtained with FYM @ 10 t/ha + A (*Azotobacter* + *Azospirillum*) + ½ NPK and became at par with full NPK (43.9 q/ha).

### Use of vermicompost on maize under terrace cultivation

Maximum grain yield of 35.20 and 34.93 q/ha were recorded when vermicompost @ 2t/ha with ½ NPK and 1/3 NPK respectively was used. The results are in good agreement with last year's findings. Vermicompost @ 2 t/ha can save at the most two-third amount of the recommended doses of NPK.

### Evaluation of local isolates of Nitrogen fixing bacteria on Maize

The isolates MK<sub>1</sub> and MK<sub>7</sub>, as well as the standard C<sub>2</sub> could not supplement the 50% N reduction. The strain MK<sub>2</sub> and MK<sub>4</sub> gave maximum grain and stover yield respectively and were at par with full dose of nitrogen. The N fixing population as enumerated in Nfb media at 45 DOS vary significantly, and higher count was observed in inoculated plots.

## MIZORAM CENTRE

### Varietal screening trial of maize for yield potential (RCRT) in Kharif season

Nine varieties of maize were evaluated for their yield potential. A uniform fertilizer dose of NPK (80:60:40) was applied. Among white seeded varieties, maximum grain yield (68.54 q/ha) was recorded in Hemant followed by MLW (62.58 q/ha). Among yellow seeded varieties the maximum grain yield (967.08 q/ha) was recorded in Vijay composite followed by RCM 1-1 (63.54 q/ha).

### Varietal evaluation of maize during rabi season

Five varieties of yellow seeded maize were evaluated. The maximum grain yield of 48.00 q/ha was recorded with variety RCRB followed by variety RCM 1-1 (45.00 q/ha).

## OILSEEDS

### SOYBEAN

#### Germplasm Evaluation

One hundred and sixty seven germplasm lines were evaluated in augmented design. Among the total genotypes 10 genotypes namely MACS43, NRC 22, NRC 24, HIMSO 50, PK 472, MACS 428, PS 1042, PS 1092, PS 1024 and Shilajeet having seed yield/plant 24.62, 24.02, 23.48, 22.56, 22.03, 21.74, 20.14, 20.00, 19.36, 19.20 g respectively were found to be promising and were selected.

#### Evaluation of selected lines

Among the previous year selected 10 genotypes JS 80-21 performed the best (Table 1). PK 416 and NRC 25 also showed better results as compared to other genotypes with respect to different traits.

#### Hybridization and progeny evaluation

F<sub>1</sub> made in diallel cross involving PK 416, Shilajeet, JS-80-21, NRC 47, Dsb 5 and MACS 694 were raised. JS- 80-21 X Shilajeet and JS-80-21 X MACS 694 were found to be heterotic and will be advanced further.

Among the F<sub>7</sub> lines three line designed as H1, H9, H10 showed very less disease score (2-4) and higher productivity yielding 2.3-2.5t/ha

#### Evaluation of botanical and chemical fungicides for the control of rust disease

Three chemicals, two botanicals and one bio-control agents were tested against soybean rust

(*Phakopsora pachyrizi*) in var. JS 335. Observations on pod blight disease complex (*Cercospora* and *Colletotrichum*) were recorded. The test chemicals, botanicals and bio-control agent were sprayed thrice at 10 days interval. Rust and pod blight were recorded on 0-5 scale and percent disease index (PDI) was calculated for both the diseases. Yield data was recorded by selecting 10 competitive plants and yield q/ha was worked out.

All the test fungicides, botanicals and bio-control agent significantly reduced rust. Least PDI was recorded in Tilt (16.2) and Bayleton (16.1) and highest in unsprayed check (79.0). Tilt and Bayleton reduced disease by 80% and were statistically at par. Bayleton and Tilt recorded higher yield i.e. 24.8 and 19.8 q/ha respectively. A botanical Wanis and biocontrol agent *T.roseum* were equally effective and recorded 16.9 q/ha and 15.3q/ha yield, respectively.

#### Screening for rust resistance

Fifty genotypes were screened against rust in field. Only one genotype i.e. EC34490 showed moderate resistance, 24 moderate susceptibility and 19 genotypes susceptibility. Six genotypes did not germinate.

#### Yield dynamic studies on soybean varieties and planting densities

Soybean varieties viz., RAUS-5, V2-NRC-41, V3-MAUS-71 and V\$ Indira Soya were tested under two planting densities viz. 30 cm row to row and 45 cm row to row distance by maintaining the varieties in the main plot and densities as sub plots with three replications in each for four years.

Table 1 : Mean of different yield attributes of 10 selected genotypes

Genotype	Days to flowering	Plant height (cm)	Branches /plant	Cluster /plant	Pods /clusters	Pods /plant	Seeds /plant	Seed yield(g)
JS-80-21	51.	69.32	6.26	34.02	2.18	60.22	110.10	16.30
NRC 25	48	59.42	5.00	19.96	2.10	40.60	77.85	9.26
PK 416	53	65.94	5.22	25.23	2.40	54.14	106.54	11.44
NRC 18	54	60.23	3.25	17.23	2.01	34.25	68.25	8.08
MACS 43	50	52.22	4.02	20.10	1.96	32.01	52.08	5.96
MACS 414	52	62.22	5.20	19.25	1.55	22.20	48.25	6.20
MACS441	52	68.24	3.04	14.59	2.04	29.18	53.81	6.08
PK1134	49	61.22	4.32	20.15	2.12	39.22	70.61	8.45
PK1137	52	52.32	2.23	12.03	2.01	24.60	41.80	5.61
MACS 38	50	47.23	4.20	19.62	2.22	38.75	69.32	7.85
Mean	50.36	59.76	4.16	20.72	2.13	39.69	73.35	9.23
CD(5%)	4.66	6.12	0.92	2.19	0.30	4.16	10.23	1.94



The data recorded on grains yield revealed that the variety RAUS-5 performed better in all the three years and produced 15.80 q/ha grain yield in the third year followed by NRC-41 (14.50 q/ha), MAUS-71 (13.50 q/ha) and Indira Soya (9.5 q/ha).

Among planting densities, 45 cm row-to-row spacing produced high grain yield of soybean (15.04 q/ha) followed by 30 cm row-to-row spacing (11.60 q/ha).

## GROUNDNUT

### Germplasm evaluation

A total of 68 germplasm comprising of 43 bunch type and 25 spreading type were evaluated in augmented design.

### Hybridization

F<sub>1</sub> made in diallel cross involving in diallel fashion involving ICGS44, ICGS76, ICGS65, JL24, TAG 24 and Gimar were raised. ICGS76 X ICGS 44, ICGS76 X TAG 24 were found to be heterotic

### Effect of organic sources of nutrient management on pod yield and yield attributes

The studies were carried out to find out the effect of different organic sources of nutrient management on pod yield and yield attributes of ground nut (ICGS-76) with an objective to find out suitable alternative to inorganic nutrition. The pooled data is presented in **Table 2**. The results revealed that inorganic sources of nutrients @ 30:50:40 kg of N,P and K/ha produced the maximum yield (30.8 q/ha) but brady rhizobium, PGPR and biocontrol agents (26.9 q/ha). Addition of rabbit slurry @ 20 t/ha on fresh weight basis, neem cake and castor cake recorded 23.6, 23.0 and 22.8 q/ha pod yield, respectively. This indicates the possibility of obtaining satisfactory yield with organic sources of nutrients.

A trial was conducted in three villages with ground nut variety ICGS – 76 with four treatments (**Table 3**). There was wide variation in the soil reaction (4.3 to 5.4) with LR from 8.9 to 18.6 t/ha. All the soils were low in available P and medium in K supply. Application of 100% NPK increased the groundnut pod yield by 6.5 q/ha over the farmers'

**Table 2: Mean growth and yield of groundnut (Cv. ICGS-76) as influenced by varying organic sources of nutrient management**

Treatments	Growth and yield attributes (On pooled basis of two years)							
	Plant height (cm)	Branches / plant	Nodules / plant	Pods/ plant	Haulm weight/ plant (g)	Root weight / plant (g)	Pod weight /plant (g)	Pod yield (q/ha)
Control	29.93	7.19	32.88	8.02	18.50	4.10	14.89	16.81
30:50:40 kg N, P2O5, K2O/ ha	36.95	9.09	79.82	14.92	27.85	7.30	35.77	30.78
Organic manure @ 10t/ ha	38.09	8.21	72.70	13.13	24.95	5.50	32.67	29.31
Castor cake @ 1000 kg/ ha	35.15	7.11	56.76	11.12	19.50	4.27	26.63	22.78
Neem cake @ 500kg/ ha	33.41	8.15	59.91	10.91	18.75	4.28	24.70	23.05
Rabbit slurry @ 20t/ ha on wet weight basis	35.26	7.99	62.40	11.34	20.87	5.17	26.70	23.57
Mulching with <i>Ambrossia sp</i> @ 20t/ ha on fresh weight basis	33.51	8.27	47.09	8.90	17.10	4.35	20.20	19.76
Seed treatment with PSM, Brady <i>Rhizobium</i> , PGPR and Bio control agent	36.38	9.04	74.51	14.34	23.45	6.62	31.37	26.94
Use of vermicompost @ 5t/ ha	32.35	8.83	51.28	9.93	17.88	5.18	21.19	20.74
Farmer's practice, Bun method (in situ application of green biomass @ 20t/ ha)	31.34	2.95	52.34	10.37	17.25	5.65	21.57	20.55
CD at P <sub>0.05</sub>	<b>0.844</b>	<b>0.366</b>	<b>1.103</b>	<b>0.28</b>	<b>0.427</b>	<b>0.411</b>	<b>0.282</b>	<b>4.255</b>

practice. The reduction of 50% NPK and addition of lime 1/10 of LR) increased the productivity by 6.14 q/ha over NPK alone. Productivity improved further by 4 q/ha with incorporation of FYM @ 5 t/ha.

#### Evaluation of botanical and chemical fungicides for the management of early leaf spot (ELS) disease in groundnut.

Two botanicals i.e. Tricure and Wanis and seven chemical fungicides i.e. Bayleton, Civic, Dithane M-45 + Bavistin, Antracol, Saaf, Baycor and Result were tested in field. The fungicides were sprayed only once at 37 DAS on susceptible var. JL 24. ELS disease was recorded at maturity using 0-5 scale and percent disease index (PDI) was calculated.

**Table 3: Effect of lime, fertilizers and FYM on groundnut productivity (q/ha) at different locations in Ri-Bhoi district of Meghalaya.**

Treatment	Bangla (Unso-miong)	Kanda-ngulu	Mawka-ndep	Mean
Farmers' practice	7.52	9.30	9.15	8.66
100 % NPK(40,60, 40 kg/ha)	12.30	14.72	15.44	15.15
50% NPK+lime (1/10 <sup>th</sup> LR)	20.60	19.86	23.40	21.29
50%NPK+lime+FYM(5t/ha)	25.04	24.49	26.36	25.30
CD (0.05)	2.26	2.71	1.62	

Results showed (Table 2) that all the fungicides reduced disease significantly (p=0.05). The lowest disease score was recorded in Dithane M-45 + Bavistin sprayed crop. The highest (42.01) PDI was in unsprayed check. Among all the test fungicides only Dithane M45 + Bavistin and Saaf treated crops recorded significantly higher yield i.e. 2039 and 2024 kg/ha when compared to check (1518kg). The organic product Tricure and Wanis significantly controlled the disease however they were not as effective as DM-45 + Bavistin and Saaf.

#### Screening for ELS resistance

Fourteen genotypes were screened under field conditions. Four lines i.e. ICG6284, 10038, 7884 and 10954 showed resistance. Eight lines i.e. ICG193922, 4747, 7897, 100032, 10925, 10756, 7013 and 10900 were moderately resistant. ICG3257 and 10935 were susceptible.

#### Response of organic sources of nutrient supply on toria.

The effect of organic sources of nutrient supply was assessed on toria. Amongst the eight treatments, maximum yield of 12.7 q/ha was recorded with the application of recommended dose of NPK (50 : 30 kg/ha) + Azolla compost (2.5 t/ha) which was 33.96 per cent higher over Azolla compost applied without inorganic fertilizer.

### RAPESEED AND MUSTARD

#### Germplasm evaluation

Out of 20 varieties evaluated, SCRT 1-2 recorded highest seed yield per plant (10.25g seed yield/plant) followed by IC 1081 (9.02g seed yield/plant) and IC 1045 (7.70g seed yield/plant). The mean values of different characters are given in Table 4.

**Table 4: Range and mean of different traits in rapeseed and mustard**

Characters	Range	Mean
Plant height(cm)	34.20-119.25	86.25
Primary branches/plant	2-8	3.96
Total braches/plant	5-20	9.26
Siliqua/plant	19-125	68.69
Seeds/plant	6-14	9.44
Seed yield /plant(g)	1.24-12.42	3.42

#### Screening of mustard varieties to acid soil tolerance

The experiment was conducted on a highly acidic soil (pH 4.5) having exchangeable Ca + Mg, K, and exchange acidity 1.35, 0.41 and 3.23 c mol (p<sup>+</sup>) kg<sup>-1</sup> soil, respectively. The lime requirement (LR) of soil was 16.8 t/ha. The treatment consisted of 6 varieties of mustard (Panchavati, TS-36, SEJ-2, TS-38, TS-46, and PT-303) and two levels of lime (0 and 1/10<sup>th</sup> LR). The lime was applied in furrows with uniform dose 40, 60 and 30 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha. Mean grain yield with liming was 3.56 q/ha whereas it was 0.46 q/ha without liming. There was a significant reduction in grain and straw yields of mustard without liming. Highest grain yield (4.00 q/ha) was in Panchavati and least grain yield (3.10 q/ha) was recorded in PT 303 with liming. None of



the tested varieties were found tolerant to soil acidity stress.

#### On-farm trial in mustard

Trials were conducted at farmers' field at 11 locations. Treatments included 1) Farmer practice (FP) 2) FP + Lime (1/10 LR), 3) 10 % Recommended Dose of Fertilizer (RDF) (NPK), and 4) 100 % RDF (NPK) + lime (1/10 LR). Results indicated that the application of lime improved the efficiency of added fertilizer to a great extent and in the absence of lime the grain yield of mustard (M-27) increased marginally. (Table 5).

#### Effect of entomopathogenic nematodes on the mortality of the grubs of coccinellidae:

Bio assay studies were carried out on the virulence of the *Steinernema corpocapsae* and *Heterorhabditis indicus* (Umiam strains) against grubs of the lady bird beetles feeding on the mustard aphids. Filter paper bio assay using 250 ij/grub was found to bring about 87.5 per cent mortality in case of *S. corpocapsae* and 95% mortality in case of *H. indicus*. It is inferred that care should be exercised in use of these bio agents when the population of the predatory beetle grubs are more in the fields.

#### Bio efficacy of insecticides

Bioefficacy of botanicals and systemic insecticides against mustard aphid *Liphaphis erysimi* was evaluated (Table 6)

All the three conventional systemic insecticides recorded higher reduction in aphid population and better yield than the three botanicals. Confidor (12.4 q/ha) performed significantly better than all other treatments except phosphamidon (9.5 q/ha). Percent reduction of aphid population over control showed that Metasystox (82.5) was significantly better than

all the other treatments, except confidor (79.74) with which it was at par. There was a significant reduction in the population of coccinellids in the other treatments except for the karanjin treated plots.

**Table 6: Bio-efficacy of Botanicals and Systemic insecticides on mustard aphid and yield**

Treatments.	Concentration a.i ml/ha	Yield (q/ha)	Increased yield over control (%)	Aphid reduction over control (%)
Econcem* 10000 ppm	12	5.70	6.94	76.58 (61.16)
Multineem* 300 ppm	0.36	7.37	38.27	66.08 (54.49)
Karanjin*µ 20000 ppm	24	7.79	46.15	68.24 (55.95)
Confidor 200 SC	44.85	12.37	132.08	95.76 (79.74)
Phosphamidon 40 SC	480	9.45	77.29	91.40 (73.63)
Metasystox 36 EC	240	8.74	63.97	98.28 (82.50)
control	00	5.33	-	00 (00)
C.D		3.61	C.D	6.10
Std.E		1.66	Std.E	2.80

\* Two sprayings.µ Population of coccinellid predators was highest.

Karanjin: a botanical insecticide extracted from *Pongamia glabra* (supplied by Agrilife Secunderabad)

#### SESAME

Nine sesame lines were evaluated. Significant differences among the genotypes for important yield

**Table 5: Effect of lime and fertilizers on mustard grain yield (q/ha)**

Sites	Mawpun					Umroi Madan				
	1	2	3	4	Mean	1	2	3	4	Mean
1	0.5	1.0	2.0	2.8	1.58	0.96	2.60	2.86	6.16	3.14
2	0.2	1.0	1.0	3.8	1.5	1.2	2.5	3.08	6.8	3.39
3	0.5	2.0	2.0	4.0	2.13	1.0	2.25	2.56	6.87	3.17
4	0.1	1.5	2.0	4.0	1.9	1.35	2.45	2.6	7.15	3.39
5	0.1	1.0	2.2	5.6	2.23	2.08	2.9	3.28	8.9	4.29
Mean	0.1	1.2	2.8	4.4	2.13	1.6	3.0	2.86	7.8	3.81
CD (p=0.05)	0.35	0.79	1.02	3.35	0.68	1.37	2.62	2.87	7.28	3.53

components were recorded. TRC Til 1-8-1 performed the best (7.03 g/plant) as compared to all other genotypes. B 67-1 also performed well. Other genotypes had shown average performance.

#### Germplasm Evaluation and characterization

One hundred and twenty nine lines of upland rice, 114 of lowland rice, 50 of maize, 28 of frenchbean, 20 of ricebean, 16 each of mustard and cowpea, 10 of blackgram, 11 of foxtail millet and 5 of other beans were evaluated. Two promising genotypes from each crop are listed in Table 7. Rice, maize, frenchbean and ricebean genotypes were tested in Augmented Design. Software was developed for analysis of data obtained using this design. Among upland rice genotypes yield ranged from 1.20-19.36g/plant and maturity ranged from 111-162 days while in the lowland rice these values ranged from 0.62 – 18.58g/plant and 132-188 days, respectively. In the maize genotypes plant height ranged from 79.25 – 257 cm and maturity ranged from 96 – 136 days. In the pulses group days to maturity and plant height ranged from 97 – 100 days and 32-42 cm in blackgram, 110-117 days and 170-308 cm in cowpea, 62-87 days and 95-130 cm in frenchbean and 108-138 days and 111.7-173.6 cm in ricebean, respectively.

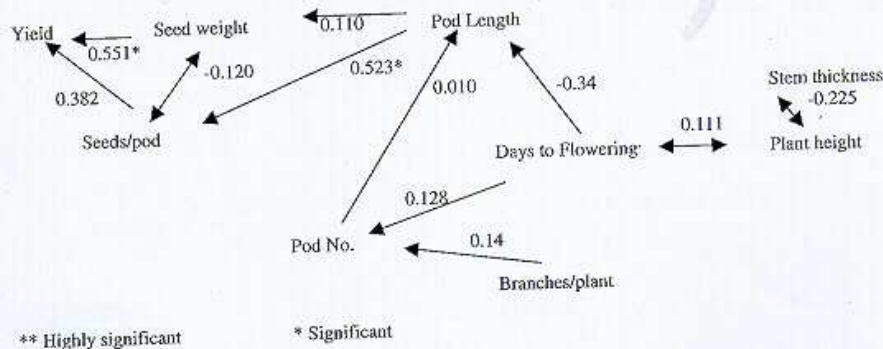
Detailed studies were made with mustard and ricebean germplasm to develop models for yield contributing pathways so that selection strategies can be made. Data collected on agronomic traits (variables) were first divided into different levels

**Table 7: Details of promising genotypes identified from germplasm collections**

Crop	Genotype	Yield/ plant (g)	Maturity (days)	Plant height (cm)
Upland Rice	IC423145*	19.36	145	125.10
	IC423354	17.40	154	128.00
Lowland Rice	IC423041	18.58	142	109.40
	IC423044	12.80	143	96.60
Maize	IC423123*	108.00	108	205.80
	IC423152*	112.16	110	234.80
Cowpea**	IC423379	17.00	109	200.00
	IC423335	17.3	109	210.00
Blackgram**	IC423082	5.15	100	41.00
	IC423101	5.32	100	41.50
Frenchbean	IC423377	34.50	81	95.00
	IC423236	30.20	81	98.30
Ricebean	IC422853*	22.90	121	173.60
	IC422887	19.27	115	137.50
Foxtail Millet	IC422837	18.60	139	118.40
	IC422875	16.55	145	110.80
Mustard	APMU2	4.81	99	57.60
	APMU14	4.19	101	83.80

\* Better than all checks \*\* Standard checks not available.

according to their hypothetical relationship decided on the basis of available information/expected role. These variables were then tested in stepwise regression to eliminate multicollinearity and arrange variables according to their observed level of contribution. Two models, one for mustard and one for ricebean are presented in Fig. 1a & 1b. As may be seen from the models, in case of mustard the



**Fig. 1a. Path diagram of yield contributing characters of ricebean arranged in order of their causal relation (values are coefficient of determination).**



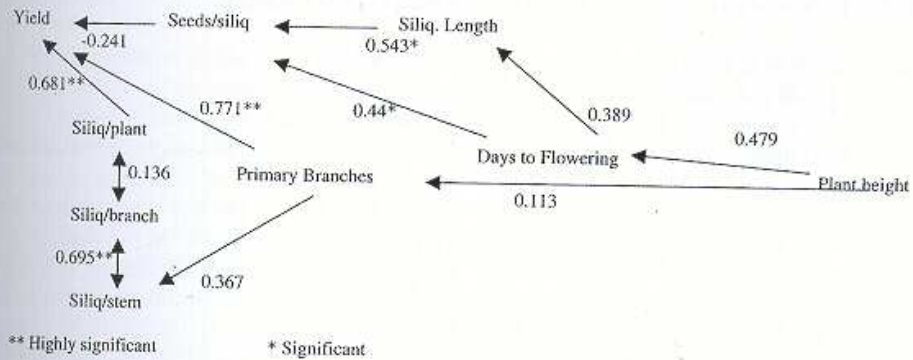


Fig. 1b. Path diagram of yield contributing characters of mustard arranged in order of their causal relation (values are coefficient of determination).

main contributing factor is primary branches/plant while in case of ricebean the main factor is seed weight. Diversity analysis of the tested genotypes was done using the agronomic data collected.

Cluster diagram obtained from the primary analysis was tested using canonical discriminate analysis and final cluster diagrams are presented in Fig. 2a & 2b

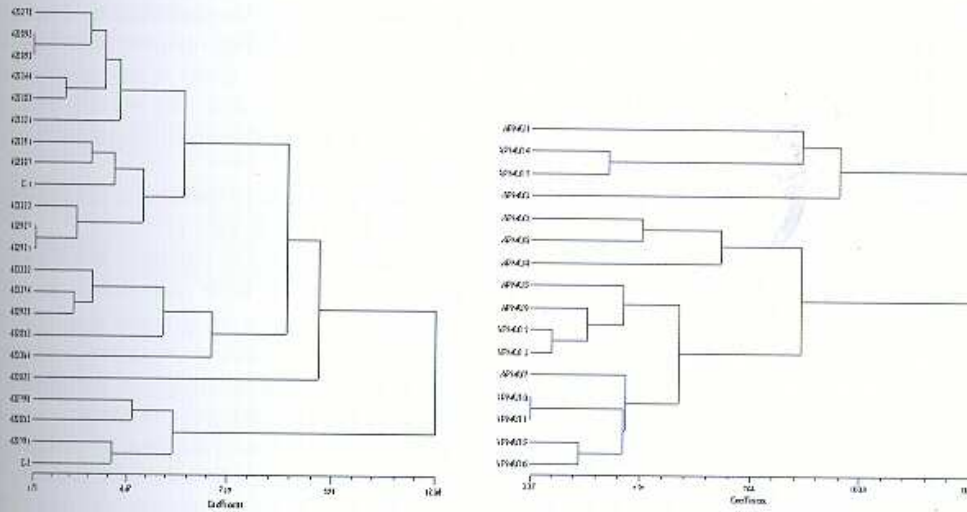


Fig. 2a & b. Dendrogram showing various clusters of ricebean (a) and mustard (b) derived from analysis of morpho-agronomic characters.

## ARUNACHAL PRADESH

### Varietal evaluation of groundnut

Thirty three groundnut varieties were evaluated during kharif 2004: (i) NRCG 1308 (ii) NRCG 6155 (iii) TKG 19 A (iv) GG-2 (v) BG-3 (vi) NRCG 7472 (vii) NRCG 7599 (viii) GG 20 (ix) NRCG 3498 (x) Fe ESG 8 (xi) ICGV 86031 (xii) M-13 (xiii) GG-7 (xiv) Fe ESG 10-1 (xv) ICGV 86590 (xvi) ICGS 76 (xvii) R 8808 (xviii) Co-1 (xix) RS-1 (xx) ALR-2 (xxi) UF 70-103 (xxii) JL 220 (xxiii) Girnar - 1 (xxiv) JSP-19 (xxv) RG 141 (xxvi) SG-84 (xxvii) Kisan (xxviii) M 197 (xxix) DRG-17 (xxx) TMV-2 (xxxi) AK-12-24 (xxxii) HNG-10 (xxxiii) SB X1. The performance of best 12 varieties are given in the Table 8

Table 8: The performance of best 12 varieties

Sl. No.	Variety	Pod yield (Q/ha)	Days to flowering	Days to maturity
1.	R 8808	31.17	37	133
2.	CO-1	31.12	37	133
3.	JL220	29.67	37	133
4.	NRCG 1308	25.17	32	128
5.	RG 141	24.50	37	133
6.	TMV-2	24.39	37	133
7.	ALR-2	21.45	37	133
8.	SG-84	20.89	37	133
9.	TKG-19A	20.73	32	128
10.	DRG 17	20.45	37	133
11.	Girnar-1	19.78	37	133
12.	Kisan	19.73	37	133

### Evaluation of Mustard and Toria

Two varieties each of mustard (Shivalik and Geeta) and toria (M 27 and TS 38) were evaluated during rabi season. The plant height varied from 62.6 cm in case of Toria variety M-27 to 121.2 cm in mustard variety Shivalik. The number of branches per plant was highest(6) in mustard variety Geeta. Highest number of siliqua (176) per plant was observed in mustard variety shivalik, though the number of seeds/siliqua was lowest (14) in this variety. The average seed yield was highest (5.45 q/ha) in case of toria variety TS 38. In case of mustard, the seed yield was very poor due to heavy rain at the time of harvest.

## NAGALAND CENTRE

### GROUNDNUT

#### Screening of genotypes

Thirty-four genotypes of groundnut received from National Research Centre on Groundnut, Junagadh were evaluated at experimental farm. Among various genotypes, M- 13 and ICGV – 86590 were found to be most suitable in terms of yield (28.84 q/ha and 25.84 q/ha) respectively. The incidence of collar rot and bacterial wilt was also observed comparatively less in M- 13 and ICGV – 86590 over remaining 32 genotypes.

#### Seed multiplication

ICGS-76 was selected for seed multiplication as its yield was recorded to be 30.00 q/ha which was significantly higher than existing best local check, i.e., JL- 24 (16.20 q/ha).

## SIKKIM CENTRE

### Integrated nutrient management in soybean and its residual effect on the performance of mustard

Mixed compost (leaves of *Eupatorium* sp., *Artemisia vulgaris*, *Alnus nepalensis*, *Schima wallichii* mixed with cow dung and soil) produced was used as nutrient source for soybean, rice and Buckwheat.

The composition of the organic manure was N – 2.2 %, P – 1.2 % and K – 1.0 %.

Studies conducted on soybean-mustard rotation during 2004-05 with integrated nutrient management in the main crop and evaluating the effect of residual nutrients on mustard with one irrigation. The treatments were a combination of chemical fertilizers as starter dose, mixed compost, neem cake and dolomite in nine combinations and one no nitrogen control. N:P:K @ 30:40:30 was applied alone and in conjunction with neem cake and dolomite @ 2 t ha<sup>-1</sup>. The conjunctive application of NPK (starter dose), neem cake and 2 t ha<sup>-1</sup> dolomite performed the best in terms of grain yield (39.5 q ha<sup>-1</sup>) and nutrition through neem cake + mixed compost + dolomite produced yield (28.6 q



ha<sup>-1</sup>) at par with the starter dose of urea + SSP + MOP (29.5 q ha<sup>-1</sup>).

A short duration, high yielding mustard variety M-27 was sown in November 2004 in the same soybean plots under integrated nutrient management and was irrigated once at the flowering stage. The grain yields followed the same trend as was in soybean the residual effect of the conjunctive application of NPK (starter dose), neem cake and 2 t ha<sup>-1</sup> dolomite produced the highest grain yield (6.4 q ha<sup>-1</sup>) and the treatment of neem cake + mixed compost + dolomite produced yield yielded (5.2 q ha<sup>-1</sup>) as compared to the no nitrogen control (2.1 q ha<sup>-1</sup>).

#### Rapeseed-Mustard Improvement Project

##### 1. Indian Mustard : *Brassica juncea*

Twenty nine varieties of Rai were evaluated during winter season without application of inorganic inputs. NDRE 4 recorded the maximum seed yield (12.5 q/ha) followed by Pusa Agrani (10.8 q/ha), Bhagirathi (10.3 q/ha) and Aravalli (9.2 q/ha)

##### 2. Toria : *Brassica campestris* var. *toria*

Twenty two genotypes of toria were evaluated without application of inorganic fertilizers. Bhawani (9.8 q/ha), Agrani (9.3 q/ha), SCRM 1-1 (9.4 q/ha), M-27 (8.9 q/ha) and Panchali (8.7 q/ha) were the suitable varieties.

##### 3. Karan Rai : *Brassica carinata*

Fourteen genotypes of Karan Rai were evaluated without application of inorganic fertilizers. Although siliqua were tolerant to shattering but this species attained maturity after March and is not a suitable species choice for Sikkim.

##### 4. Brown Sarson : *Brassica campestris* var. *brown sarson*

**Varietal evaluation trial :** Evaluation of fourteen genotypes of brown sarson without application of inorganic fertilizers showed that BSH-1 and BSC 87 were the high yielding varieties at 1000 m amsl with seed yield of 8.1 and 7.9 q/ha respectively.

**Evaluation of advanced generation breeding materials :** Twenty six stabilized brown sarson lines derived through 6 x 6 half diallel mating were evaluated during the second consecutive year.

Among the pedigree derivatives, YSP 842 x SS 1b-1 (16.94 q/ha) and YSP 842 x SS 1b-2 (20.93 q/ha) recorded the highest seed. Among the bulk derivatives, YSP 842 x SS 1b (14.48 q/ha), YSP 842 x SS-2 (13.71 q/ha), YSC 68 x SS 1 and YSC 68 x YSK 8501 were found promising for seed yield

##### 5. Yellow Sarson : *Brassica campestris* var. *yellow sarson*

**Varietal evaluation trial :** Forty two varieties and improved strains of yellow sarson namely were evaluated during winter 2004-05 at 1000 m amsl without application of inorganic fertilizers. PRYOS 9805 (13.5 q/ha), Jhumka (11.4 q/ha), IC 398652 (10.3 q/ha) and Binoy (8.3 q/ha) were found promising for seed yield.

**Evaluation of advanced generation breeding materials :** Twenty three stabilized yellow sarson entries derived through 6 x 6 half diallel mating were evaluated. Three pedigree derivatives, YSC 68 x SS 3, YSP 842 x SS 3 and YSC 68 x SS 2 (b) recorded more than 18 quintal seed per ha. Three bulk derivatives, YSP 842 x SS-3 (19 q/ha), YSK 8501 x SS 1 (12.48 q/ha) and SS 3 x SS 2 (19 q/ha) were also recorded high seed yield.

##### Generation advancement

Sixth filial generation of 7 single cross & 7 three way cross derivatives were advanced to F<sub>7</sub> generation.

##### Hybridization

New crosses were made during this year involving Jhumka, Pusa Gold, SS-1, SS -2, PROYS 9805, PYS 9804, YSC 38, YSWBX, & YSWB 955 B. Crossed seeds from 29 combinations were harvested.

#### TRIPURA CENTRE

##### MUSTARD

##### Breeding Oilseeds for increasing productivity in Tripura State.

##### Evaluation of Rapeseed & Mustard varieties

In total 42 lines were evaluated. The highest yield was produced by IVT line TCN -03-6 with

1499 kg/ha, followed by Bio 902 with 1444 kg/ha and TCN-03-21 with 1430 kg/ha. The yield performance of the lines are presented in Table 5.

In tripura Rapeseed & Mustard has the potential of becoming an important oilseed crop. Keeping this in mind available germplasm were evaluated for yield performance, disease and pest reaction.

## TORIA

The experiment was conducted to find out the effect of different agronomic package of practices on productivity of Toria under Tripura condition. The experimental details are as below:

### Design: RBD

Replication: 3; Plot size: 4x2=8 m<sup>2</sup>; Gross-5.5 m<sup>2</sup>; Spacing – Row to Row 30 cm, Plant to Plant – 8 to 10 cm; Fertilizer dose (N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O Kg/ha) – 60:80:40; Date of Sowing – 5-11-03; Date of Harvesting – 31-1-04; Name of the Insecticide – Endosulfan 35% EC; No of spray -3; Incidence of Pest: Aphid at Flowering and Pods stage; Toria variety – T S-36

Treatments are as below:

Symbol	Treatment
T1	R. P. (Recommended package of practices)
T2	R. P. – 50% fertilizer
T3	R. P. – Weed control (W. C. )
T4	R. P. – Plant Protection (P. P.)
T5	R. P. – 50% fertilizer and W. C.
T6	R. P. – 50% fertilizer and P. P.
T7	R. P. – W. C. and P. P.
T8	R. P. + 33% higher seed rate

## GROUNDNUT

### Groundnut Evaluation Trials

Total 85 NRCG lines were evaluated in unreplicated augmented design for morphological characters for characterization. NRCG-7599 gave highest yield (2680 Kg/ha) followed by NRCG-12438 (2345 Kg/ha).

15 elite groundnut lines of ICRISAT were evaluated for morphological and yield characters. Highest yield was recorded for ICGS-37 (2212 Kg/ha) followed by ICGV-92217 (2030 Kg/ha).

100 germplasm of groundnut was screened for their tolerance to soil acidity and some of them showed a decline in pod and kernel weight upon liming thus indicating their tolerance to the prevailing soil acidity condition.

### Disease management of groundnut

Carbendazim (0.05%) and Tridemorph (0.05%) were most effective for the control of leaf spot and rust diseases, respectively. The combined effect of the two and the mixture of carbendazim (0.05%) and mancozeb (0.2%) solutions were effective to control both the diseases simultaneously when sprayed at 15 days interval after 30 days of sowing onwards.

## SESAME

- 20 lines were evaluated under IVT 2004 AICRP trial. All lines were found to be susceptible to alternaria leaf blight. Maximum number of capsules/plant was recorded in IVT-04-15 (27.4). Highest yield was recorded for IVT-04-14 (707.5 Kg/ha) followed by IVT-04-20 (304.3 Kg/ha).
- 11 lines were evaluated under AVT 2004 trial. Plant height was recorded highest in AVT-04-7 (113.4 cm) and highest yield among lines was recorded in AVT-04-10 (312.5 kg/ha). The crop was severely affected by alternaria leaf blight.
- 13 lines were evaluated under this trial. 3 lines failed to give good germination. Plant height was recorded highest in EWSV-5 (126.4 cm). The incidence of alternaria leaf blight occurred more than 75% and lower yields were recorded.

## LINSEED

### IVT (Rainfed) Linseed Trial:

18 lines were evaluated under IVT (rainfed) trial. The line 040111 produced the highest yield of



812kg/ha followed by 040120 with 750 kg/ha and 040105 with yield of 646 kg/ha (Table 9)

**Table 9: Performance of linseed lines**

Entry	040101	040102	040103	040104	040105
Yield/ ha (kg)	417	604	450	448	646
Entry	040106	040107	040108	040109	040110
Yield/ ha (kg)	450	521	417	450	488
Entry	040111	040112	040113	040114	040115
Yield/ ha (kg)	812	333	437	333	333
Entry	040116	040117	040120		
Yield/ ha (kg)	573	604	750		

The results indicated that variety Padmini when sown in the 1<sup>st</sup> week of October produced highest yield of 617.5 kg/ha, followed by variety Sweta sown in 1<sup>st</sup> week of October. It indicated 1<sup>st</sup> week of October is the most ideal time for linseed sowing in Tripura.

## MANIPUR CENTRE

### GROUNDNUT

#### Evaluation of recently released groundnut varieties and their nutrient efficiency lines

Out of the varieties the highest yield (21.94 q/ha) was recorded in ICGV 86590 followed by NRCG-4659 (21.92 q/ha) and NRCG 162 (21.49 q/ha).

Observation on Tikka disease, *Cercospora* sp. Was recorded on 24 varieties of groundnut and were found highest in NRCG-4659 (71.16%) next to check JL-24 (74.08 %) followed by FESG-8 (69.06%) and TG-26 (58.95%) and lowest in NRCG-72061 (42.50%) followed by RKVG-8 (45.41%) and NRCG-7599 (45.60%). It is also observed that temperature fluctuation from 13.87-29.06°C and relative humidity from 53.33-95.50% was favourable for the development and spread of tikka disease *Cercospora* sp. on groundnut.

#### Integrated nutrient management in groundnut based cropping system

The pod yield increased significantly by Lime application @ 500 kg/ha + FYM @ 10t/ha (21.60 q/ha) over the control (12.73 q/ha). The fertilizer

level NPK (18.21 q/ha) could increase the pod yield significantly over control. The N and P uptake by the pods showed similar trend as that of the pod yield. The haulm yield increased significantly with lime + FYM over control. The N and P uptake by the haulm showed similar trend as that of its yield. Interaction of fertilizers with main treatment was significant for pod yield.

#### Effect of *Rhizobium* in combination with lime and *Azospirillum*

Rhizobial inoculation with JCG48 gave maximum yield in both the unlimed (33 q/ha) and limed ((35.5 q/ha) conditions followed by the strain NC 92. Furrow liming in general increased the pod yield in all the treatments. However, JCG 48 in combination with *Azospirillum* could not produce more than rhizobial strain alone. Lime increased the nodular mass possibly making better environment for rhizobial activity through increased pH and abundant supply of calcium an essential component for Ca-binding protein required for attachment of rhizobia to the root surface before penetration into the roots of groundnut.

### SOYBEAN

#### Effect of spacing and dates of sowing on growth and yield of soybean

Soybean sown on June 3 gave higher yield than that sown on July 3. One-month delay in sowing recorded 64.87 % decrease in seed yield of soybean. Further spacing of 30x5 cm was found optimum for the variety NRC 20 as increase in plant-to-plant spacing reduced the seed yield.

## MIZORAM CENTRE

### SOYBEAN

#### Varietal evaluation trial on soybean

Eighteen varieties of soybean were evaluated. Maximum seed yield 15.25q/ha was recorded in variety JS 89-48 followed by variety JS-80-21 (14.25q/ha), the latter was sown at the different dates beginning from 15<sup>th</sup> May to 30<sup>th</sup> July at an interval of 15 days. The highest seed yield (19.33



q/ha) was recorded when the crop was sown on 30<sup>th</sup> June followed by 15<sup>th</sup> June (18.50 q/ha).

## GROUNDNUT

### Varietal evaluation trial on groundnut

Among thirty six varieties of groundnut evaluated, maximum pod yield (27.62 q/ha) was from the variety ICGV-86590. However, NRCG-6131 recorded maximum shelling percentage (76.15 %). Variety GG-20 recorded highest test weight (59.57g). Variety NRCG-7206 recorded maximum kernel yield (19.11q/ha) followed by variety ICGV-86590 (18.01 q/ha)

Out of 117 varieties of HY genotypes received from NRCG, Junagarh variety NRCG – 5422 recorded maximum pod yield of 16.65 q/ha followed by NRCG – 11881 (15.55 q/ha.).

### Monitoring of insect pest and their management

Major insect pests recorded on soybean were semilooper, stem fly, and blister beetle. Among diseases root rot and leaf spot were observed to cause significant infestation.

Groundnut leaf eating caterpillar and aphids were major insect pests damaging the groundnut crop. Among diseases cercospora leaf spot was recorded as major disease.

## PULSES

### Ricebean Station Trial

Fourteen superior genotypes of rice bean identified in 2003 were re-evaluated. The average yield performance (over two years) of the two genotypes (IC 97882 and RBS 35) was significantly better than that of RCRB 1-6 .

### Ricebean Germplasm Evaluation

Thirty eight germplasm lines of rice bean were evaluated for yield and yield contributing traits in augmented block design. RCRB 1-6 and RCRB 6-10 were used as check genotypes. Five germplasm lines identified as superior in 2003 were found superior in 2004 also.

### Photoinsensitive Rice Bean Evaluation

Seven photoinsensitive rice bean genotypes were evaluated in pre-kharif and kharif seasons. All of the genotypes took 15-32 more days to flower in pre-kharif season than in kharif season (Fig 11). In 2003, this difference was narrow (3-18 days) probably because of rather late sowing (27<sup>th</sup> March) as compared to this year's sowing (4<sup>th</sup> March). In kharif season, individual genotypes took comparable number of days to flower in two years. These results suggest for the thermosensitive nature of photoinsensitive genotypes.

F<sub>2</sub> progeny of four crosses between photoinsensitive and photosensitive parents was evaluated for flowering response in long day conditions of pre-kharif season. In all of the crosses wide range of flowering duration was observed. The plants exhibiting flowering by 22<sup>nd</sup> June were categorized as photoinsensitive since day length starts decreasing from this day. Observed ratios conformed to the expected ratios. These F<sub>2</sub> progenies were screened for peroxidase and polymorphism for this isozyme was observed.

### Pulse Biotechnology :

Attempts were made to transform shoot buds and cotyledon-derived calli of chickpea using *Agrobacterium*-mediated transformation method. Calli and multiple shoots were induced following protocols developed in the laboratory. Two different strains of *Agrobacterium* – LBA4404 and EHA105 containing *cryIA(c)* gene (pCAMBAC) were used for transforming isolated embryos and calli. Putative transgenics were initially selected on medium containing 25mg/l kanamycin/hygromycin and then on 50mg/l kanamycin/hygromycin. Most of the transformed embryos failed to survive the second selection although a few of them formed roots in the selection medium (50mg/l kanamycin). Cotyledon-derived calli survived the second selection at a frequency of 6 -7.5%. PCR analysis showed presence of the gene of interest and marker genes. Transformed calli are being used for plant regeneration.

### DNA fingerprinting and diversity analysis of ricebean :

Diversity analysis of ricebean germplasm was attempted with 50 core genotypes selected from the



collection made up to 2002. As there is no information available about any marker in this species, initially primers for 40 cowpea microsatellites were tested. Then primers for 15 genic microsatellites (genus *Vigna*) were used. Software based on PERL language was used for this purpose. Cowpea primers mostly produced non-specific amplification products while some of the genic markers from *Vigna* produced expected size of product. Based on the microsatellite the genotypes were grouped into 10 clusters after verification of the tree using canonical discriminant analysis (Fig. 1).

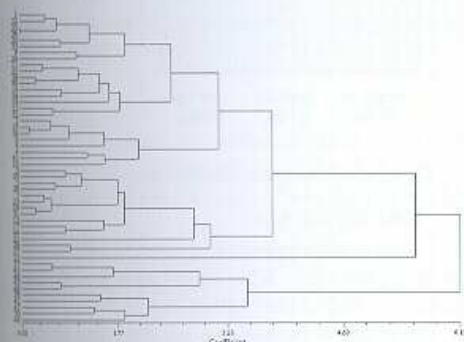


Fig. 1. Dendrogram showing various clusters derived from microsatellite analysis of 50 genotypes of ricebean.

#### Development of microsatellite enriched genomic library in ricebean:

Attempts were made to isolate microsatellite containing sequences from ricebean genome. A modified affinity capture method was used for isolating microsatellite containing sequences. An enriched genomic library containing small inserts (500 – 1500bp) of microsatellite containing sequences was developed (Fig. 2). The library is the first of its kind in this species. The library would be sequenced for identifying specific microsatellites for the species.

#### Parasitization of *Apion clavipes* eggs with local *Trichogramma* sp.

*Apion clavipes* eggs were glued on small chart paper piece and were allowed for parasitization with local *Trichogramma* sp. inside a glass tube for 48



Fig. 2. Ricebean genomic library in pGEMT vector

hours. Three days after parasitization, *A. clavipes* eggs showed the symptom of *Trichogramma* parasitization that is egg colour turns black. The per cent parasitization was 21.74%. Adult *Trichogramma* emerged after fifteen days of parasitization and the emergence percentage was 40%. Thus this local species could be utilized for management of *A. clavipes* in pulses.

#### Isolation and bioefficacy of entomogenous fungus *Nomurea riley*:

An entomogenous fungus, *Nomuria riley* was isolated (Fig. 3) from the naturally infected semilooper (*Plusia orichalsia*) larvae of the pigeon pea and other pulses. Bio efficacy was tested on the semiloopers of litchi and also on the soybean feeding *Spodoptera litura*. Cent per cent mortality was observed in the laboratory after 48 hours of infection by the fungus in both the test insects.



Fig. 3. Entomogenous fungus infected larvae



### Disease management

The effect of chemical, botanical and bio-control agents on rust and pod blight diseases and yield of soybean are presented in Table 1

**Table 1: Effect of chemical, botanical and bio-control agents**

Fungicide (Dose/litre)	Percent disease index		Yield (q/ha)
	Rust	Pod blight	
Dithane M45 (2g)	61.42b	19.78abc	8.7bc
Tilt (1g)	16.15d	13.23cd	19.8a
Wanis (3ml)	37.39c	15.54bcd	16.9ab
Tricure (3ml)	64.27b	23.78a	5.4c
Bayleton (1g)	16.06d	11.41d	24.8a
Troscurm (2* 10 <sup>6</sup> /ml)	56.42b	13.95cd	15.3ab
Check	79.04a	22.96ab	2.9c

### SIKKIM CENTRE

#### Black gram Improvement

Two accessions of local black gram cultivars called Pahelo dhal (*Vigna mungo* var. *viridis*) were collected from Sikkim. Together with existing collection, this centre has 10 accession of Pahelo dhal differing for quantitative traits like maturity and yield. 17 green seeded genotypes were compared for yield and yield attributes at 1000 m elevation during post rainy reason. The trial was conducted without application of any inorganic inputs. Among all, local cultivar Pahelo dhal -3 recorded the highest yield (985 kg / ha). Apart from 21 released varieties were introduced and evaluated at Sikkim. Variety K1 recorded the highest yield (16.4 q/ha). Among the 53 improved strains and germplasm lines evaluated during Aug-Nov 2004, TRU 99-2 was found promising (14.6 q/ha). Pahelo dal, crosses were made between Pahelo dal and ten donor parents (B local, CO-5, GU 1, K-1, PLU 856, PUSA 9302, RK 08/2003, T -9, UG 109 and VBN 3). Hybrid seeds from 16 crosses were secured.

### TRIPURA CENTRE

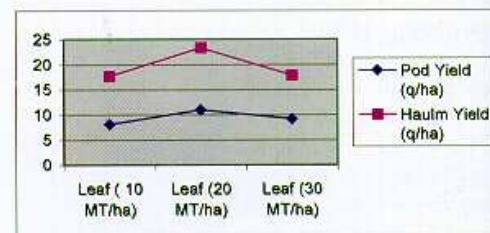
#### Trials under MULLaRP

##### A BLACK GRAM

This trail was conducted during autumn season. 7 Entries were sown and data recorded for seed

color, pods per plant, plant height, days to 50% flowering, days to maturity and seed yield. KU-4-259 gave higher yield (1406.3 kg/ha) followed by KU-4-262 (1375 kg/ha).

The effect of gliricidia leaf was also studied in black gram ( var.T-9 ) and the data are presented in Fig 4. It is indicated that the application of gliricidia leaf ( 20 MT/ha) obtained from the terrace riser could produce the maximum yield of pod (10.86 q/ha) and haulm (23.33 q/ha) of black gram ( var. T-9 )



**Fig 4. Effect of gliricidia leaf on black gram**

##### B GREEN GRAM

5 lines were evaluated for morphological and yield characters. KM-4-104 and KM-4-110 performed well (416.7 kg/ha).

The effect of biofertilizer on green gram ( var. UPM -79-4-12) was also studied and the data are presented in Table 2.

**Table 2: Effect of biofertilizer on green gram(q/ha)**

Treatment	Pod	Haulm	Per cent increase over control	
			Pod	Haulm
T <sub>0</sub> Control	1.97	4.53	—	—
T <sub>1</sub> Cowdung 5t/ha	3.70	9.34	88	106
T <sub>2</sub> Cowdung 10t/ha	4.91	13.80	149	205
T <sub>3</sub> NPK 60:30:30	5.30	11.70	169	158
T <sub>4</sub> PSB	2.23	5.27	13	16
T <sub>5</sub> NPK + PSB	4.65	9.45	136	109
T <sub>6</sub> Cowdung 5t/ha + NPK	4.95	10.10	151	123
T <sub>7</sub> Cowdung 10t/ha + NPK	6.79	14.95	245	230
T <sub>8</sub> Cowdung 5t/ha + PSB	4.29	10.56	118	133
T <sub>9</sub> Cowdung 10t/ha + PSB	4.56	12.05	131	166
T <sub>10</sub> Cowdung 5t/ha + NPK + PSB	4.16	9.85	111	117
T <sub>11</sub> Cowdung 10t/ha + NPK + PSB	4.96	13.55	152	198
CD (5 % )	0.59	2.36	—	—

Application of cow dung (10 MT/ha) in combination with NPK and bio-fertilizer produced



an appreciable rise in the pod and haulm yield over control..

#### C FIELD PEA

Highest yield was produced by FP 451 with 2424 kg/ha, followed by FP 440 with 2399 kg/ha and FP 453 with 2161.6 kg/ha.

#### D CHICK PEA

7 entries were evaluated for cold tolerance. The line NCT-6 produced highest yield of 1471 kg/ha, followed by NCT-2 (1191.4 kg/ha) and NCT-5 (957.1 kg/ha). GL-23082 was found to be very bold seeded (30 g 100 seed wt.). Highest number of pods/plant was produced by NCT-6 (19.4), followed by NCT-3 (18.8). NCT-6 was tallest among the entries (44.7 cm).

#### E LENTIL

20 lines were evaluated. Highest yield was produced by L-139 with 1686 kg/ha, followed by L-140 with 1624 kg/ha and L-144 with 1045kg/ha.

### MANIPUR CENTRE

#### RICEBEAN

One hundred fifty four accessions of rice bean collected from different locations of the region were evaluated. Out of these 4 accessions were found with determinate growth habit. Days to flower initiation ranged from 38 to 52 days. Pods/plant was ranging from 4 to 36. Similarly number of seeds per pod was found from 3.4 to 10.2.

#### FRENCH BEAN

##### Evaluation of germplasm

Thirty-nine accessions of French bean were evaluated. The green pod yield of Acc No. 15, 20, 22 and 19 of pole types have been recorded as 152, 147, 127 and 126 q/ha respectively as against the average yield of 32 q/ha in local cultivar. Days to 50% flowering have been recorded as 36 days in Acc No. 20 and 21 of pole type as against the local check of 39 days. Acc No. 27, 36 and 8 of Bush type recorded 87, 69 and 68 q/ha against the average yield of 58.5 q/ha from the local check.

### COWPEA

##### Evaluation of germplasm

Twenty-four distinct type of cowpea accessions were evaluated. Days taken for 50% flowering were recorded as 55, 56 and 56 days in Acc No. MCR-2, 1230-A and local check (MCR-5B). Highest number of pods/plant was recorded in Acc No. 1230-A as 14.6 pods/plant followed by 18 pods/plant in 1230-B. Higher green pod yield/ha was recorded in Acc No. 1230-A as 301 q/ha as compared to 185.5 q/ha in local check (MCR-5B). Though the length of pods was higher in local check (37.9cm), no. of pods (24.6/plant) and the green pod yield (301 q/ha) was highest in Acc No. 1230-A.

## II. HORTICULTURE

### FRUITS

#### CITRUS (Khasi mandarin)

##### Growth performance of nucellar, micro propagated and grafted plants

Nucellar seedlings showed the maximum plant height (145.20 cm), number of leaves/plant (308 nos.) and mean plant spread (55.10 cm<sup>2</sup>) whereas grafted plant (Khasi mandarin on *Citrus volkamariana* rootstock) showed the maximum stem diameter (2.42 cm) and leaf area (14.48 cm<sup>2</sup>) after three years of planting.

##### Growth performance of different provenances

Eleven provenances of Khasi mandarin were evaluated for growth parameters after two years of planting. The maximum increase in plant height (53.58 %) and stem diameter (54.54 %) was recorded in provenance CRS-3 and CRS-5, respectively. Whereas, maximum increase in number of leaves/plant (243.58 %) was recorded in provenance CRS-4.

##### Propagation time and condition on graft success and sprouting days

An experiment was executed on soft wood grafting in Khasi mandarin under three condition



viz. poly house, net house and open condition at 15 days interval from June, 15 to October, 15, 2004. Maximum graft success under poly house condition (95%) was recorded when grafting was done during June 30 to August 15 followed by open (90%) and least under net house condition (75%). Buds sprouting were earliest in polyhouse by one week than open condition and two weeks earlier than net house.

#### **Effect of different rootstocks on graft success through soft wood grafting**

Soft wood grafting of Khasi mandarin was performed on different rootstocks viz. *C. jambhiri*, *C. karna*, *C. reshni*, *C. latipes*, *C. taiwanica*, Tanzelo dancy, *C. grandis*, Naity Jamir and Karun Jamir root stocks in the month of July. Ninety five per cent graft success was recorded on *C. jambhiri* followed by Naity Jamir (92%) and *C. latipes* (85%). The maximum graft survival (98%) with minimum days for sprouting was recorded in *C. jambhiri*.

#### **Citrus trunk borer**

Management studies of citrus trunk borer a major insect pest responsible for decline of citrus in the region were undertaken. Crude pheromone extracted from female genitalia lured about 60% adult beetles under laboratory conditions and 40% male adult beetles under field conditions when pheromone traps were kept 10 m apart. This is the first record of long distance pheromone in trunk borers.

## **LEMON**

#### **Varietal performance**

Three varieties of lemon namely Assam lemon long, Assam lemon round and Kachai lemon were evaluated for growth parameters after three years of planting. The maximum plant height (130.11 cm), stem diameter (2.13 cm), leaves/plant (94 nos.) and leaf area (25.76 cm<sup>2</sup>) were recorded in Assam lemon long followed by Assam lemon round. The commencement of flowering was also noticed, during the reported period in Assam lemon long.

Four varieties of lemon namely Assam lemon, Gandharaj, Ureka lemon of two year old and one

year old Pant lemon were evaluated for growth parameters. The maximum plant height (106.64 cm), stem diameter (2.08 cm), leaves/plant (61.67 nos.), number of primary branches/plant (3.63) and leaf area (39.11 cm<sup>2</sup>) were recorded in Gandharaj followed by Assam lemon. Whereas Pant Lemon attained the average plant height of 44.92 cm, stem diameter 0.88 cm, number of primary branches 3 and leaf area of 13.19 cm<sup>2</sup>.

## **GUAVA**

#### **Growth, yield and Physico-chemical studies on guava cultivars**

Plant growth, yield and physico-chemical characters of fruits of five year old six guava cultivars viz. Hybrid-1, Hybrid-2, Hybrid-11, Allahabad Safeda, L-49 and EC-12 were evaluated. Hybrid-11 was found superior in plant growth like stem diameter (9.28 cm) and mean plant spread (2.89 m) as well as yield (24.50 kg/tree). However, Hybrid-1 was found superior in quality traits like total soluble solids (10.42%) and total sugar (8.54%).

#### **Budding method fixation for propagation in guava**

A comparison of the two methods of budding in guava cultivars Allahabad Safeda and Lucknow-49 during January to March 2005 showed that patch budding is superior to shield budding with respect to time taken for bud-take, per cent bud sprout, sprout length and survival in both cultivars. Patch budding method in Allahabad Safeda recorded the maximum success (70-80%).

The ideal period for patch budding for white flesh (Hybrid-1) and red flesh (Hybrid-4) was found to be the third week of February.

To examine the genotypic amenability, patch budding was practiced in Selection-11, Hybrid-1, Hybrid-4, Allahabad Safeda and Sardar guava during third week of February 2005. Hybrid-1 was found highly responsive for time taken for bud-take (12-21 days), bud sprout (90-95%) and sprout length (7.5-12.5cm) at two months after budding while the poor bud sprout (35-45%) was noticed from Selection-11.



## PEACH

Comparison of three low chilling peach varieties viz., TA-170, Flordasun and Shan-e-Punjab evaluated for quality traits showed that TA-170 is superior to other with an average weight of 48.50g per fruit.

## PASSION FRUIT

To enhance the shelf life of passion fruit (purple) by using different packaging materials, revealed that fruits packed in white polythene (300-gauge) and stored at room temperature, recorded 18 days shelf life without any decay and shrivelling. Fruits had good flavour without much deterioration in chemical properties of juice, than under open conditions where fruits started rotting and shrivelling within 5 days at room temperature.

## ARUNACHAL PRADESH

### CITRUS

A new germplasm block of all citrus genotypes was established with 14 varieties of sweet oranges, 8 of mandarin oranges and 10 rootstocks.

#### Performance of micropropagated plants of Khasi Mandarin

Micropropagated 40 numbers of khasi mandarin plants planted in 1998 were observed for their growth and yield parameters. Average plant height, canopy spread, stem growth, number of primary branches, number of fruits per tree and number of fruits drop per tree were recorded to be 3.24 m, 176x174 cm, 5.9 cm, 15 and 8, respectively.

Similarly, fruit length, diameter, weight, peel weight, thickness, segment, juice, TSS and acidity were found to be 5.2 cm, 6.45 cm, 99.83 g, 37.4 g, 0.36 cm, 9.8, 34 ml, 10.04 Brix and 0.63%, respectively.

#### Performance of budded oranges:

Four types of mandarin oranges (Khasi Mandarin, Nagpur Santra, Hill Mandarin and Sikkim Orange) and six species of rootstock. (Tanyum, *C. volkamariana*, *C. latipes*, Trifoliolate

Orange, Rough lemon and Karna Khatta), planted during 2001 were evaluated. Tanyum root stock was found most promising recording desirable growth parameters and early fruiting with Sikkim, Nagpur, and Hill mandarins with increased fruit size and TSS.

#### Performance of Khasi mandarin under H.D. Planting:

Khasi mandarin was planted with five different spacing of 2 x 2 m, 2.5 x 2.5m, 3 x 3 m, 4 x 4 m and 5 x 5 m. Highest numbers of fruit (33.9), maximum height (4.58 m) and stem girth (5.82 m) was recorded in the spacing of 2 x 2 m.

#### Rejuvenation of old orchard of khasi mandarin and acid lime by dehorning.

A twenty years old orchard of Khasi mandarin and acid lime cv. ARL-1 were identified for rejuvenation (Top working) at different heights as well as pruning at primary branch level.

Out of four treatments primary branch pruned trees recorded maximum number of fruits (79) with maximum fruit weight (87.6g) and TSS (13.8) than other treatments. This emanates that declined orchards can be rejuvenated by pruning at primary branch level.

#### Effect of pruning in rejuvenation of old declined orchard of Acid lime

The trees of acid lime (cv. 'ARL-1), pruned at four different heights of the main plant. Primary branch pruned trees in second year, produced maximum number of fruits/plant (237.6) with maximum fruit weight (70.83) and pulp weight (50.56) followed by pruning at 1.50 m and 1.0 m.

#### Maintenance of germplasm of indigenous fruits

Out of 21 species of indigenous fruits established, taktir, tarak, kompe, taglam and jamun came into bearing this year. Vegetative growth parameters of all 21 species were recorded. Three separate orchards of local fruits of taktir, hisir and buri have been established. Seedlings of kompe (local peach) have been raised in the nursery for using as rootstocks to graft with improved varieties of peach. Ripe fruits of taktir are utilized for preparation of squash and juice.



## GUAVA

### Performance of two improved varieties of guava at different spacing:

Allahabad Safeda showed better growth and production in terms of plant height, canopy spread, number of fruits/tree and fruit weight over L-49 in both spacing (3 X 4m and 4 X 4M). Closer spacing produced larger sized fruits in both genotypes. Total soluble solids and acidity of mature fruits were not affected by genotypes and spacing.

## AONLA

Out of six varieties of aonla, Assam local showed maximum vegetative growth in terms of plant height (4m), and Canopy spread (388 cm x 354 cm) followed by NA-6, NA-7, Kanchan, Chakaiya and NA-10., Assam local started bearing fruits (30-40/ tree) after seventh year of planting

## BANANA

### High density planting in Banana:

Different planting densities (1.5m x 2m), (3m x 2m) in four varieties of banana viz. Chini Champa, Malbhog, Hatidath and Jahajee. were compared. Out of four varieties, chini Champa came into bearing first in wider spacings along with significant vegetative and reproductive growth. Closer spacing (2m x 1.5m) had beneficial effect on bunch weight in Hatidath followed by Malbhog.

Out of 30 varieties maintained in the germplasm block, Karpura chakrakelli attained maximum vegetative growth. Highest bunch weight (6150g), number of hands (13) and Number of fingers/hand(19) were recorded in chini champa. Individual finger weight was maximum in Karpura Chakrakelli (100g) followed by Malbhog(90g).

## NAGALAND CENTRE

### Effectiveness of different intercropping in banana

Different banana based intercropping systems were evaluated. Banana intercropped with ginger+ cowpea showed the highest cost/ benefit ratio (1:

1.52) followed by banana + bean + tomato (1:1.32) and banana + chilly + pea.

### Effect of different planting times on growth, yield and quality of banana

The suckers of banana were planted at 2.0x 2.0 m spacing in the second week of April, to August. Results showed that maximum height (178.34 cm), pseudostem girth (57.45 cm) and number of functional leave (13.27). Highest bunch weight (22.47 kg), size of finger in terms of length and breadth (14.36 x 10.47 cm) and yield (37.62 t/ ha), minimum physiological weight loss (11.63%) were recorded in June planting. The highest significant number of hands (8.39) and number of fingers (43.29) and TSS (20.34%) were observed in August planting followed by June planting.

### Population dynamics of stem weevil (*Basilepta subcostatum*) on banana

The pest activity was initially observed in the last week of March and assumed its peak in the last week of August (45.52 beetles/plant) and reached lowest 2/plant in the last week of October.

## SIKKIM CENTRE

### Effect of time and severity of pruning on flowering of kiwifruit bloom in Cv Allison.

Pruning operations done during different months of dormancy with different number of buds on pruning canes (2-8). Maximum flowering was observed in the pruning of the Dec-Jan month with six buds (80%) and minimum in the month of March-April (45%) for non terminating spurs. Dec-Jan month pruning at six bud stage gave very good return bloom whereas non pruned canes gave very scanty flowering in the subsequent year. Flowering intensity of the terminating spur was not affected by the time and severity of pruning whereas non terminating spurs were adversely affected by the late pruning.

### Effect different treatments on rooting of kiwifruit cuttings.

Winter pruned cuttings were treated with NAA, IBA (@3000,4000 AND 5000 ppm) and planted in rooting medium consisting of (FYM 75%+



sand 25%). Maximum rooting (90%) was recorded in the cuttings treated with IBA 4000 ppm

#### Collection of new varieties of temperate fruits

Varieties of different temperate fruits from Australia viz., Apple (Lady Williams), Cherry (Noir De Guben, Van, Early Burlat, Stella, and Bing), Nectarin (Fantasia, Sunlighand Goldmine), Peach (Frager, Golden Queen, O'henry and Flavourcrest), Plum (Simka, Rooby Blood, Mariposa, Black Amber, Santa Rosa, Gulf Ruby, Satsuma and Narabeen ) And Pear (Beaurey Hardy, Corella, Abe Fetele and Pakham Triumph) were evaluated. Except pear all the new varieties have adopted to the local conditions and attained new flushes.

### TRIPURA CENTRE

#### PINEAPPLE

##### a. Effect of size and weight of suckers on fruit maturity and quality of pineapple

Effect of three grades of suckers (300g, 600g and 900g) on fruit maturity and quality was tested. The earliest maturity (first week of May) was observed under 900g suckers. The maximum fruit weight (1.12kg) was recorded under 300g followed by (1.05kg) in 600g and minimum (0.720kg) was in 900g suckers. The TSS was maximum (15.2) under 900g followed by 300g (14) and minimum (13.6) under 600g suckers.

##### b. Effect of planting time on flowering, fruit maturity, quality and yield.

Comparisons of four plantings were made for fruit yields and quality the highest yield (45 t/ha) was harvested in October planting and lowest (25 t/ha) in December planting. Maximum TSS (14.5) was recorded in October planting, and minimum (14.0) under December planting. Off-season flowering, fruiting, fruit maturity and yield were observed in December planting.

##### c. Effect of pinching on fruit quality and yield of pineapple

To find out most suitable time of pinching to increase fruit quality and size of pineapple cv.

Queen. binching was done at (20,30,40,50 days after flowering). Maximum fruit weight (1.34 kg) and TSS (15.6%) was recorded under 30 days followed by (1.20 kg) in 40 days while check recorded only 890g. Early maturity time (92 days) was recorded in 20 days pinching and late pinching done at 50 days after flowering.

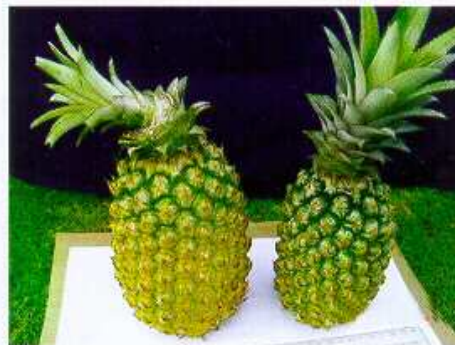


Fig.1. Pinched and non-pinched pineapple

#### LITCHI (*Litchi chinensis*)

##### Response of NPK on fruit quality and yield of litchi Cv. Bombai

Three different levels of N: P: K viz. 700: 600: 600g, 1000:900:900g, 1300:1200:1200g were evaluated. The earliest flowering was observed in plants with out fertilizer application. whereas late flowering was noticed under highest level of NPK. pH value was maximum under high doses of NPK and was lowest under no fertilizer application. Maximum fruit weight (38g) was recorded in 1300:1200:1200g NPK followed by (32g) in control. Maximum fruit yield (4500 fruits/plant) was recorded with highest NPK dose followed by lower doses and the minimum (1256 fruits/plant) in trees with out any fertilizer treatment.



Fig. 2. N:P:K,1300:1200:1200g Control



### Effect of different level of NPK on litchi fruits

#### a. Evaluation of citrus

Three lime (*Citrus aurantifolia*) varieties Saisarbati, Pramalini, Vikram along with Nagpur mandarin (*Citrus reticulata*) and Mosambi (*Citrus sinensis*) were introduced at the Centre in September 2003. The survival of the plant was 100% except Nagpur mandarin.

#### b. Aonla (*Emblica officinalis*)

Two Aonla varieties kanchan and NA-7 were introduced and planted in July 2004. The growth of NA-7 was better than kanchan. The plant height of 110 and 78 cm was recorded by NA-7, and Kanchan respectively.

## MANIPUR CENTRE

### Evaluation of mango germplasm

Out of thirty-five mango genotypes flowering and fruit set was observed in only 10 accessions. Earliest flowering was observed in Acc No. 7, 34 and 13 where as late flowering in Acc. No. 7. Longest panicle (27.4 cm) was recorded in Acc No. 35 followed by Acc No. 8 (26.2 cm) and the shortest (8.8 cm) in Acc No. 38.

### Effect of mulching and INM on the yield and quality of pineapple

The plant height (62.4 cm), number of leaves (31.3) and leaf width was higher in poly mulch followed by dry grass mulch (49.55 cm and 26.48) and control (49.88 cm and 26.24) respectively.

### Evaluation of banana germplasm

Among the ten accessions collected from Manipur (Imphal East, Imphal West and Ukhrul District) and Mizoram, the growth of the Dwarf Cavandish and Robusta were found superior. The performance of Dwarf Cavandish under foothill condition are quite satisfactory. Out of ten accessions only two i.e. dwarf Cavandish and Robusta recorded early flowering (271 days) followed by Bhimkol (300 days). The highest bunch

weight was recorded in Dwarf Cavandish (24 kg) followed by Robusta (17.5 kg).

### Effect of drip irrigation on the yield and quality of different varieties of passion fruit (*Passiflora edulis*)

Higher number of fruits per plant was recorded in both Kaveri (115) and Purple (136) varieties when irrigation was scheduled at 15 days interval. Fruit yield/ha was maximum (139 and 57.8 q/ha) under drip irrigation at 15 days interval followed by irrigation at 20 days interval (118.5 and 57.8 q/ha) in var. Kaveri and Purple respectively.

Juice content of cv. Kaveri (31.7ml) was almost three times than that of Purple (10.5ml). Irrigation schedule did not affect the juice content of either variety. Though higher TSS was recorded in cv. Kaveri than Purple, the irrigation schedule did not affect the TSS of the fruit.

### Effect of drip irrigation and nitrogen application on the yield and quality of passion fruit

Irrigation at 12 days interval took more days (117.6) to flower with maximum yield (46.59q/ha) than irrigation at 18 (45q/ha) and 24 days (38.1q/ha). Treatment involving no irrigation has taken least number of days (85.8) to flower with yield 31.9q/ha followed by grass mulch (32.1 /ha) at 99.3 days. Amongst the three nitrogen doses, 150kg/ha recorded late flowering (108.6 days) with maximum yield of 40.58q/ha as compared to 50kg/ha (100.5 days) with yield of 36.32q/ha and 100kg/ha (101.2 days) with yield of 39.5q/ha. Highest number of fruits per plant was recorded in irrigation at 18 days interval (81.9 fruits) as compared to 12 days interval (73.6 fruits) and at 24 days interval (67.1 fruit).

### Financial analysis of Kachai lemon cultivation in Manipur

The costs and returns from different age groups of orchards were compiled on the basis of annual cash inflow and cash outflows. The average cost of production was found to be Rs. 15,539 in which human labour accounted 89% of the cost. Manures and fertilizers and plant protection chemical formed a minimal of 0.32% and 1.48% respectively. The net present value at 12% discount rate was found to be Rs. 98,604 which is higher than the initial investment cost.



## MIZORAM CENTRE

### BANANA

#### Effect of bio-fertilizers on yield and quality of Banana

Application of  $N_{375} P_{187.5} K_{600}$  kg./ha + *Azospirillum* @ 4kg/ha + PSM @ 4kg/ha induced the earliest shooting (243 DAP), maximum number of hands (10/bunch), fingers per bunch (112/bunch) with yield of 23.2 t/ha, TSS of 24° Brix and minimum acidity of 0.20% in Giant Cavendish (Fig. 3.)



Fig. 3. Banana var. Giant Cavendish

#### Effect of planting materials on yield and quality of Banana

Five different planting materials of cv. Giant Cavendish viz., sword sucker, water sucker, peeper (sword sucker), peeper (water sucker) and rhizomes were taken for experiment with recommended fertilizer dose of NPK 200:100:300g/ plant. Sword sucker was found to be the best in respect of growth (35cm/month), early shooting (235 DAP), maximum number of hands (10/bunch) fingers (121/bunch), yield (24.5t/ha), TSS (24.5° Brix) and minimum infestation of insect pests (15%) followed by peeper of sword sucker.

#### Effect of different manures on yield and quality of Banana

Among different combinations of manures (FYM, poultry manure and pig manure) the maximum number of hands (10/bunch), fingers (112/bunch), yield (22.7 t/ha) and TSS (24° Brix) were recorded with the application of FYM+ poultry

manure in 1:1 ratio @ 20t/ha applied to cv. Giant cavendish.

#### Monitoring of insect pests and diseases in banana

The most common insect pests in banana were pseudostem weevil (*Odioporus longicollis*), rhizome weevil (*Cosmopolites sordidus*) (Fig. 4.) and banana beetle (*Nodostoma subcastatis*), while sigatoka and wilt were recorded as major diseases. The infestation of banana pseudostem weevil and sigatoka were recorded to be 25% and 28.5 % respectively. Maximum economic loss was found to be caused by pseudostem weevil and panama wilt (Fig.5).



Fig. 4. Infestation of banana rhizome weevil



Fig. 5. Panama wilt in banana

### PASSION FRUIT

#### Effect of bio-fertilizers on yield and quality of passion fruit

*Azospirillum* and PSM bio-fertilizers were applied to the purple variety (Fig. 6) with different



fertilizer doses of N, P and K. The maximum number of fruit (85/vine), maximum fruit yield of 3.5 t/ha and maximum TSS of 16.5° Brix were recorded with the application of N100P<sub>75</sub>K<sub>125</sub> kg/ha +azospirillum @ 1.0 lt/ha. +PSM @ 1.0 lit./ha followed by N<sub>100</sub>P<sub>75</sub>K<sub>125</sub> Kg/ha+ azospirillum @ 4 kg./ ha..



Fig. 6. Passion fruit (variety-Purple)

## CITRUS

### Effect of different growing environments on growth of Khasi mandarin seedlings

Khasi mandarin seedlings were grown under four different conditions viz. mist house, net house, poly house and field condition (Fig. 7). The maximum growth rate (2.5 cm/week) of citrus seedling was recorded under mist house followed by net house condition (2.3 cm /week). However, the infestation of powdery mildew (32.5%) and leaf miner (43.5%) was more under mist house condition.



Fig. 7. Khasi mandarin seedlings production

## PAPAYA

### Effect of potting mixtures on seedling growth and flowering

Ten different potting mixtures were prepared by mixing soil, FYM, poultry and pig manure in different combinations were evaluated for studying growth and yield parameters of cv. Surya. Soil +FYM (1:1) took minimum time for germination (11 DAS), maximum growth rate (7.6cm/week) and early flowering (69 DAP).

## PINEAPPLE

### Effect of plant density on the growth and yield of pineapple.

Pineapple (var. Kew) was planted in four different spacing viz. 0.4 x 0.5 x .75m, 0.3 x 0.5 x 0.6m, 0.4 x 0.6 x 0.9m in double row planting system and 0.5 x 0.75m in single row system. The maximum growth and the early flowering was observed with the spacing of 0.4 x 0.6 x 0.9m in double row system.

## GUAVA

### Effect of different types of manures on yield and quality of guava.

Among different combinations of manures, application of FYM+ poultry manure (1:1) @ 20t/ha recorded the highest yield (22.7 kg/tree) with maximum number of fruits ( 120/plant), weight (180g/fruit) and TSS (13° Brix)

### Studies on Strawberry

Strawberry runners of Sweet Charlie were planted in pots under net house conditions (Fig. 8). Flowering was observed in the month of January



Fig. 8. Evaluation of Sweet Charlie for yield



and fruits were harvested from February onwards. The average number of fruits per plant was 12 fruit weight 10g and TSS of fruit was 7 with acidity of 0.8 %.

## VEGETABLES

### BRINJAL

#### Inter-specific hybridization in brinjal

Inter-specific hybridization was done between *S. melongena* and *S. gilo* to study the crossability and transfer the resistance for shoot and fruit borer from *S. gilo*. Four varieties of *S. melongena* group namely, Pongal Green, JC-7, Arka Keshav and RCMB-1 were taken as a female to obtain interspecific  $F_1$  hybrid with *S. gilo* (Fig. 1). On the basis of field performance of  $F_1$ 's, it was observed that temperature plays an important role in fruit set of  $F_1$ 's. No fruit set was observed in the month of July, but fruit setting started with the decrease in temperature during November and December. In the month of January, fruit set was recorded around 90% in all the  $F_1$  crosses, but no seed was found in any of the crosses.

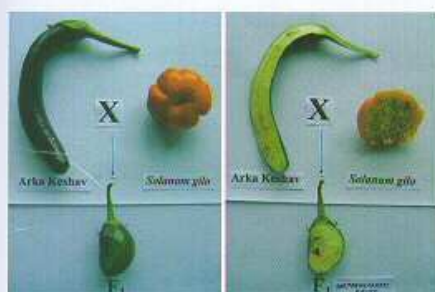


Fig. 1. Interspecific hybridization

#### Generation advancement and selection of superior segregates

Twenty long type, five round type and one green type brinjal lines were selected on the basis of yield performance from segregating population in  $F_3$ .

#### Varietal development

One advance line of brinjal developed at this Institute was evaluated for its yield performance and reaction to bacterial wilt disease. The variety is erect type, having 2-3 fruits per cluster with average fruit length of 25 cm and also tolerant to bacterial wilt. The average yield was 400 q/ha.

### TOMATO

#### Development of $F_1$ hybrids for high yield, tolerance to bacterial wilt and blight disease

Twenty eight crosses were made in diallel fashion by taking eight lines namely KT-10, Shakti, Arka Abhijit, KT-15, Sel-1, Arka Shreshtha, BT-10 & Flora-Dade.  $F_1$  seeds were collected for evaluation.

#### Development of variety

Four homozygous, advance lines of tomato developed and evaluated for their yield performance and reaction to late blight disease. The yield recorded was in the range of 391-556 q/ha (Table 1). These lines were found tolerant to late blight under field conditions.

### CHILLI

#### Collection of chilli germplasm

A total of 93 lines of chilli were collected from different states of NE region viz Assam (3),

Table 1. Performance of some advance lines of tomato tolerant to late blight.

Advance Lines	Plant height (cm)	Fruit wt. (g)	No. of fruits	Pericarp thickness (cm)	TSS %	Acidity %	No. of locules	Yield (q/ha)	Reaction to disease
RCMT-11-1	65.34	56.29	28.12	0.64	5.2	0.86	4	514.4	T
RCMT-6	62.23	48.23	29.35	0.52	4.8	0.82	3, 4	556.8	T
RCMT-14	72.26	68.23	24.36	0.53	5.4	0.78	4	485.4	T
RCMT-12	68.23	44.23	26.29	0.51	5.2	0.95	4	391.2	T

T= Tolerant



Nagaland (12), Mizoram (15) and Meghalaya (63), respectively. The germplasm is maintained for future use.

#### Improvement of legume vegetables

##### *Dolichos* bean: Generation advancement and Selection

Twelve promising lines were selected from eighty genotype of Indian bean. The highest yield was recorded in RCDL-115 (144.6 q/ha) (Fig. 2) followed by RCDL-37 (136.8 q/ha) and RCDL-143 (131.6 q/ha). RCDL-115 line has been included in All India Coordinated Vegetable Improvement for testing at National level.

Different packaging materials were used to enhance the shelf life of Indian bean. The maximum shelf life of 13 days was recorded in perforated waterproof paper bag with 10 per cent weight loss when stored in the month of December.



Fig. 2. Dolichos selection (RCDL-115)

##### French bean: Generation advancement and selection

Thirteen superior lines of pole type French bean were selected from forty lines evaluated. Sel-19 (125 q/ha) recorded highest yield followed by Sel-35 (110q/ha) (Fig. 3) and Sel-33 (103.3 q/ha). The line Sel-35 has also included in All India Coordinated Vegetable Improvement for national

level testing. Among promising bush type French bean lines, none was found superior to check variety Contender (108.3q/ha).



Fig. 3. French bean (Sel-35)

#### Cowpea

##### Generation advancement and selection

Among different lines of cowpea evaluated, RCCP-1 recorded highest yield (55 q/ha) (Fig. 4) and the same has been included All India Coordinated Vegetable Improvement Project for testing at national level.



Fig. 4. Cowpea RCCP-1

#### COLE CROPS

In cauliflower, 12 hybrids with 5 open pollinated varieties for early group, 10 hybrids including 6



varieties for mid group and 14 hybrids with 6 open pollinated varieties for late group were evaluated for yield and yield contributing characters (Table 2). Promising varieties identified for early, mid and late season were Himkaran, Pusa Sharad and Himani, respectively.

**Table 2: Varieties/hybrids of cauliflower recommended for different season**

Season	Var./hybrids	Days to 50% curd maturity	Yield q/ha
Early season	Himkaran	45	247
	Pusa Early Synthetic	68	230
Mid season	Pusa Sharad	72	320
	No.497	70	240
Late season	Himani	90	440
	Mahima	92	310
	Poosi	95	350
	Meghalaya Local	150	420

### CABBAGE

Thirty hybrids/ varieties for early, 28 for mid and 32 for late season were evaluated. Green Empress, Bahar and Raj – 2 (large) were identified most suitable for early, mid and late season (Table 3).

**Table 3: Varieties/hybrids of cabbage recommended for different seasons**

Season	Var./hybrids	Days to 50% curd maturity	Yield q/ha
Early season	CH-21	63	290.00
	CH-2200	65	300.00
	Green Empress	72	320.00
Mid season	Pusa Ageti	68	280.00
	Bahar	85	750.00
	BC-76	85	650.00
	BC-79	78	548.00
	Pride of India	75	308.18
Late Season	Raj-2(Large)	98	648.00
	Raj-2	88	572.00
	Green Challenger	90	500.00
	Green Voyager	85	470.00

### BROCCOLI

Seven hybrids/varieties of broccoli were evaluated during winter season of 2004-05. Hybrid Fiesta recorded maximum yield (215 q/ha) followed

by Lucky (219 g and 205 q/ha), Solan Green Head (190 g and 192 q/ha) and Pushpa (186 g and 189 q/ha), respectively. Curd weight also followed a similar trend in these varieties.

### Integrated nutrient management in cabbage

A field experiment was conducted with eight treatments viz: T1-Recommended dose (20 tones FYM+ 150:60:60 Kg NPK), T2- Poultry manure 10tones + half dose of NPK, T3- Half dose of T1, T4- FYM 15 tones + 4 sprays of Panchkavya, T5- FYM 15 Tones + 4 sprays of Amrit pani, T6- Poultry 10 tones +4 sprays of Panchkavya, T7- Poultry 10 tones +4 sprays of Amrit Pani, and T8-FYM 15 tones + 1.0 tones Neem Cake to study the response of integrated nutrient management in cabbage (Bahar). The treatment poultry manure 10 tones + half NPK registered highest yield (476 q/ha) followed by poultry manure 10 tones + Panchkavya (460 q/ha) and recommended dose (402 q/ha).

### Organic farming in broccoli, cabbage, and cauliflower

In broccoli, an experiment was conducted with 10 treatments consisting of FYM (20 tones), poultry manure (10 tones), pig manure (10.5 tones) rabbit manure (10.5 tones), neem cake (3.8 tones), 15 tones FYM + 4 sprays of panchkavya, 15 tones FYM+ 4 sprays of Amrit Pani, 8 tones Poultry+ Panchkavya 4 sprays, 8 tones Poultry + Amritpani 4 sprays and 150: 60: 60 kg/ha NPK (Check). Hybrid Fiesta was used as subjected variety. Before starting the experiment the soil of experimental field contained pH-5.1, high in organic carbon (2.26%) and available phosphorous (28.25 Kg/ha), medium in available nitrogen (389.92 kg/ha) and potassium (198.76 kg/ha). The calcium and magnesium was 0.7 and 0.3 c mol (P<sup>+</sup>) kg<sup>-1</sup>. After harvesting of first and second crop, there was a slight increase in pH in FYM, poultry manure, pig and FYM+ amritpani treatments. Organic carbon and available nitrogen decreased after harvesting of first crop and after second crop they were increased slightly. Available phosphorous, potassium, Ca and mg increased after harvesting of first crop but after second crop decrease was recorded. The highest plant height (38.51cm) was recorded from poultry manure followed by FYM (37.9 cm). The highest average head weight (257.8g) and yield (190 q/ha) was



found in poultry manure followed by FYM (246.00g & 182 q/ha ) and poultry + Amritpani (235.4g & 174.8q/ha) respectively. Among the qualitative characters, the highest dry matter (13.06%) and ascorbic acid (52.16 mg/100g) was recorded from Poultry + Amritpani treatment followed by FYM+Amritpani (12.89 % & 51.11mg/100g) respectively. The treatment poultry+ panchkavya recorded highest carotenoid content (8.6 mg/100g) followed by poultry+ Amritpani (7.7 mg/100g) and FYM+Amritpani (7.1mg/100g).

### Cabbage & Cauliflower

The experiment was conducted for 2<sup>nd</sup> consecutive year on cabbage hybrid Green Challenger and cauliflower hybrid Himani with nine treatments viz. F.Y.M. (20 tones), poultry manure (10 tones), pig manure (10.5 Tones), rabbit manure (10.5 Tones), neem cake (3.8 tones), 15 tones FYM+ Panchkavya 4 sprays, 8 tones poultry+ panchkavya 4 sprays, 15 tones FYM+ 5 tones Poultry Manure and 150:60:60 kg/ha NPK (Check). In cabbage, highest net wt. of head (950 g) and yield (380 q/ha) was found in FYM+ poultry manure followed by poultry manure (930g & 372 q/ha) and pig (900g & 360 q/ha) while in cauliflower highest net weight of curd (870 g) and yield (348.00 q/ha) was recorded from FYM followed by poultry manure (855.6g), (342.24 q/ha) and FYM + Panchkavya (832.86g), (333.14 q/ha) respectively.

The experiment was conducted on hybrid Fiesta with three plant spacing ( $S_1$ : 45x30 cm,  $S_2$ : 45x45 cm and  $S_3$ : 60x45 cm) and three doses of nutrients ( $T_1$ : 100-80-60 Kg NPK,  $T_2$ : 150:80:60 Kg NPK and  $T_3$ : 200-80-60 Kg NPK). A spacing of 45x30 cm and 200-80-60 kg NPK/ha have recorded highest yield (236.3 q/ha) and recommended for yield optimization of broccoli.

## COLOCASIA

### Evaluation trial

Thirty-five varieties/genotypes of colocasia were evaluated for yield attributing characters. The highest yield was recorded in ML-1 (227.5 q/ha) (Fig. 5) followed by Meghalaya Collection-1 (212.5 q/ha), ML-9 (207.5 q/ha), Kandha-5 (206.3) q/ha and ML-2 (205 q/ha).



Fig. 5. Colocasia variety ML-1

### Screening of colocasia varieties/genotypes against *Phytophthora* leaf blight

Varieties/genotypes were evaluated for their reaction to *Phytophthora*. Disease appeared in almost all the genotypes. But varieties/genotypes like ML-1, Nadia Local, and BCC-1 were found moderately resistant with less than 15% diseased area. BK Col-2 (60%) & KCA-1 (55%) were susceptible genotypes.

## SWEET POTATO

### Evaluation trial on sweet potato varieties

Nineteen varieties of sweet potato were evaluated for their growth and yield attributing parameters. Among the varieties, the variety having long tubers were S-30 (18.22 cm), Kokrajhar Red (17.35 cm) and S-107 (15.81 cm) while the highest tuber diameter was recorded in Sree Ratna (9.2 cm) followed by Sonipat-2 (8.96 cm) (Fig. 6) and H-620 (8.88 cm). The highest tuber yield was recorded in Sonipat-2 (270 q/ha) followed by S-107 (230 q/ha) and CIP-440/27 (230 q/ha).



Fig. 6. Sweet potato variety Sonipat-2



Five varieties of sweet potato were evaluated at farmer's field of Sumer area of Meghalaya. Variety H-42 recorded highest yield (308.3 q/ha) followed by H-720 (125 q/ha).

#### Effect of different organic manures on sweet potato

An experiment was conducted on sweet potato variety H-620 using locally available organic manures. The different treatments were FYM (20t/ha), Pig manure (10t/ha), Rabbit manure (10t/ha), Bioplus(10t/ha), Neemcake (6 t/ha),  $\frac{1}{2}$  FYM +  $\frac{1}{2}$  Bioplus,  $\frac{1}{2}$  FYM +  $\frac{1}{2}$  Neemcake and control (only recommended dose of fertilizer). Highest yield of 222.4 q/ha was recorded by application of FYM. Application of Rabbit manure recorded tuber yield of 173.8 q/ha.

#### Experiment on Nursery Refinement

An experiment was conducted to study the effect of storage of vine cuttings with and without leaves on tuber yield of sweet potato. Comparison of the treatments showed that vine cuttings with leaves planted 4 days after storage recorded highest tuber yield 343.3 q/ha, giving additional tuber yield (30.4 %) as compared to vine cuttings without leaves planted on the same day.

#### Tolerance of French bean (rajmash) varieties to soil acidity

The trial was conducted in acidic soils (pH 4.6) and lime requirement (LR) determined by SMP method was 16.7 t/ha. Six varieties of rajmash (Amber, Arka komal, HUR-14, HUR-15, HUR-139 and HUR-168) were evaluated for their response to lime (1/10<sup>th</sup> LR) applied in furrows. All the tested varieties were responsive to liming and least response was observed in HUR-15 and maximum with HUR-168. The mean maximum yield was recorded in Amber (10.8 q/ha) and minimum in HUR-15 (4.4 q/ha).

## CABBAGE

#### Effect of various bio-rational insecticides against cabbage insect pests

Field trial was conducted to evaluate various botanicals and insecticides against insect pest of local cabbage varieties. It was found that spraying

of two botanicals/viz. Karanjin @2ml/l and Anonin @ 2ml/l were effective against cabbage butterfly *Pires brassicae* and diamond back moth (*Plutella xylostella*) recording 100 and 93% reduction, respectively but Imidacloprid gave an effective control of cabbage aphid, *Brivicornye brassicae* (Table 4).

**Table 4: Efficacy of biorational introduction on pests of cabbage.**

Treatments	% reduction over control 7 DAT		
	Aphids	Diamond back moth	Cabbage butterfly
1. Econeem (1%)	65	43	67
2. Multineem (0.03%)	86	25	68
3. Karanjin (2%)	82	71	81
4. Anonin (1%)	72	92	100
5. Imidachloprid ( 17.8SL)	100	70	86
6. Phosphamidon(40SI)	96	50	87

## YAM

#### Laboratory evaluation of local Entomopathogenic nematodes (EPNs) against Sawfly

The Sawfly, (*Anisoartha coerulea*) Cameron was recorded a major pest of yam *Dioscorea alata*. The larvae were found feeding gregariously during the initial instars and cause 85-97 per cent defoliation resulting in reduction in yield. A filter paper bio assay was conducted using isolated indigenous strains of *Steinernema corpocapsae*, and *Heterorhabditids*. Results indicated that *S. corpocapsae*, killed 82 per cent of larvae after 24 h and 93 and 97% after 48 and 72 h of release of infective juveniles compared to *H. bacteriophora* which showed mortality of 72% after 24 h and 89 and 99 % after 48 and 72 hours of exposure. Both the local isolates were effective in bringing high mortality of the larvae. The time taken for infective juveniles emergence was 7-10 days in case of *S. corpocapsae* and 8-12 days in *H. bacteriophora*. Infective juvenile production was also higher in *H. bacteriophora* compared to *S. corpocapsae*.

Aqueous and methanol extracts from various plant parts of different botanicals like fresh turmeric



(rhizomes, powder) *Lantana camara* (leaf) Ginger (rhizome), *Alpinia galangal* (leaf and rhizome) and *Curcuma zedoria* (rhizome) were evaluated. Different concentrations viz. 5%, 3%, 2%, 1% and 0.7% were tested on yam (*Dioscorea alata*) sawfly (*Anisoartha corulea*) and taro corm borer (*Haplosynx chlaybaeus*). Among the different plant extracts used, *Lantana camara* leaf extract, *Alpinia galanga* plant extract and *Curcuma zedoria* rhizome extract were found to be highly effective in controlling the yam saw fly. Both water extract and methanol extract were found to be highly effective in causing the mortality of the test insects.

Among different botanicals evaluated, the turmeric extracts both the fresh rhizomes and the processed turmeric were found to reduce the feeding in the treated corms compared to untreated control. Lowest feeding was observed in treated water with processed turmeric extract. Higher concentrations of the extracts like 5 per cent and 3 per cent were highly efficient in management of the pest by reducing the feeding. For the first time insecticidal property of the rhizome extract of wild turmeric *Curcuma zedoria* which is found in abundance in the mid altitude area of Meghalaya was recorded and could be effectively used in the pest management.

#### **Toxicity of various insecticides to the larvae of yam saw fly**

Betacyfluthrin, Phosphmidon and karanjin were tested for their toxicity against larvae of yam saw fly by direct spray method under potters tower. The larvae were treated with different concentrations. Observations on mortality were taken 24 HAT. The data obtained was subjected to profit analysis and  $LC_{50}$  was obtained, which was 0.000356, 0.00197, 0.00148 for betacyfluthrin, Phosphmidon and karanjin, respectively

#### **Plant-parasitic nematode of vegetable crops:**

A random survey of vegetable crops viz. brinjal, tomato, chili, cabbage, sweet potato, salad, colocasia, cabbage, cauliflower, knol-khol, broad bean and radish was conducted to assess the nematode with these crops. *Meloidogyne incognita*, *Helicotylenchus* sp., *Tylenchorhynchus* sp., *Hirshmenietta* sp., *Ditylenchus* sp., *Xiphinema* sp. and mycophagous nematode namely

*Aphelenchoides composticola* and *Aphelenchus avenae* were found infesting these crops. The Relative Density (RD) and Prominence Value (PV) of *M. incognita* was 22.6 and 301.2 respectively followed by *Helicotylenchus* sp., (17.5 and 246.7), *Ditylenchus* sp., (7.4 and 37.3) *Tylenchorhynchus* sp. (3.5 and 15.3); and *Aphelenchoides composticola* (1.5 and 5.5) respectively. Free-living and predatory nematodes were also found at different locations giving RD and PV of 19.5 and 255.2 and 4.2 and 18.4, respectively. A local weed *Galinsoga parviflora*. L. (Asteraceae) was found as alternative host for root-knot nematode (*Meloidogyne incognita*). This weed is widely distributed in the region and thus root-knot may prove more destructive and widely distributed in the region.

#### **Biocontrol of predominant nematode species:**

During survey of bio agents for nematode management, nematode trapping fungi *Arthrobotrys oligospora* was isolated in the soils of Meghalaya. Application of *A. oligospora* resulted in the significant improvement of plant growth (65.4%) as compared to check. The effect of *Paecilomyces lilacinus*, on the other hand was not discernible as far as plant growth is concerned. Significant improvement in plant growth (67%) was recorded by the combined use of these two organisms, when compared to check (nematode alone). The final nematode population reduction was 76.9% in presence of *A. oligospora*, while 22.8% in presence of *P. lilacinus*.

#### **ARUNACHAL PRADESH**

Package for production have been developed for cauliflower, broccoli, pea, palak and coriander under mid hill conditions (Basar) Palak variety Pusa Harit and All Green recorded 91 and 82 t/ha green leaf leaf yield, respectively in five cuttings. Pusa Harit was of shorter duration (80 days) than All Green (105 days). Performance of cauliflower Pusa Himjyoti and Broccoli (KTS-1) was evaluated. Curd initiation in Pusa Himjyoti was observed on 58 days and matured after 79 days of transplanting done on 20<sup>th</sup> November. Curd size was medium (13.7 cm dia, 8.8 cm height) with 256 g weight. Broccoli (Cv.



KTS-1) showed early curd initiation (34 days) and maturity (57 days).

Performance of Pea (Cv. Azad) was evaluated for its growth and yield parameters when sown in last week of October. 50% flowering was recorded after 65 days with first pod picking on 80<sup>th</sup> day of sowing. The duration of variety was 135 days with pod yield of 149 g/plant.

## NAGALAND CENTRE

### Effect of nutrient sources on the fruit yield of tomato

The combination of 50% of nitrogen through FYM + 50% of N through urea induced the highest plant height (96.52 cm), number of fruits/plant (36.7), fruit weight (73.2 g) and yield (32.4t/ha). Lower yields were recorded where only FYM (31.5%) or vermicompost (34.7%) or combination of both (24.6%) was used in comparison to yield obtained with recommended dose of NPK.

### Effect of organic manures and *rhizobium* inoculation on growth and yield of French bean

Plant height and number of branches of French bean (cv. Contender) increased significantly with the application of FYM + *rhizobium* inoculation at 20, 40 and 60 days after sowing. Maximum pod yield (137.7 q/ha) was obtained with 10t FYM/ha + *rhizobium* inoculation, followed by 5t pig manure/ha + *rhizobium* inoculation (128.5 q/ha). Minimum pod yield (116.4 q/ha) was recorded when vermicompost was applied @ 2 t/ha.

### Effect of organic and inorganic manures on growth and yield of cabbage

Maximum yield (34.3 t/ha) with marketable heads (4.8/M<sup>2</sup>) of cabbage was obtained with the application of 10 t pig manure/ha which was significantly higher than to recommended dose of NPK (28.7 t/ha) and 5 t vermin compost/ha (29.2t/ha). Application of pig manure @ 10t/ha recorded 20, 13 and 9 per cent increase in head volume and 23, 16 and 5 per cent in weight as compared to recommended dose of NPK, FYM and poultry manure.

## Population dynamics of blister beetle on Okra and its management

Seasonal incidence of blister beetle showed peak population in the month of July. May and June sown okra was found to be severely affected than April and March sown crop. Light blue, bright blue, yellow, green and red plastic containers with soap water were kept in the field above the canopy during entire cropping period of cv. Arka Anamika crop. Among 5 colours tested, bright blue and yellow colour containers were found to attract 120 and 100 adult beetles respectively which were drowned in soap water. This indicates an easy method to keep the beetle under check.

## SIKKIM CENTRE

### COLE CROPS

#### Efficacy of bio pesticides against insect pest of major cole crops.

Different biopesticides available in the market were evaluated along with recommended insecticides. Among ecofriendly insecticides delfin 3G @ 500 g/ha checked the population of *Agrotis* sp and *Tricoplusia* sp effectively in all selected crops while Carbofuron @ 1.00 kg ai/ha provided good control of cutworm in cabbage and cauliflower whereas endosulfan @ 0.07 % checked the population of Semilooper effectively in cabbage, cauliflower and broccoli..

## TRIPURA CENTRE

### TOMATO

#### Management of bacterial wilt

Out of 12 genotypes evaluated for identifying resistance against bacterial wilt disease, genotypes BT-1 and BT-10 were found to be most resistant to wilt, followed by CKVT-17, Sikkim local and Arka Aloke, respectively.

#### Effect of different sources of organic manures on Tomato yield

Out of 16 treatments, Glyricidia @ 500+Poultry manure @ 500g+ Acacia@750g+ Cowdung 1kg/



4m<sup>2</sup> gave the maximum yield (13.83 t/ha) against 5.05 t/ha in control.

#### Evaluation of Tomato varieties for yield

Nine varieties of tomato including local were evaluated. BT-10 recorded maximum yield (36.40t/ha) than Tura local (14.07t/ha.)

### BRINJAL

#### Management of bacterial wilt

Twelve genotypes of brinjal were tested for their tolerance to the bacterial wilt under field condition. BB-40, BB-64, Green round (local), White round (local) and Singhnath (local) were found tolerant.

#### Germplasm Collection and Conservation of Indian Bean (*Dolichos lablab*)

A wide variability was observed in local *Dolichos* beans with respect to stem, leaf and pod colour (Fig. 7). Pod colour varied to large extent but prominence of green colour with purple margin with various shades was observed. Large variation in pod length (7-23 cm) and breadth (2-5 cm) was recorded.

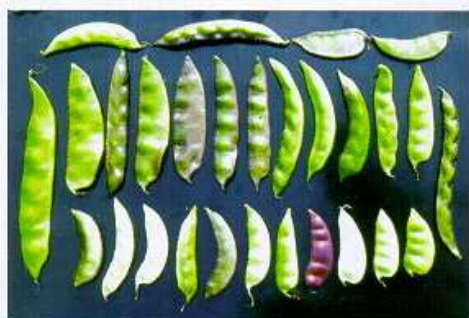


Fig. 7. Genetic variability in Dolichos beans

#### Evaluation of Bottle Gourd (*Lagenaria siseraria* L.)

Six bottle gourd varieties such as B-9, DVB-9-2, DVB-9-1, DVB-4-35 and two local collections were evaluated. DVB-4-35, was early in bearing (75 days) but was found prone to fruit fly attack. DVB-9-2 was found late in bearing (108 days) but yielded maximum (62.5t/ha). Local selection 1 and 2 from Tripura were resistant to fruit fly with yield of 51.2 and 49.1 t/ha, respectively.

### CHILLI

#### Evaluation of Chilli hybrids for yield

Among the 11 chilli hybrids tested, Skyline, BSS-268, Bola and Simi were found promising. Sky line recorded the maximum fruits yield (877.3g) and number (118.2), per plant, respectively.

### MANIPUR CENTRE

#### Development of Tomato varieties for low land ecosystem

Forty-two advance breeding lines of F<sub>7</sub>, F<sub>8</sub> generation and selections were evaluated. Acc No. TMC-1, 2, 6 and MCTR-7B recorded fruit yield of 29.2, 26.6, 27.4 and 26.4 t/ha, respectively as compared to 13.2 t/ha in Manikhamnu. A wide range of variability was observed in number of fruits/plant and yield/ha. Seed material of two-advance generation lines/selection of superior performance viz., RCMT-1 (Sel.9A) and RCMT-2 (Sel. 11) was selected to be included in All India Co-ordinated Research Project on vegetables.

#### Evaluation of brinjal germplasm for bacterial wilt resistance.

Seven promising lines developed through hybridisation were selected based on different growth and reproductive characters. Maximum yield was obtained in Sel. 4 (217.3q/ha) followed by Sel. 3 (215.2q/ha) and Sel.1 (205.0q/ha.).

#### Evaluation of different onion accessions

Eight varieties/lines including one hybrid H-49 and two selections 383 and 402 were evaluated. Early Grano recorded maximum plant height (59.5cm), productivity (39.4 t/ha) and bulb weight (119.4 g) with lowest neck thickness followed by Hybrid-44 (34.3 t/ha).

#### Effect of date of planting and nitrogen application on yield and quality of onion

The variety Nasik Red was grown with three nitrogen doses (75, 100 and 125 kg/ha). Maximum yield (20.94t/ha) was obtained with 2<sup>nd</sup> fortnight of November transplanting, which was similar to 1<sup>st</sup> week of December transplanting (20.97t/ha).



#### Water management in cabbage:

The mean yield of cabbage obtained from various treatments indicated that sprinkler irrigation increased the yield (21.12t/ha) by 146 per cent over the control (14.50t/ha) followed by thatch grass mulch (17.57t/ha) and paddy straw mulch (17.55t/ha) with 121.2% and 121% yield increase, respectively.

### MIZORAM CENTRE

#### TOMATO

##### Evaluation of tomato varieties

Ten tomato varieties viz. Arka Shrestha, Pusa Divya, Sioux, Shakti, Sel.1, Sel.2, Sel.3, Shakti, PKM -1 and Best of All were evaluated for fruit yield, quality and disease resistance. Arka Shrestha (Fig. 8), Sioux, Sel-2 and Pusa Divya performed better with fruit yield of 74.0, 53.0, 40.0 and 52.0t/ha, respectively. Pusa Divya was highly susceptible to *Fusarium* wilt while, Sel-1 was found highly susceptible to blight. Arka Shrestha was found tolerant to wilt and blight diseases.



Fig. 8. Arka Shrestha

##### Effect of bio-fertilizers on yield of tomato

Maximum fruit yield of 56.6 t/ha were recorded with number of fruits per plant (45), fruit weight (85g) with the application of  $N_{75} P_{80} K_{80}$  kg/ha +Azotobacter @ 4 kg/ ha. +PSM @ 4 kg/ ha.

##### Rice based tomato cultivation:

Tomato varieties Pusa Divya and Sel.-2 recorded 34.0 and 30.0 t/ha fruit yield when planted in the month of November with the application of N50, P40 and K 40 kg/ha after the harvest of rice utilizing the residual moisture.

### CABBAGE

##### Evaluation of cabbage varieties

Four cabbage varieties viz. Bahar, Green Challenge, Pusa Mukta and Golden Acre were evaluated. The yield potential of Bahar and Pusa Mukta was 48.0 and 42.0 t/ha, with average head weight of 1.75 and 1.60 kg, respectively. Both the varieties were early maturing.(70-75 days).

##### Effect of bio-fertilizers on yield of cabbage

Application of  $N_{75} P_{60} K_{80}$  +Azotobacter @ 4.0 kg/ha.+PSM @ 4.0kg/ha to cv. Bahar recorded maximum yield of 50.6t/ha with head weight (1.8 kg).



Fig. 9. Cabbage var. Mukta

### CAULIFLOWER

##### Evaluation of cauliflower varieties

Three cauliflower varieties viz. Poosi (Fig. 10), Barkha and PKSB-1 were evaluated. Poosi and Barkha recorded 24.0 and 21.0 t/ha yield, with curd weight of 900g and 800g, respectively. Barkha was found to be early maturing (68 days) than Poosi (78 days),



Fig. 10. Cauliflower var. Poosi



## BROCCOLI

### Effect of bio-fertilizers on yield of broccoli

A trial was conducted to study the efficacy of bio-fertilizer in broccoli var. Aishwarya. *Azospirillum* and PSM were applied at the rate of 1.25 l/ha and different N, P and K doses were applied in different doses. Maximum yield of 27.8t/ha and head weight (700 g), were recorded with application of  $N_{75} P_{60} K_{80}$  +Azotobacter @ 1.25 l/ha +PSM @ 1 l/ha.

## KNOLKHO

### Effect of bio-fertilizers on yield of knolkhol

A trial was conducted to study the efficacy of bio-fertilizer (*Azospirillum* and PSM) in knolkhol (var. White Vienna). Maximum yield of 34.0t/ha with knob weight (800.g) were recorded with the application of  $N_{75} P_{60} K_{80}$  +Azotobacter @ 4kg/ha +PSM @ 4kg/ha.

## SPICES

### Organic farming in ginger and turmeric

An experiment was conducted on nutrient management of ginger(Nadia) and turmeric(Megha Turmeric-1) through organic manures viz. FYM (18t/ha), poultry manure (10t/ha), pig manure (12t/ha), rabbit manure (12t/ha), Bioplus (3t/ha), neem cake (4.5 t/ha). the treatments were compared with recommended inorganic fertilizer dose ( 90:60:90 kg NPK /ha). The initial soil status for both the crops before starting the experiment was pH-5.3, high in organic carbon (2.47%), available phosphorous (33.16 Kg/ha), medium in available nitrogen (476.67 Kg/ha) and potassium (210.56 Kg/ha). Organic carbon and available nitrogen has decreased after harvesting of first crop and after second crop these values increased slightly. Available phosphorous, potassium, Ca and Mg increased after harvesting of first crop and recorded highest in FYM and poultry manure but after second crop these decreased in each treatments. In ginger,

the significantly highest yield (193.6 q/ha) was recorded from poultry manure followed by FYM (182.5 q/ha), and Neem cake (170.4 q/ha). In turmeric highest yield (393 q/ha) was recorded in FYM followed by poultry manure (386 q/ha) and pig manure (308 q/ha). The average rhizome weight also followed a similar trend (597, 583 and 483 q/ha, respectively)

### Ginger intercropping

A study on inter-cropping of French bean, cowpea, okra, chilli and brinjal were undertaken with ginger. The highest ginger equivalent yield (236.9 q/ha) was obtained from ginger + chilli intercropping while it was 221.0 q/ha in ginger sole crop which remained at par with ginger + cowpea intercropping (220.7 q/ha). Observations also revealed that problem of soft rot were less in chilli intercropping.

### Varietal trial of ginger and turmeric for yield and quality characters

31 varieties/genotypes of ginger were evaluated for yield and quality characters. Highest yield (215 q/ha) was recorded from Nadia followed by Varada (210.5q/ha) and Basar (190.8 q/ha). Dry matter content of rhizome was highest in genotype Jugijan (30.00%) followed by No.45 (29%), No.64 (29%) and Karakai (28.9%). Low fibre content was recorded from Ernad (4.08%) followed by No.179 (4.36%), No.45 (4.05%), No.294 (4.59%) and Suprabha (4.63%).

In turmeric, out of 32 varieties, highest yield was recorded from Megha Turmeric-1 (260 q/ha) followed by G.L Puram (219 q/ha) and Lakadong (212 q/ha). Highest curcumin content was obtained from PCT-5 (7.27%) followed by PTS-13 (6.82%) and Megha Turmeric-1 (6.67%).

## SIKKIM CENTRE

### Varietal evaluation of turmeric (*Curcuma longa*) for ratoon cropping

The germplasm selected were RCT (1,3) ACC No. ( 3, 4, 96, 97, 211, 296, 331, 368, 620) Prabha, Pratibha, Suguna, Suvarna, Alleppy and local. Among all the selected germplasms maximum plant height (158.67 cm ) was recorded in ACC No.211



whereas minimum (83.87 cm) was recorded in Suguna. Minimum number of leaf /plant (5.8), leaf length 937.73 cm and leaf width (10.97 cm) was recorded for Sudarshana. Maximum fresh weight of rhizome (496.67 gm/plant) was recorded in Sudarshana and minimum (291.33g/plant) was recorded in ACC No.96. Maximum dry weight per cent (48.6%) was recorded in ACC No.620, whereas maximum yield ( 608.79 Q / ha) was recorded in ACC No.97. minimum yield (184.57 Q / ha) was recorded in ACC No.4.

#### Impact of different tree leaf mulching for

The impact of chilaune, utis banmara and titepati mulching was observed on the growth and yield of ginger cv. Bhaise. Maximum plant height (67.8 cm) was recorded in banmara mulching whereas minimum ( 34 cm) was recorded without any mulching. Minimum fresh and dry weight (180 gm/plant and 7.13% respectively) was recorded without any mulching whereas maximum fresh weight ( 13 gm/plant) was recorded in chilaune and 7.8% dry weight in dhokere mulching. Maximum yield (87.14 Q / ha) was recorded in chilaune whereas significantly lowest yield ( 10 Q / ha) was recorded without any mulching.

#### Effect of rhizome size, method of sowing and intercropping on productivity of ginger

Maximum plant height (73.6 cm) was observed when the rhizome of 75g weight was planted in double row with french bean as intercrop. Maximum yield (223.4 Q / ha) was recorded when bigger size (75 gm) rhizome were used in double row + french bean whereas minimum (70.16 Q / ha) was recorded when small size ( 25 gm) rhizome were used in single row with french bean intercrop.

### MIZORAM CENTRE

#### GINGER

##### Effect of plant density and N levels on growth and yield of ginger cv. Nadia.

The maximum weight of clump (285.0g) and maximum yield (22.4 t/ha) was recorded with spacing 25 x 30cm and N @ 120 kg/ha (Fig. 1).



Fig. 1. Ginger var. Nadia

#### TURMERIC

##### Effect of plant density and N levels on the yield of turmeric cv. RCT – 1.

Three spacings viz. 25 x 30 cm., 30. x 40 cm. and 40. x 40 cm. were taken as main plot treatment with five levels of nitrogen 0, 60, 90, 120 and 150 kg/ha as sub-plot treatments. A common dose of P 80 kg/ha and K 80 kg/ha were applied as basal at the time of sowing. A significant increase in the height of plant (85.5 cm), weight of clump (298.0), number of finger/clump (11.1) and yield (29.8 t/ha) was recorded with the spacing of 30 cm x 40 cm with N 120 kg/ha. (Fig. 2).



Fig. 2. Turmeric RCT-1

#### FLORICULTURE

##### Gladiolus

A field experiment was conducted to study the response of different doses of nitrogen, phosphorus and potassium @ 0, 10, 20, 30, and 40 g/m<sup>2</sup> of each treatment on gladiolus cv. Pusa Shabnum. Nitrogen at 40g/m<sup>2</sup> resulted into maximum plant height (86.53cm), spike length (71.53cm), rachis length (45.30), number of florets per spike (14.00) and duration of flowering over the control.

An experiment was carried out on gladiolus cv. Pusa Shabnum to study the effect of growth



regulators viz., GA<sub>3</sub>, NAA, TIBA @ 100 & 200ppm and BA @ 50 & 100ppm and distilled water as control at three and six leaf stage. Maximum plant height (90.86cm), spike length (75.50cm), rachis length (51.20cm) number of florets per spike (14.25) and flower size (8.1 cm) was recorded with spraying of 200ppm of GA<sub>3</sub>. Earliest heading (76.5 days) was observed with 100ppm GA<sub>3</sub>.

An investigation was carried out to study the effect of benzyl adenine @ 0, 25, 50, 100, 150, 200, 250, and 300ppm with 24 hours dipping of mother corms on cormel production of gladiolus cv. Snow Princess. Maximum number of cormel (9.23), cormel weight (9.9 g) and propagation coefficient (193.3%) was recorded when corms were dipped in BA 150ppm.

### Gerbera

Seven exotic varieties of gerbera were evaluated under polyhouse condition. Piton produced longest stalk (61.78cm), followed by Monarch (60.00cm) while Pink Elegance had a capacity to produce sturdy stalk with increased diameter of 0.81mm and largest flower diameter (13.08cm). The next best flower diameter was measured in Piton (12.50cm).

Four-treatment combinations viz., 4%Sucrose+ 8-Hydroxy Quinoline Citrate (8-HQC) 200ppm, 4%Sucrose+ Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> 300ppm, 4%Sucrose + AgNO<sub>3</sub> 50ppm, 4%Sucrose+NaOCl 25ppm and tap water as control were tried on gerbera cv. Black Heart to enhance the post harvest life of cut flowers. Maximum gain in fresh weight on 2<sup>nd</sup> day (0.24g) and at senescence (0.053g), longest vase life (10.5 days) were recorded with Chemical combination of 4% sucrose+ 8-HQC (200ppm). However, maximum water uptake (7.66ml) on 2<sup>nd</sup> day in vase

was noted in vase solution containing 4% sucrose+ Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> 300ppm.

An experiment was conducted to study the effect of stalk length (15, 20, 25, 30cm) on flower longevity of cut gerbera cv. Black Heart. On 2<sup>nd</sup> day, 15cm stalk length gained fresh weight (0.056g) over initial fresh weight while others exhibited loss in fresh weight. At senescence, maximum loss of fresh weight (-1.02g) was recorded in longest stalk length of 30cm tested.

On 2<sup>nd</sup> day and at senescence, maximum water uptake of 4.76g and 17.32g was noted in 30cm stalk length. Longest vase life (9.20) was recorded with longest stalk of 30cm.

## MUSHROOM

### Mushroom cultivation

#### Effect of rice bran supplement on yield of oyster mushroom species/strains

Rice bran supplement @ 5% on dry wt. basis was added in paddy straw substrate to study its effect on yield of oyster mushroom species/strains during month of May. The mushroom crop was grown using block culture method. The substrate was sterilized using CST method. *P. citrinopileatus*, *P. sapidus*, three strains of *Pleurotus sajor-caju* and *P.flabellatus* were used in this study. Addition of rice bran significantly increased (30%) the yield in *P.sapidus* and reduced the yield in *P.sajor.caju* (W) and *P.flabellatus* (O) by 33.8 and 26% respectively (Table 1).

**Table 1: Evaluation of exotic varieties of gerbera under protected condition**

Varieties	Form	Colour	Stalk length (cm)	Stalk diameter (cm)	Flower diameter (cm)
Foske	Double	Creamy	50.25	0.55	11.72
Sazou	Semi-double	Cream yellow	45.50	0.56	11.55
Magnum	Semi-double	Purple	46.44	0.66	11.85
Monarch	Double	Red	60.00	0.57	11.32
Piton	Semi-double	Yellow	61.78	0.71	12.50
Sangria	Semi-double	Orange	57.90	0.73	12.22
Pink Elegance	Semi-double	Pink	50.00	0.81	13.08



**Table.1: Effect of rice bran supplement on yield (g/kg paddy straw) of oyster mushroom species/strains**

Mushroom spp/str	Without rice bran	With rice bran @5%	Increase/decrease	Mean (%)
<i>P.sajor-caju</i> (A)	1039	933	-10.2	986
<i>P.sajor-caju</i> (P)	841	733	-8.1	807
<i>P.sajor-caju</i> (W)	810	536	-33.8*	673
<i>P.flabellatus</i> (O)	955	706	-26.0*	830
<i>P.flabellatus</i> (R)	747	638	-14.6	692
<i>P.flabellatus</i> (S)	805	900	+11.8	852
<i>P.citrinopileatus</i>	723	656	-9.3	690
<i>P.sapidus</i>	860	1118	+30.0*	989
Mean	847.5	782.5		

\*Significant at  $p=0.05$ , L.S.D. ( $p=0.05$ ) for Supplement N.S., Mushroom spp/str 154.4, Mushroom spp/str x Supplement 218.4

#### Effect of herbal formulations on yield of oyster mushroom *P. sajor-caju* A

Two formulations i.e. Neemshield, (a plant food) @60g/ block and Wellbloom, (n-triacontanol) @ 0.5 ml / block were compared with check. Neemshield recorded 20% and Wellbloom 18.9% increase in yield .

#### Nematodes associated with White button mushroom

Two mycophagous nematode species viz. *Aphelenchoides composticola*, *Aphelenchus avenae* along with predatory (*Seimura* sp.) nematodes were found in samples of mushroom compost. *A. composticola* was observed predominant with population density 19 / 100 g of compost. *Agaricus bisporus* (S-11), *Paecilomyces lilacinus*, *Fusarium* spp. were found good host whereas, *Neumuria reley*, *Aspergillus flavus* were found poor host *Beauveria basiana* was found as a non-host.

### III. FARMING SYSTEM RESEARCH PROJECT

#### Dairy based farming system (FSW-1)

Dairy based farming system was evaluated in microwatershed of 1.39 ha on 32.02% slope during the reported period. Two milch cows with their

followers were kept during the year. To meet the green fodder requirement of the cows, annual fodders were grown on terraces and perennial grasses on risers and bunds. The total output in terms of green fodder yield (41055 kg) was Rs. 13,548/- (@ Rs. 0.33 per kg). The animals yielded 4396 kg milk during the period amounting to Rs. 52,752/- (@ Rs 12 per kg) and produced three trucks of cow dung which earned Rs 45,000/- .

The animals during the reported period consumed 4338 kg of concentrate feed (worth Rs. 35,571/- @ Rs. 8.2 per kg) and 4290 kg of paddy straw (worth Rs. 5148 @ Rs. 1.2 per kg) making the total cost input from outside the system to Rs. 40,719. Considering family labour as system of employment for dairy based farming, the system recorded an input output ratio of 1:1.4

#### Agro-pastoral System (FSW-4)

Agro- pastoral system was developed on 0.58 ha area having 32% slope. The system was designed to meet the food requirement of one nucleus family (Two adults and three children). The effective area under terrace was 0.49 ha which was used for crop production while the terrace risers of 0.33 ha was used for growing of Guinea grass for supply of green fodder to one unit of dairy cow and heifer. The one third area followed the cropping sequences of Rice – Buckwheat – French bean, Rice – Toria – French bean, Rice – Mustard - French bean (300% cropping intensity) and another one third area was put under 200% cropping intensity with French bean - Groundnut and Groundnut – Toria cropping sequence. The remaining 1/3<sup>rd</sup> area was put under Maize – Fallow crop sequence. It was observed that availability of fodder for one milch cow and one heifer was sufficient enough to feed during rainy season. The animal component contributed 75% of the total farm income. Agroforestry system helped to improve the land utilization/production efficiency by increasing the cropping intensity besides conserving 90-100% rain water within the farm area. The preparation of compost from dairy excreta and farm residues reduced the dependence on external inputs like FYM and fertilizers up to 34%. The sustainability index of the system was also found to improve with the adoption of vegetable component in the cropping system and animal component in the agro-pastoral system. The details



of crop grown in FSW-4 are given in the **Table 1** below.

**Table 1: Details of crops grown in Agro-Pastoral system (FS-W4)**

Sl. No.	Crop	Variety	Area (m <sup>2</sup> )	Production
1.	Paddy	RCPL 1-29	882.24	93 kg
2.	Maize	RCM 1-1	1583.49	3777 cobs
3.	Ground nut	ICGS- 76	549.13	85 kg
4.	Ginger + French bean	Nadia + Meghalaya local	308.85	34 kg mother rhizome 175 kg ginger 45 kg green pod of F. bean
5.	Pigeon pea + French bean	UPAS - 120 Meghalaya local	216	Pigeon pea damaged due to pod borer 34 kg green pod F.bean
6.	Mustard	M-27	1072.29	45 kg
7.	Buckwheat	Meghalaya local	232.52	20 kg
8.	Toria	TS-38	303.58	13.5 kg

#### Agri horti silvipastoral system (FSW-5)

Out of 1.03 ha of watershed area, 0.33 ha was under horticulture and agricultural crops. Paddy was grown in lower terraces in 548 M<sup>2</sup> area. Maize-toria cropping sequence was assigned middle terraces while in upper terraces maize-radish and maize-cabbage were grown. Although the yield of cabbage was low due to water stress in winter season, it was observed that vegetable based cropping sequence were highly remunerative and productive as compared to maize-toria and rice crop sequence. The land use efficiency and production efficiency were maximum with vegetable based cropping system. Among the horticultural crops, Assam lemon, Khasi mandarin and guava have been planted in the middle of watershed and in between

the Assam lemon, pine apple has also been planted on contour bunds. Assam lemon has started fruiting this year. The upper most area of the watershed is under broomgrass (*Thysanolaena maxima*) and forest tree spp. namely, *Alnus napalensis*, *Symingtonia populnea* and *Ficus auriculata*. The age of plantation is about 13 to 14 years and this spp. is a good source of green fodder during lean period.

**Table 2: Yield performance of different crops under farming system**

S. No.	Crop	Area m <sup>2</sup>	Yield(q/ha)
1	Radish (Root only)	143	187.41
2	Cabbage	46.2	41.3
3	Paddy	548	19.52
4	Maize (grain)	228.6	26.88
5	Toria	548	7.03

#### Hydrological behaviour of experimental watersheds

The hydrological behaviour of the experimental watersheds have been studied in terms of total water yield, base flow, surface flow (runoff) and peak flow as presented in Tables 1 and 2. The total water flow ranged from a maximum of 483.14 mm in AE-W<sub>1</sub> to a minimum of 0.75 mm in FS-W<sub>1</sub> against an annual rainfall of 2842.5 mm during the year. Base flow of water in different watersheds is depicted in **Table 3**. During the month of October a considerable amount of flow was observed in the watersheds resulting from a high rainfall of 584.5 mm received in that month (**Table 4**). No flow was recorded from FS-W<sub>4</sub>, FS-W<sub>5</sub>, FS-W<sub>7</sub> and FS-W<sub>8</sub>. There was very little or no soil loss from the different experimental watersheds.

**Table 3: Annual water yield, base flow, surface flow, peak flow and soil loss from experimental watersheds of FSRP during 2004**

Parameters	Experimental watersheds								
	FS-W <sub>1</sub>	FS-W <sub>2</sub>	FS-W <sub>3</sub>	FS-W <sub>4</sub>	FS-W <sub>5</sub>	FS-W <sub>6</sub>	FS-W <sub>7</sub>	FS-W <sub>8</sub>	AE-W <sub>1</sub>
Surface flow (mm)	0.00	53.38	66.58	0.00	0.00	83.96	0.00	0.00	75.65
Base flow (mm)	0.75	393.97	344.35	0.00	0.00	108.62	0.00	0.00	407.49
Total flow (mm)	0.75	447.35	410.93	0.00	0.00	192.58	0.00	0.00	483.14
Peak flow (mm/hr)	0.08	0.78	0.81	-	-	4.11	-	-	6.82
Soil loss (t/ha)	-	Trace	Trace	-	-	Trace	-	-	Trace



**Table 4: Monthly water yield from different experimental watersheds of FSRP during 2004**

Months	Rainfall (mm)	Water yield(mm) from experimental watersheds								
		FS-W <sub>1</sub>	FS-W <sub>2</sub>	FS-W <sub>3</sub>	FS-W <sub>4</sub>	FS-W <sub>5</sub>	FS-W <sub>6</sub>	FS-W <sub>7</sub>	FS-W <sub>8</sub>	AE-W <sub>1</sub>
Jan	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	13.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	31.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	306.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	210.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	432.2	0.00	6.10	5.62	0.00	0.00	0.25	0.00	0.00	21.14
Jul	747.3	0.00	189.55	163.35	0.00	0.00	142.14	0.00	0.00	118.79
Aug	189.8	0.48	44.83	62.59	0.00	0.00	0.41	0.00	0.00	125.12
Sept	263.4	0.25	27.85	49.71	0.00	0.00	6.49	0.00	0.00	98.01
Oct	584.5	0.02	159.59	112.27	0.00	0.00	42.32	0.00	0.00	100.73
Nov	59.6	0.00	18.67	17.29	0.00	0.00	0.97	0.00	0.00	18.50
Dec	4.4	0.00	0.76	0.10	0.00	0.00	0.00	0.00	0.00	0.85
Total	2842.5	0.75	447.35	410.93	0.00	0.00	192.58	0.00	0.00	483.14

**Mixed forestry block (FSW-2)**

Under this system, multipurpose tree species (MPTs) like *Acacia auriculiformis*, *Michelia oblonga* and *Symingtonia populnea* have been planted. During the period under report 112 nos of *Acacia*, 123 nos of *Michelia*, and 30 nos of *Symingtonia* plants survived and growth parameter data were taken. The growth performance in terms of height, CD, DBH and spread of ten sample trees were recorded (Table 5).

**Table 5: Growth performance of different MPTs**

Sl. No.	Plants spp		Min (m)	Max (m)	Mean (m)
1.	<i>Acacia auriculiformis</i>	1) Height	14.25	32.25	23.13
		2) CD	0.35	0.58	0.47
		3) DBH	0.27	0.45	0.37
		4) EXW	2.30	6.64	4.39
		5) NXS	2.69	6.22	4.23
2.	<i>Symingtonia populnea</i>	1) Height	20.50	24.75	22.20
		2) CD	0.46	0.54	0.51
		3) DBH	0.38	0.45	0.42
		4) EXW	3.00	5.15	3.82
		5) NXS	3.87	6.20	4.68
3.	<i>Michelia oblonga</i>	1) Height	11.50	21.75	15.25
		2) CD	0.29	0.50	0.37
		3) DBH	0.21	0.39	0.28
		4) EXW	3.10	5.59	3.66
		5) NXS	2.20	4.34	3.23

After pruning of *Acacia auriculiformis*, large cardamom was planted to utilize the land floor to

increase the out put. 250 plants were established. The observation for the growth will be carried out in the coming season.

**Silvi-pastoral System (FSW-3)**

In this system, fodder trees namely *Bauhinia variegata* and *Symingtonia populnea* were planted to get fodder during lean period and broom grass were planted on 50% top portion of block. Total 25 nos of Black Bengal goats were maintained on the fodder produced from this block. At initial stage stall feeding were done. At the next stage rotational grazing has been planned to reduce the maintenance cost and to increase the growth performance. Under this system whole block has been fenced and new goat shed has been constructed. Mixed grasses are being allowed between the spaces of fodder trees

**Silvi-horticulture (FSW-6)**

Under this system bottom 50% area were utilized for horticulture component. Assam lemon, Guava were planted and in between Pineapple (double row) was planted on contour lines to check the soil erosion. In total, 150 nos Assam lemon, 150 nos. of Guava and 5000 nos of pineapple were planted during the year 2003. More than 80% plants have survived. Under forestry component *Alnus nepalensis* has been planted in the upper portion of the microwatershed. In the interspace of *Alnus nepalensis*, large cardamom has been planted to get extra out put. Total 400 nos of large cardamom



plants were established. Unutilized area of Alder block has been used for bamboo plantation. Total 25 nos of bamboo seedlings were planted during the year.

#### Farming System New Block

Argri – Horti system was been developed in the area under new block of 1.59 ha. In the upper slope portion, 35, 90, 50, and 35 plants of Assam lemon, Khasi mandarin, guava and pear respectively were planted during the reported period. The survival percentage of the fruit plants varied from 69 to 98%. Pear recorded the lowest survival rate (69.1%) while the survival rates of others are above 91% (Table 6)

**Table 6: Survival percentage of the fruit plants**

Species	Total no of plants planted	Mortality	Survival (%)
Assam lemon	35	2	94
Khasi mandarin	90	8	91
Guava	50	1	98
Pear	35	11	69

In the lower portion of the slope, agriculture crops like maize, French bean, groundnut and black gram were grown in the kharif season while radish, toria and mustard were grown on residual moisture during the rabi season. The seed yield of maize (3.62 q/ha) and french bean (1.45 q/ha) grown on the terraces were not satisfactory due to pest attack. The yield obtained in case of ground nut and black

gram were 15.95 (pods) and 6.49 q/ha respectively. In case of radish, root yield of 114.6 q/ha was obtained while yields of mustard (M-27) and toria (TS-38) were only 2.4 and 2.1 q/ha probably due to delayed sowing because of heavy rains during sowing period.



Toria crop in Agri-Horti-Silvi-Pastoral system (FS-W5)



View of agri-horti-pastoral system



Rice crop Bhalum-1 in Agro-pastoral system (FS-W4)



View of farming system





**Guava plantation in farming system**



**Rice crop Bhalum -in agri-horti-silvi-pastoral system**

#### Soil quality indices

##### Exchangeable Cations and Soil acidity Indices

Distribution of exchangeable cations and various forms of soil acidity in surface and sub-surface soils under various land use systems was studied. Exchangeable Ca+Mg was highest in agriculture [4.46 c mol (p<sup>+</sup>) kg<sup>-1</sup>] followed by forestry [2.67 c mol (p<sup>+</sup>) kg<sup>-1</sup>] and the lowest in animal based system [1.40 c mol (p<sup>+</sup>) kg<sup>-1</sup>] in surface soil and decreased down the depth up to 60 cm. Maximum total soil acidity of 18.4 c mol (p<sup>-</sup>) kg<sup>-1</sup> was recorded in forestry while minimum in natural fallow system [9.5 c mol (p<sup>+</sup>) kg<sup>-1</sup>]. The highest exchangeable acidity was observed in agri-horti-silvipastoral system [2.84 c mol (p<sup>+</sup>) kg<sup>-1</sup>] followed by natural forest and the lowest in the agriculture based system [2.41 c mol (p<sup>+</sup>) kg<sup>-1</sup>]. All the forms of acidities

decreased down the soil depth upto 60 cm. The highest soil pH was recorded in agriculture followed by agri-horti-silvipastoral system.

#### Long Term Effects of Various Farming Systems on Soil Physical Behaviour

Long term effects of different land use system viz Agriculture, Agri-horti-silvi-pastoral, Forestry, Live stock based land use, Natural fallow and Shifting cultivation were evaluated on the basis of soil physical and hydraulic properties. Bulk density increased with soil depth in all the systems, ranging from 0.94 to 1.23 Mg m<sup>-3</sup>. There was a significant increase (29.44 %) in soil structural index (MWD) and decrease in dispersion ratio (52.89 %) due to adoption of modified land use systems like Agri-horti-silvi-pastoral system over the shifting cultivation. Similarly, the transmission pores (<50 mm) were increased under different land use systems in the order of forestry>natural forest>livestock based> agri-horti-silvi-pastoral> agriculture> shifting cultivation. Soil water retention characteristics showed that at saturation stage, the water content (è<sub>s</sub>) in forestry system (54.63 %) was 23.29 per cent higher than that of shifting cultivated areas (44.31 %). In other systems i.e. agri-horti-silvi-pastoral, natural fallow, livestock based and agriculture systems, the è<sub>s</sub> were 12.4, 11.8 and 10.6 per cent higher, respectively, than shifting cultivation. The maximum available water content increased by 24.02 - 36.51 % under modified system over the shifting cultivation and decreased by 1.07 - 10.12 % over the natural fallow system. Significant increase in available water capacity under modified land use systems as compared to shifting cultivated areas may be attributed to the differences in quantity and nature of colloidal materials present, pore size distribution and organic carbon content.

#### Seasonal Soil Moisture Distribution Pattern under various land use systems

Effect of different land use systems on seasonal soil moisture distribution pattern were evaluated on the basis of gravimetric soil moisture content throughout the year. The field capacity and permanent wilting point of the farm area were analyzed by taking multi-location specific soil samples for comparing the water surplus and deficit



among the various land use systems. The soil moisture distribution pattern (Fig. 1) maximum moisture content of soil throughout the year was recorded in forestry and minimum in shifting cultivated areas. During rainy season particularly from the month of June to October, the moisture content was higher than the field capacity under all land use systems except in shifting cultivation system where, the moisture content above the field capacity was recorded during the peak rainy season i.e. July and August (Fig. 1). In shifting cultivation, the moisture content below the permanent wilting point was observed from November to March whereas in agri-horti-silvi-pastoral, agriculture, livestock based land use system, it was recorded from the month of December to February, because of the adoption of soil and water conservation measures. The moisture contents under forestry and natural fallow system never crossed the permanent wilting point which might have been attributed to high organic matter and improved soil physical properties.

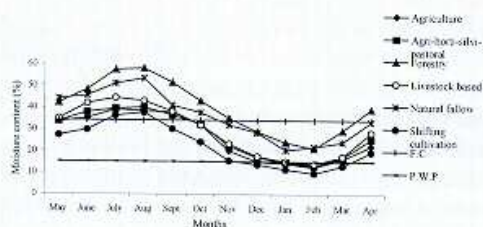


Fig. 1. Soil moisture distribution pattern under different land use systems

#### Effect of edible bamboo species on soil properties

Soil profile samples collected from eleven different locations of bamboo growing areas of Meghalaya and Manipur were analyzed to study the effect of edible bamboo species on soil properties. Highest increase in soil pH was in *Dendrocalamus giganteus* (0.49 units) followed by *D. hookeri* (0.26 units) when compared to their respective control values (3.85 and 4.60 respectively), whereas, in other sp. like *D. hamiltonii*, *B. pallida*, *D. longispathus*, *T. wightii* and *M. baciferra* the pH was decreased by 2.15, 0.68, 0.38, 0.21 and 0.17 units compared to the

respective control values (6.59, 4.72, 4.10, 3.98 and 4.85, respectively). Organic carbon increased in all the species of bamboo. Highest increase in available N content (126.5 kg/ha) was recorded in *B. multiplex* followed by *D. giganteus* (94 kg/ha). There was a reduction in available P content in almost all the species and maximum reduction (4.4 kg/ha) was in *D. hamiltonii*. Highest increase in available K was in *D. hookeri* (207 kg/ha). *D. giganteus*, *D. hookeri* and *B. nutans* were comparatively the better species of edible bamboo in restoring soil fertility whereas *D. hamiltonii* resulted in depletion of soil fertility.

#### Loss of soil fertility in watersheds

Silt samples were collected after heavy showers during July – September from 7 micro watersheds of Umroi maidan watershed and analyzed for fertility status. Maximum loss of fertility was under agriculture with bun system of cultivation where loss of organic carbon, available P, K and Ca + Mg through silt were 856, 62, 3.3 and 33 kg/ha, respectively. Agri-Horti Watersheds with soil conservation measures like half moon terracing + bench terracing recorded minimum loss of nutrient through run-off.

#### Chemical properties of soils under various farming systems

Soil samples from five different farming systems at three altitudes (bottom, middle and top) and at three depths (0-15, 15-30 and 30-60 cm) were analyzed for chemical properties (Table 8). The results revealed that the soil pH varied from 4.43 – 5.33 across all the farming systems irrespective of altitude and soil depth. Among the systems, lower pH was observed in forestry, while it was relatively higher in agriculture and natural fallow. Soil pH decreased with depth in all the systems. Highest organic carbon (1.84 %) was recorded in forestry followed by agriculture and livestock based farming system. However, available N was found highest in agriculture (263.3 kg/ha) followed by forestry and livestock based farming system. Higher available P (11.27 kg/ha) was recorded in forestry followed by agriculture (10.57 kg ha<sup>-1</sup>), whereas agriculture has recorded highest available K (211.4 kg/ha) followed by natural fallow (207.0 kg/ha) and livestock based system (196.5 kg/ha).



### Available sulphur and micronutrient status in farming systems

Surface and sub-surface soil samples were analyzed for available micronutrient status in various farming systems. Available S content was maximum in agriculture (12 ppm) and minimum (5.5 ppm) in natural fallow (Table 7). Exchangeable Al ranged between 0.41 to 1.36 me% with minimum in agriculture system. Available Zn ranged between 0.02 to 0.21 ppm and was below the critical limit (0.6 ppm) in almost all the systems. Available Fe, Mn and Cu were well above the critical limits (4.5, 2.0 and 0.2 ppm, respectively).

### Soil microbial biomass under different farming systems

Microbial biomass in the soils of different farming systems was estimated by chloroform

fumigation extraction method. Of all the systems, highest microbial biomass carbon (378.0 mg/kg) was observed in forestry irrespective of altitude and soil depth followed by agriculture (291.1 mg/kg) and natural fallow (239.7 mg/kg), while it was lowest (193.9 mg/kg) in livestock based system (Table 8). Highest microbial biomass N (15.41 mg/kg) was observed in forestry followed by agriculture (12.57 mg/kg) and natural fallow (11.36 mg/kg). It was observed that forestry has recorded highest microbial biomass P (10.73 mg/kg) followed by natural fallow (6.95 mg/kg) and agriculture (5.68 mg/kg). Highest microbial biomass in Forestry emphasized higher biological activity, which helped in transformation of various essential nutrients and their availability.

It was observed that organic C had highly significant relationship with MBC ( $r=0.50^{**}$ ) > MBP

Table 7: Effect of various farming systems on soil available micronutrient status (ppm)

Farming system	Exch. Al (me%)	S	Fe	Mn	Zn	Cu
Agriculture	0.41	12.0	10.27	4.26	0.12	0.30
Forestry	1.36	7.6	15.04	2.94	0.02	0.26
Live stock	1.05	8.1	16.01	3.13	0.18	0.30
Natural Fallow	0.78	5.5	14.91	5.53	0.05	0.38
Agri-Horti-Silvi-pastoral	0.85	8.9	18.35	5.99	0.21	0.57

Table 8: Effect of various farming systems on soil microbial properties

Farming system	pH	Org. C (%)	Available nutrient (kg/ha)			Microbial biomass (mg/kg)		
			N	P	K	MBC	MBN	MBP
<b>1. Agriculture</b>								
a. Bottom	4.96	1.52	263.3	11.87	186.3	229.3	12.17	7.58
b. Middle	4.82	1.44	248.7	10.68	216.5	304.5	15.82	5.69
c. Top	4.53	2.27	278.1	9.17	231.4	339.2	9.73	3.79
<b>2. Forestry</b>								
a. Bottom	4.53	1.87	265.5	12.35	191.7	401.6	17.03	9.46
b. Middle	4.78	1.89	257.1	11.41	153.6	405.9	17.03	13.26
c. Top	4.58	1.76	240.4	10.06	159.9	326.6	12.17	9.47
<b>3. Livestock</b>								
a. Bottom	4.80	1.76	253.0	9.32	204.0	191.7	10.95	3.78
b. Middle	4.55	1.63	240.4	9.05	165.0	235.6	10.95	9.48
c. Top	4.77	1.70	221.6	8.42	220.7	154.4	7.30	1.90
<b>4. Natural fallow</b>								
a. Bottom	4.50	1.73	227.9	12.62	226.6	302.3	11.03	7.58
b. Middle	4.79	1.22	217.4	7.95	141.4	287.6	15.82	7.58
c. Top	5.02	1.33	215.3	8.06	253.1	248.0	7.30	5.69
<b>5. Agri-horti-silvi-pastoral</b>								
a. Bottom	4.70	1.26	255.1	12.0	151.3	334.1	8.52	7.58
b. Middle	4.71	1.14	225.8	7.41	189.1	195.1	9.73	1.90
c. Top	4.79	1.30	221.6	7.52	189.3	164.1	7.30	3.79

MBC: Microbial biomass carbon; MBN: Microbial biomass nitrogen; MBP: Microbial biomass phosphorus



( $r=0.44^{**}$ ) > MBN ( $r=0.42^*$ ). MBC showed significantly positive relationship with MBP ( $r=0.65^{**}$ ) and MBN ( $r=0.61^{**}$ ). However, the MBC showed significant relationship with available P ( $r=0.61^{**}$ ) and available N ( $r=0.52^{**}$ ). Thus, the results indicated that microbial biomass had positive relations with available nutrients and it had direct impact on nutrient transformations as well as nutrient availability. Improvement in microbial biomass will not only help in enhancing the soil fertility but also for sustainable crop production.

#### Soil fertility status of various integrated farming systems in a degraded land

The physico-chemical properties of the soils in different integrated farming systems developed over degraded lands after 3 year of plantations were studied. Surface soil pH was relatively low at the beginning (ranged from 3.25 to 4.53) and it increased significantly after 3 years of plantation (4.34 -6.05), irrespective of farming systems. Similarly, the subsoil pH was also significantly improved with the plantations in the respective integrated farming systems. The mean organic carbon content declined marginally (1.03 - 1.69%) after 3 years of plantation over the initial status under various integrated farming systems. Among the systems, horti-silvi-pastoral cum aquaculture has recorded highest organic matter status followed by horti-silvi-pastoral-dairy cum aquaculture and agri-horti-silvi-pastoral-piggery cum aquaculture.

The available N content under various integrated farming systems was found to be 179.8-359.6 kg/ha, with a mean of 219.4 kg/ha. Among the systems, highest available N status was recorded in agri-horti-silvi-pastoral-piggery cum aquaculture and horti-silvi-pastoral-goatery cum aquaculture. The available P was found to be deficient at the initial and ranged from 5.94-9.85 kg/ha and a significant improvement was observed in all the farming systems, ranging from 7.22-11.35 kg/ha. The available K was found to be high in all the integrated farming systems at initial and decreased marginally in all the systems over 3 years period (316.1 - 378.1 kg/ha), however, as per the crop requirements, it was in optimum range. The mean exchangeable Ca in the farming systems at the initial and after 3 years ranged from 3.06 to 6.0 and 1.75 to 4.67 c mol (p<sup>+</sup>)/kg, respectively. The exchangeable Mg in all the

farming systems at the initial and after 3 years, ranged from 2.54 to 3.39 and 1.63 to 4.08 c mol (p<sup>+</sup>)/kg, respectively. Higher accumulation of Ca and Mg was observed in the surface soils across all the systems, while it was relatively lower in deeper layers. The study revealed that the fertility status of the degraded lands was considerably improved over a period of 3 years under various integrated farming systems due to accumulation/incorporation of biomass, crop stubbles, leaf litter and other agricultural wastes as well as forestry/horticultural species.

## IV. SOIL AND WATER RESOURCES

#### Soil Test Crop Response Correlation on Maize, Soybean and rice

Three field experiments were carried out for developing target yield equations for maize, soybean and rice to NPK fertilizers. The experimental soil of maize was *Ultic Hapludalf* with pH 4.75, organic carbon 1.83 per cent, exch.Ca + Mg 1.76 c mol (p<sup>+</sup>) kg<sup>-1</sup>, available N, P and K 477, 11.5 and 167 kg/ha respectively. Four fertility gradient strips were developed by growing maize var. RCM-1-1 as exhaustive crop with four graded dose of N, P and K i.e. N<sub>0</sub>P<sub>0</sub>K<sub>0</sub>, N<sub>1/2</sub>P<sub>1/2</sub>K<sub>1/2</sub>, N<sub>1</sub>P<sub>1</sub>K<sub>1</sub> and N<sub>2</sub>P<sub>2</sub>K<sub>2</sub> (NPK: 80, 60, 40 kg/ha respectively). The grain and straw yields in these four strips were 2.1, 10.4, 21.1, 35.1 and 9.6, 26.9, 41.3, 51.6 q/ha, respectively.

The experimental soil of soybean was *Ultic Hapludalf* with pH 4.96, organic carbon 1.62%, exch. Ca + Mg 1.97 c mol (p<sup>+</sup>) kg<sup>-1</sup>, available N, P and K 546, 12 and 317 kg/ha respectively. The grain and straw yield of exhaustive crop of maize in these fertility strips was recorded as 6.6, 9.8, 13.6, 20.7 and 15.2, 29.9, 32.0, 43.7 q/ha, respectively. Each of these four gradient strips were further divided into 20 plots after harvest of maize to develop target yield equations by growing soybean in the next season.

The experimental soil of rice was *Typic Haplaquent* soil with pH 4.2, organic carbon 1.84 %, exch.Ca+Mg 2.55 c mol (p<sup>+</sup>) kg<sup>-1</sup> and available



N, P and K were 674, 11 and 321 kg/ha respectively. Four fertility gradient strips were developed by growing rice var. Shah Sarang -I as exhaustive crop. The grain and straw yield in  $N_0P_0K_0$ ,  $N_{1/2}P_{1/2}K_{1/2}$ ,  $N_1P_1K_1$  and  $N_2P_2K_2$  strips were 24.8, 26.8, 30.7, 36.3 and 25.6, 28.8, 37.9, 40.7 q/ha, respectively. These strips after harvest of paddy were sub-divided into 30 plots for growing rice and to develop target yield equations.

#### Effect of P levels and lime on available micronutrient status

Effect of P levels (0, 30, 60 and 90 kg  $P_2O_5$ /ha) and lime (0, 0.25 LR, 0.5 LR and 1.0 LR) on available micronutrient status were studied in Alfisol and Entisol of Meghalaya under laboratory incubation. Liming decreased the available Fe, Mn, Zn and Cu in both Entisol and Alfisols. The extent of decrease due to liming @ 1.0 LR was 59.5, 27.7, 27.7 and 18.4 per cent in Entisol for available Fe, Mn, Zn and Cu, respectively whereas it was 27.5, 31.1, 16.1 and 0.0 in Alfisol. Available B was increased at 1.0 LR level in both Alfisol and Entisol by 16.4 and 27.0 %, respectively. Increasing P levels had no effect on soil available micronutrients.

#### Break through Curves of N concentration vs pore volume under various water management practices

A column study was carried out to evaluate the movement and distribution of N through undisturbed soil profile under continuous and intermittent flooded condition. The break-through curves (BTC), which is the standard form of presenting the concentration changes of the solute in the effluent from a soil column shows different peaks for different forms of N i.e.  $NH_4^+$ -N,  $NO_3^-$ -N and urea- N. Significant difference between the BTC's under continuous and intermittent flooding treatments was the relative concentration of  $NO_3^-$ -N. Significantly higher concentration of  $NO_3^-$ -N particularly at higher pore volumes under intermittent flood condition could be because of the higher mineralization rate under aerobic condition of intermittent watering with wetting and drying intervals.

Mathematical equations like power function, Semilog and Elovich equations were tested for predicting leaching of N in different forms under

both the water management practices. It was found that Elovich equation could effectively describe leaching of N under both these conditions.

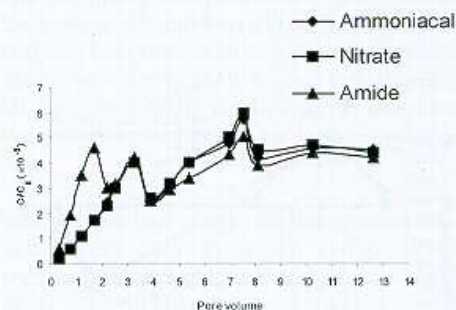


Fig. 1. Breakthrough curves of different forms of N under continuous flooding

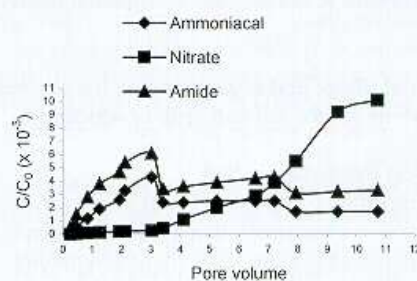


Fig. 2. Breakthrough curves of different forms of N under intermittent flooding

## WATER MANAGEMENT

### Profile soil moisture distribution pattern of Meghalaya

The soil moisture content at surface and subsurface was higher than the field capacity during the period of June to October. The surface soil (0-15cm) moisture status was lower than the permanent wilting point and subsurface (below 15 cm) soil moisture status was in between the permanent wilting point and field capacity during the period of December to March (Fig.1). It indicated that proper drainage within rhizosphere is required



during June to October for aerobic crop production like vegetables, ginger, turmeric maize etc and life saving irrigation is needed during December to March for winter crops cultivation. Deep rooted (>15 cm) crops are other options during the stress period.

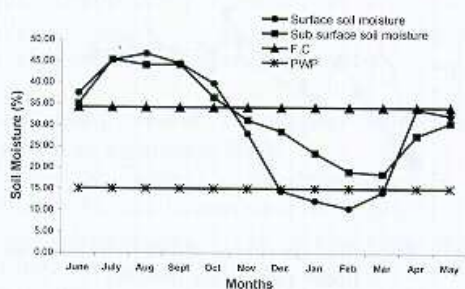


Fig. 1. Profile of soil moisture distribution pattern

### Effect of tillage and organics on hydro physical behaviour of rice soil and crop production

#### Physical Properties of Soil

Continuous puddling brought significant reduction in water transmission behaviour over the zero tillage. Maximum (20.2 cm/h) and minimum (8.8 cm/h) infiltration rate was recorded under zero tillage and power tiller tilled plots, respectively. The infiltration rate under deshi plough and manually tilled plots was recorded 13.6 and 16.4 cm/h, respectively. Maximum reduction (33.9%) in hydraulic conductivity was recorded in power tiller over the zero tillage plots. Among the organics applied @ 10t/ha., maximum build up of organic carbon content was recorded in FYM treated plots (2.28%) followed by *jungal* grass (2.16%) and *Ambrossia* (2.10%). The application of organics in the soil reduced the bulk density from 16.7 to 27.8%, increased the infiltration rate from 39.2 to 44.6% and hydraulic conductivity from 9.7 to 28.8% over the plots where no organics were applied.

#### Rice Grain and Straw Yields

During fifth year, continuous puddling decreased the grain and straw yield in comparison to zero

tillage. Maximum (36.7 q/ha) grain yield was recorded in zero tillage followed by 33.5, 33.1 and 31.5 q/ha in manual, power tiller and deshi plough tilled plots, respectively. Application of organics showed significant impact in enhancing grain and straw yield. Maximum grain yield was recorded in FYM treated plots, which remained at par with the application of *jungal* grass or *Ambrossia*.

### Effect of different bun systems on soil health and crop productivity

#### Ginger Rhizome Yield

Raised bed method (*Bun* method) of cultivation significantly increased ginger rhizome yield over the flat system. The maximum ginger yield (309.2 q/ha) was recorded in FYM-bun followed by alternate year close burnt bun and grass bun (288.4 q/ha), grass bun (271.2 q/ha), close burnt bun (208 q/ha), ridge (154.3 q/ha) and flat (94.3 q/ha). Yearly burning either through close system or open system significantly reduced the ginger yield in comparison to FYM and grass bun, whereas the alternate year burning and grass bun systems produced more yield than continuous grass bun system. It may attributed to better soil physical and chemical environment of soil. The lowest ginger rhizome yield (94.2 q/ha) was recorded in flat bed system which might be due to the high soil moisture status during growth period.

The availability of nutrients like  $P_2O_5$ ,  $K_2O$  and organic carbon increased from 8.0 to 17.9 kg/ha, 182.4 to 320.6 and 1.20 to 2.11 per cent under bun system over the initial status except under open bun system. Bulk density of soil reduced from 1.09 to 0.84 and mean weight diameter (MWD) increased from 1.24 to 3.36 mm under bun systems. The improvement in physical behaviour of soil probably created better anaerobic conditions during high rainfall (June to September) resulting in better crop yield in comparison to flat system.

### Effect of conservation tillage, lime and crop residue on soil and crop productivity

Combined application of crop residue, lime and 75% chemical fertilizer as NPK was most effective for producing maximum maize grain yield at both the zonal and conventional tillage method. The



maize grain yield under 50% NPK + crop residue + lime was almost equal with the yield 100% NPK treated plot. The residual effect of lime and crop residue also increased urd yield over control and chemical fertilizers alone. Maximum urd grain yield (6.43 q/ha) was obtained in plots with 75 % NPK + lime + crop residue. The enhancement in organic carbon and moisture status were recorded under different treatments. The organic carbon content ranged from 1.14 to 1.30% and 1.07 to 1.26% under zonal and conventional tillage method, respectively. The profile soil moisture status under different treatment combination ranged from 30.3 to 41.7 cm/90 cm in zonal tillage and 26.4 to 36.2 cm/90 cm in conventional tillage.

#### **Effect of soil moisture regimes and nutrient interaction on soil – plant – water relationship.**

Raised beds without bunds significantly increased the grain and straw yield of maize over the other moisture regimes i.e. banded plots and flat beds. Raised bed system had the maximum grain (mean 44.9 q/ha) and straw yield (mean 31.4q/ha). Plots with 30 cm side bunds, produced the lowest grain and straw yields 32.7 and 23.2 q/ha, respectively. The soil moisture contents varied from 27.7 to 35.7 and 28.7 to 35.8 per cent in raised beds whereas in banded plots, it fluctuated between 28.6 and 36.0 and 31.4 to 39.4 per cent at 0- 15 cm and 15- 30 cm soil depth, respectively.

#### **Effect of raised : sunken bed system (RSB) on rice and French bean production**

Experiment was conducted to conserve inter plot rain water and their effect on rice and French bean production. The French bean was grown on raised beds and rice was transplanted in sunken beds. The sunken beds remained flooded with water up to 90 - 100 days after transplanting. The average submergence depth in sunken plots varied from 1.1 to 4.24 cm. Among different ratio RSB, highest grain yield (39.4 q/ha) was recorded in 1:2.5 R.S.B ratio. The rice grain yield under 1:1 width ratio of R.S.B was lower than the control plots. The rice yield under the ratio of 1:1.5, 1:2, 1:2.5, 1:3 and 1:3.5 width ratio were 10.5, 14.4, 25.9, 25.6, 19.8 per cent higher than control plot.

The moisture content in R.S.B. during 20 to 90 DAS at 0-15 cm soil depth varied from 29.4 to 35.3 per cent and 26.4 per cent in control. The results

also showed that the difference in moisture content between control and raised bed narrowed with increased ratio of R.S.B. The green pod yield of french bean was significantly lower in R.S.B. system except in 1:3.5 ratio where the yield was statistically at par with the yield of the control plot. Relatively lower soil moisture content in control plots due to no ponding of water between two raised beds facilitated better aeration in the root zone which might be responsible for higher green pod yields.

#### **Effect of panikheti system on rice production**

The method of irrigation and nutrients significantly influenced the rice and straw yield. Among the irrigation level maximum rice yield (26.2 q/ha) was recorded in intermitant irrigation system followed by Panikheti (24.1 q/ha) i.e. continuous flow of water from the plot and rainfed system (22.4 q/ha). The application of neem coated urea with P and K also showed significant increase in rice grain yield over the 100% NPK and control plots. The response of neem coated urea was more effective for crop production in comparison to direct application of urea in the plots in *panikheti*.

#### **Standardization of pit size of *Jal Kund*, anti-evaporates of storage of rain water and recycling for high value crops**

At upper ridges of hills, the availability of water is one of the major constraints. Under this situation the *jalkund* method of rainwater harvesting (micro tank) have been found very useful in providing life saving irrigation and cost effective at upper ridges. The estimated cost per litre of stored water in the *Jalkund* was Re. 0.14, which may further decrease on long-term basis. The maximum water productivity (Rs. 155/ m<sup>3</sup> water) was recorded when frequency and amount of irrigation to tomato plant was 1 lit/ day. The suitable size of the *jalkund* under sloppy and high rainfall areas was 12,000 to 30,000 litres water capacity for long duration management. Thus, this type of low cost and need-based water harvesting structure may provide new livelihood options for the resource poor farmers in the region.

The technology was demonstrated at 4 farmers field in two villages of Ri-Bhoi and Nongpoh district of Meghalaya on participatory mode. The capacity of *jalkund* was 20,000 to 30000 litres water. Out of four farmers, two farmers used the water for



kitchen gardening and another two farmers gave the preference for pig, goat and poultry management where water was used for irrigation by siphoning during stress period. About 400 m<sup>2</sup> area of kitchen garden having crops like cabbage, cauliflower, carrot, radish, bean, pea, tomato etc

## V. AGROFORESTRY

### Intensive Integrated Farming System (IIFS) for Sustainable Land Use in Eastern Himalayas

Crop productivity in different IIFS models has been evaluated and shown in Table 1. In all six systems were evaluated for their productive potential. All the systems have been found productive. The crop productivity was comparable in all the systems, however fish productivity was found highest in cattle-fish integration followed by duck-fish integration.

### Rehabilitation of marshy lands for IIFS

Out of 10 ha of the experimental site, 3.31 ha was marshy where cultivation of crops was not

possible. To rehabilitate such land, six nos. of earthen water harvesting structures were created over 0.71 ha area and 2.6 ha of land have been brought under cultivation of various crops/vegetables/medicinal herbs etc. Cost of water harvesting, conservation and recycling has been shown in Table 2.

### Growth performance of livestock/birds in IIFS

Data on growth performance of different categories of livestock/birds have been collected and compared with traditional animal husbandry practices. The data indicated that the growth of pig and goat was higher in IIFS (0.342 and 0.035 kg/day, respectively, to pig and goat) compared to traditional farming system where the growth of pig and goat was 0.248 and 0.0312 kg/day, respectively. The average slaughtering weight of pig and goat was recorded as 123.12 and 25.20 kg in IIFS and 89.28 and 22.46 kg in traditional animal husbandry practice.

Ducks (Indian runner) also showed better growth rate in IIFS (0.00387 kg/day) compared to traditional farming system (0.00318 kg/day). The average slaughtering weight of ducks was recorded

Table 1: Total productivity of different IIFS

Sl. No.	IIFS	Area (ha)	Productivity/yr
1	Chicken-crop-fish-duck-horticulture alongwith hedgerow on contour bunds.	1.05	Paddy- 25.9q; Paddy straw- 34.2q; Finger millet- 1.6q; Straw- 8.07q; Mustard- 2.27q; Potato- 36.5q; Tomato- 4.6q; Knol-khol- 3.64q; Radish- 9.2 q; Hedgerow biomass- 11.6q; Duck egg- 3410 nos.; Duck meat- 1.21 q*; Dressed-chicken- 15.12q; Green fodder from the bunds- 35.2q; Fish-2.53q; Crop residue and weed biomass- 104.2 q.
2	Crop-fish-poultry-multipurpose trees	0.97	Upland paddy- 13.6q; Paddy straw- 21.4q; Rice bean- 0.43q; Buckwheat-3.8q; Potato-28.5q; Green fodder from bund grass- 25.0q; Egg- 5320 nos.; Dressed-chicken- 0.82q*; Fish- 1.80q; Crop residue and weed biomass- 84.2 q.
3	Crop-fish-goat-multipurpose trees	1.04	Upland paddy- 9.04q; Paddy straw- 14.3q; Ginger-36.06q; Turmeric- 30.92q; Mustard- 2.27q; Tomato- 22.8q; Radish-11.5q; Green fodder-23.8q; Meat-0.35q; Fish-1.06q; Crop residue and weed biomass- 91q.
4	Crop-fish-pig-vermicompost-bamboo-multipurpose trees-hedgerow-broom	1.04	Upland paddy- 8.85q; Paddy straw- 12.5q; Colocasia-17.0q; Maize-9.4q; Brinjal- 3.9q; Radish-5.7q; Potato- 34.2q; Buckwheat- 1.1q; Meat- 1.95q; Fish- 1.68q; Hedgerow biomass-3.6q; Green fodder from bunds- 12.8q; Vermicompost- 11.6q; Broom-0.94q and Broom fodder-1.79q; Crop residue and weed biomass 98q.
5	Crop-fish-dairy-mushroom-vermicompost-horticulture-hedgerow	1.17	Upland paddy- 18.07q; Paddy straw- 28.5q; Green fodder from bunds- 52.5q; Fodder from jobs' tear- 5.6q; Liquid manure-16293 litres; FYM- 90.60q; Mushroom-12.5q; Vermicompost- 5.4q; Milk- 3132 litres; Hedgerow biomass-14.8q; Green fodder from bunds- 63.75q; Fish-2.43q; Crop residue and weed biomass 74 q.
6	Crop-fish without integration (control)	0.95	Upland paddy- 9.6q; Paddy straw- 15.2q; Maize- 7.5q; French bean-21.4q; Fish- 0.7q; Green fodder from bund grass-30.0q; Crop residue and weed biomass 34.2q





Fig. 1. Upland paddy with Khasi mandarin in IIFS.



Fig. 2. Mushroom cultivation in IIFS



Fig. 3. Recycling of farm waste for vermicompost.



Fig. 4. Separation of worms from vermicompost



Fig. 5. Hedgerow cultivation along contour bunds (left) and crop cultivation in the interspace.



Fig. 6. Duck-fish integration in IIFS



Fig. 7. Pig-fish integration in IIFS



Fig. 8. Cattle-fish integration in IIFS



**Table 2: Cost of water harvesting structures and water recycling**

Sl. No.	Units	Cost involved (Rs.)	Water conservation (m <sup>3</sup> /pond)	Cost of water conservation (Rs/m <sup>3</sup> )	Water recycling (m <sup>3</sup> ) under IIFS
1	Water harvesting structure I	28,800.00	1000m <sup>3</sup>	28.8	Vegetables- 70m <sup>3</sup> Fruit trees- 5.3 m <sup>3</sup> Fishery- 924.7m <sup>3</sup>
2	Water harvesting structure II	50,100.00	1800m <sup>3</sup>	27.83	Vegetables- 83 m <sup>3</sup> Duckery- 37 m <sup>3</sup> MPTs- 4.5 m <sup>3</sup> Fishery- 1675.5 m <sup>3</sup>
3	Water harvesting structure III	36,920.00	1200m <sup>3</sup>	30.76	Vegetables- 67.5 m <sup>3</sup> Poultry- 126.0 m <sup>3</sup> MPTs- 3.2 m <sup>3</sup> Fishery- 1003.3 m <sup>3</sup>
4	Water harvesting structure IV	50,600.00	1300m <sup>3</sup>	38.92	Vegetables- 89.5 m <sup>3</sup> Goat- 36.0 m <sup>3</sup> MPTs- 4.5 m <sup>3</sup> Fishery- 1170.0 m <sup>3</sup>
5	Water harvesting structure V	46,040.00	1320m <sup>3</sup>	34.88	Vegetables- 76.5 m <sup>3</sup> Pig- 54.0 m <sup>3</sup> Fruit trees- 3.4 m <sup>3</sup> Vermiculture- 63.1 m <sup>3</sup> Fishery- 1123.0 m <sup>3</sup>
6	Water harvesting structure VI	46,600.00	1440m <sup>3</sup>	32.36	Vegetables- 56.4 m <sup>3</sup> Cattle- 108.0 m <sup>3</sup> Mushroom- 81.0 m <sup>3</sup> Vermiculture- 25.2 m <sup>3</sup> Fishery- 1169.4 m <sup>3</sup>
<b>Average</b>				<b>32.26</b>	

The average water harvesting cost was estimated to be Rs. 0.03/litre of water in I<sup>st</sup> yr and II<sup>nd</sup> yr onwards, there was no financial involvement for water conservation.

as 2.79 kg in IIFS and 2.29 kg in traditional practices. Khaki Campbell ducks were also reared in IIFS, which showed the average growth rate of 0.00402 kg/day with an average of 2.89 kg/duck at the time of slaughtering, i.e., after 2 years.

Broiler chicken and layer birds have also been reared for integrated fish farming in IIFS. The growth rate of broiler chicken and layer birds was recorded to be 0.0404 and 0.00312 kg/day with average slaughtering weight of 1.69 and 2.25 kg, respectively. The broiler chicken was slaughtered at 6 weeks of age and layer birds were slaughtered after 2 years of age.

#### Organic base of IIFS

In various IIFS, duck, layer birds, broiler chicken, pig, goat and cow were reared. Total manure/dropping production has been recorded. On

an average, the dung production was highest (90.60 q) through cattle and lowest (3.30 q) through goats (Table 3). The data indicated that a total of 156.28 q of manure was produced by different livestock/birds, reared in the IIFS. A total of 33.72 q (dry weight basis) was used for integrated fish farming and rest (122.56 q) of the manure could be recycled into the system for cultivation of various agricultural crops. On an average, 3.2, 0.75, 1.18, 2.09 and 2.00 kg/day of cow dung, goat manure, pig dung, duck droppings and poultry droppings was added in fish ponds. Besides these manures, about 120 q of crop residue/weed biomass (70.2 q on dry weight basis) was recycled for vermicompost over the year. From 70.2 q of biomass, 24.3 q of vermicompost was obtained per annum. Thus, a total of 180.6 q of organic manure was obtained per annum from IIFS which was sufficient to cultivate about 15 ha of agricultural land.



**Table 3: Manure production through various livestock/birds in IIFS**

Sl. No.	Animal/ birds	Livestock/ birds reared (nos./yr)	Total dung/ dropping production (F.W. basis-q)	Total dung/ dropping production (D.W. basis-q)
1	Cow	02 milching cow and 02 calves	186.15±5.23	90.60±3.56 (19.5m <sup>3</sup> of liquid manure)
2	Goat	06	4.25±0.23	3.30±0.29
3	Pig	02	10.95±0.67	7.42±0.58
4	Duck	72	34.70±1.10	7.65±0.92
5	Poultry (layer birds)	52	27.52±0.85	17.50±0.45
6	Broiler chicken	1200 (200 per batch)	61.25±1.32 (per batch 360.0 kg of poultry manure and 658.0 kg of sawdust)	29.81±0.78
	<b>Total</b>		<b>324.82</b>	<b>156.28</b>

#### Vermiculture

In an experiment conducted in IIFS, different source of materials were tested for vermicomposting by releasing 2000 worms/m<sup>2</sup> biomass. It has been observed that 50 to 80 days were required for composting of various materials. While *Ambrosia artemissifolia* took lowest period (52 days) for composting, foliage of *Erythrina indica* took maximum time (80 days) for the same. The multiplication of worms also varied. Maximum worms were obtained from spent spawn of mushroom, i.e., 4450 and lowest (2950) in maize straw (Table 4). The nutrient content in

vermicompost varied based on the material used as evidenced from Table 5. The conversion efficiency of the worms could also be manipulated by increasing their stocking density.

**Table 4: Conversion efficiency of different biomass used for vermicomposting**

Source of material	Quantity of bio-mass used including cow dung (D.W. basis)	No. of worms obtained after vermin-composting	Days required to make the vermin-compost	Quantity of vermin-compost produced (kg)
Common weeds	250.0	4000	65	100.0
Foliage of <i>Erythrina indica</i>	61.5	3527	80	18.0
<i>Ambrosia artemissifolia</i>	97.3	3000	52	27.0
Maize	130.0	2950	80	27.7
Spent spawn of mushroom	90.0	4450	60	45.0

\*The experiment was conducted in 1 X 1 X 0.6 m sized pits. Worms were released in the month of September in each pit, and fresh cow dung was used @ 65 kg/pit having 48% dry matter content.

#### Economics of the vermiculture unit

Establishment and production cost of the small unit with bamboo thatched shed of 12 Ft X 6 Ft X 2 Ft has been worked out. On an average, farmers could earn a net benefit of Rs. 16,227/- through vermicompost. If family labour is engaged for the work, the net return could increase up to 23,427/- from the unit of same size (Table 6).

**Table 5: Proximate analysis of various materials used for vermicomposting**

Source of material	DM%	M%	N%	P%	K%	Ca	Mg
Common weeds	51.3	48.6	2.11±0.386	0.94±0.097	1.32±0.016	1.25±0.016	4.72±0.024
Erythrina leaves	40.4	59.4	2.47±0.04	0.82±0.179	1.35±0.016	0.52±0.041	1.7±0.163
Ambrosia	40.3	59.6	3.22±0.032	0.3±0.163	1.83±0.016	2.03±0.0244	7.75±0.082
Maize	46.2	53.8	2.82±0.024	1.2±0.163	1.54±0.041	1.5±0.0244	3.25±0.024
Spent spawn of mushroom	41.7	58.3	3.36±0.057	1.0±0.245	1.59±0.089	2.5±0.0244	8.75±0.057
Mean	44	56	2.8	1.05	1.53	1.56	5.23

**Table 6: Economics of the Vermiculture Unit**

S. No	Materials	Quantity	Cost (Rs.)
<b>Establishment cost</b>			
1.	Bamboo culms	35	1,400
2.	Binding wire	5 kg	240
3.	Thatched grass	180 bundles	1,800
4.	Beds construction with bricks (R.R 1:6) complete		4,910
5.	Labour cost of collection of crop residue/weeds, chopping, collection of compost, collection of worms and their maintenance etc.		7,200
6.	Bags, sieve, basins etc.		500
7.	Transportation and Miscellaneous costs		1,000
8.	Earthworms @ 2000/m <sup>2</sup>		13,223
<b>Total expenditure</b>			<b>30,273</b>
<b>Production</b>			
9.	Vermicompost – Minimum 50 kg/m <sup>2</sup> /two months- Price @ Rs.10/- per kg	992	9,920
10.	Earthworms- Minimum three multiplications/yr (doubling the worms in every four months, i.e., 85784) (13223 worms are required/6.6 m <sup>2</sup> for maintenance) 72000 worms are available for sale @ Rs. 0.50 per worm		36,000
11.	<b>Gross return</b>		<b>46,500</b>
12.	<b>Net return/yr</b>		<b>16,227</b>

**Nutrient content in organic manures**

Different sources of manure available in IIFS were analyzed for nutrient contents. Among various sources of nutrients, goat manure showed maximum nitrogen content followed by vermicompost. Potassium content was recorded highest in vermicompost followed by farmyard manure. Poultry manure exhibited highest phosphorus content followed by pig manure. Farmyard manure also exhibited highest amount of calcium and magnesium. Pig and poultry manure ranked after farmyard manure in calcium and magnesium, respectively (Table 7).

**Table 7: Nutrient content (± S.D.) in some important organic manures**

Source	N (%)	K (%)	P (%)	Ca (%)	Mg (%)
Poultry manure	2.12±0.05	1.16±0.05	1.40±0.02	2.32±0.16	2.45±0.25
Farmyard manure	0.65±0.05	0.50±0.08	0.18±0.02	3.82±0.33	3.96±0.02
Goat manure	1.16±0.22	1.09±0.09	0.40±0.04	3.20±0.25	3.65±0.25
Vermi-compost	2.15±0.50	0.95±0.07	0.55±0.06	4.15±0.24	3.60±0.33
Pig manure	0.50±0.27	0.28±0.02	0.35±0.05	2.15±0.33	2.85±0.24
Liquid manure	0.56±0.03	0.18±0.04	0.45±0.01	0.10±0.00	20.07±0.01
Cow dung	0.81±0.08	0.75±0.08	0.52±0.02	2.46±0.23	2.77±0.12
Duck manure	1.85±0.10	0.98±0.07	1.46±0.11	1.99±0.22	2.22±0.23

**Monetary Input/output**

The monetary input has also been calculated for each subsystem. Crop-fish-dairy-mushroom-vermicompost-horticulture IIFS has maximum input in terms of currency, followed by chicken-crop-fish-duck-horticulture IIFS. On an average, the monetary input was highest for labour component required for agricultural operations, followed by concentrate feed. These two components required almost 50% of total inputs in all the IIFS. Labour input for livestock rearing was hardly 2-3% of the total input. Monetary input was 3-4 fold higher for integrated systems compared to control. The monetary output was highest to crop-fish-dairy-mushroom-vermicompost-horticulture IIFS, followed by chicken-crop-fish-duck-horticulture integrated system. Meat contributed highest (46.6%) in case of chicken-crop-fish-duck-horticulture, followed by crop-fish-pig-bamboo-multipurpose tree species-vermicompost (15.9%). In chicken-crop-fish-duck-horticulture, broiler chicken added significantly to monetary output through meat. On an average, there was net profit of 12.0-15.0 rupees/bird after rearing for six weeks. Monetary income through egg production was recorded 15.5% of total monetary output in case of crop-fish-poultry-multipurpose tree species.

Monetary output through crops ranged from 8.6 to 15.6% under different types of integration. In case of crop-fish-dairy-mushroom-vermicompost-horticulture IIFS, monetary output was highest (68.7%) through milk, followed by cow dung (9.4%) and fish (8.6%). Liquid manure (prepared



by collecting the cow urine and decomposing it in small cemented tanks for six weeks) contributed 3.1% to total monetary output.

The total output/input ratio was highest (1.76) to crop-fish-dairy-mushroom-vermicompost-horticulture, followed by chicken-crop-fish-duck-horticulture (1.58), crop-fish-goat-multipurpose tree species (1.55), crop-fish-layer birds-multipurpose tree species (1.51), crop-fish-pig-bamboo-vermiculture (1.42) compared to control (without integration) where the output/input ratio was 1.10. The monetary output/input could further increase if family labour is engaged for adopting IIFS. However, crop-fish-dairy-mushroom-vermicompost-horticulture ranked first even after deducting the cost of labour component, i.e., output/input ratio of 2.24 (Table 8).

**Table 8: Monetary input/output pattern (Rs/yr) of IIFS, Meghalaya, NEH, India**

IIFS	Total input	Total output	Output/ input ratio (including labour component)	Output/ input ratio (excluding labour component)
Chicken-crop-fish-duck-horticulture-hedge row	1,05,722.0	1,67,331.0	1.58	2.24
Crop-fish-poultry-MPTs	60,137.0	90,625.0	1.51	2.12
Crop-fish-goat-bamboo-MPTs	59,442.0	91,880.0	1.55	2.40
Crop-fish-pig-hedge row-MPTs-vermiculture	77,243.0	1,09,887.0	1.42	1.86
Crop-fish-dairy-mushroom-liquid manure-broom-horticulture-vermiculture	1,70,120.0	2,98,735.0	1.76	2.38
Crop and fishery (without integration)	31,773.0	34,894.0	1.09	1.50

\*Input includes cost of labour, seed/planting material, concentrate feed, fish fingerlings, livestock/birds, farmyard manure, pond preparation, shed for livestock/birds and electricity charges. Output includes cost of egg, meat, milk, dung, fish, farmyard manure, liquid manure, crops, crop byproduct and green fodder.

### Productivity of shade loving crops under different MPTs

Studies on performance of shade loving crops (ginger and turmeric) under different MPTs in arboratum block showed that maximum turmeric yield was recorded under the canopy of *Parkia roxburghii* (15.4 t/ha) followed by *Alnus nepalensis* (14.6 t/ha). Similarly, maximum yield of ginger was recorded under *A. nepalensis* (9.9 t/ha), followed by *P. roxburghii* (9.8 t/ha). Comparison of growth of MPTs showed that, *P. roxburghii* attained the maximum height and diameter at breast height (24.99m, 27.95cm), followed by *Michelia oblonga* (23.88m, 27.45cm), *A. nepalensis* (19.77m, 26.81), *Gmelina arborea* (18.95m, 31.52cm) and *Prunus cerasoides* (13.43m, 21.20cm).

### Productivity of maize varieties as intercrop under different fruit tree species

Three maize varieties RCM-1-1, RCM-1-3 and Vijay composite were cultivated as intercrop in an existing fruit plantation (400 plants/ha) of guava (cv Allahabad safeda), Assam lemon and Peach (cv. TA 170). The maximum height, collar diameter and crown spread were recorded for peach, followed by guava and Assam lemon. Fruit yields of 52.2, 25.7 and 55.8 q/ha were recorded for peach, Assam lemon and guava, respectively. Average grain yield of all the three maize varieties were recorded higher in control plots (without tree – 34 – 35 q/ha) than in understorey fruit trees (26 – 32 q/ha). On an average, RCM-1-1 exhibited maximum grain yield as well as plant height in association of fruit trees compared to other maize varieties (29 – 32 q/ha).

### Evaluation of aquaculture agroforestry system

The aquaculture based farming system was undertaken in an area of 1650m<sup>2</sup> allocated to different components of the system. Rice variety RCPL-1-87-8 was cultivated in low land (500m<sup>2</sup>) adjacent to fishpond (525 m<sup>2</sup>). Brinjal (*khariif*) and cabbage (*rabi*) was cultivated in hutment area and Chilli (*khariif*), pumpkin (*khariif*) and french bean (*rabi*) in pond embankments as intercrop with peach. Composite fish culture with a species composition of rohu (*Labeo rohita*) 20%, catla (*Catla catla*) 20%, silver carp (*Hypophthalmichthys molitrix*) 10%, grass carp (*Ctenopharyngodon idella*) 15%, Japanese pundi (*Puntius japonicus*) 15% and



Kalabasu (*Liabeo calbasu*) 15% were reared in the pond at a stocking density of 6000 fingerlings /ha. The yield of different components of aquaculture based integrated farming system are presented in **Table 9**.

Among the fish species, highest growth parameters and productivity was recorded with silver carp. In terms of productivity Japanese pundi and kalabasu were also found promising. The total productivity of fish from the pond was 67 kg after 12 months of stocking.

**Table 9: Component wise productivity of agro aquaculture agroforestry system**

Component	Area under crop (m <sup>2</sup> )	Crops	Economic yield (Kg/ unit area)	Income/ unit area (Rs.)
Hutment area (400m <sup>2</sup> )	150	Farm shed	-	-
	250	Brinjal	186	930
		Cabbage	154	1232
Pond embankments	225	Chilli	25	500
		Pumpkin	201	1005
		French bean	75	750
		Peach	82	656
Fish pond	525	fish culture	67	4020
Low land area	500	Rice	196	980
		Cauliflower	59	590
		Carrot	47	470
		Teeta champ	-	-

Total income (Rs) from 1650 m<sup>2</sup> farm area = **Rs. 11,133.00**

#### Evaluation of multi-storied AFS

Studies were initiated on performance of multi-storied systems with its different components viz. alder, tea, black pepper and turmeric. The black pepper was allowed to grow on alder tree and turmeric was intercropped between two rows of tea across the hill slope (20 to 28%). Light intensity patten of the system showed that 40% light is available to the understorey crops and 60% light reflected by the tree. Tea flourished well in the shade of alder due to its favorable microclimate. The turmeric, Black pepper (dried), and tea (Fresh buds) gave the average yield of 16.25 t/ha, 165 g/plant and 6.0 t/ha respectively. On the basis of present findings, this system was found productive in terms of economic returns and also enriched the soil, as

the entire pruned biomass of tea as well as other crops residues were incorporated into the soil. The average height, diameter at breast height, crown spread and timber volume was recorded 25.17m, 26.90cm, 7.15m and 203.78/ ha (0.51/ tree), respectively.

#### Studies on silvi-horti-pastoral systems

Under this system, pineapple (var. Kew) was cultivated beneath the canopy of silver oak (*Grevillea robusta*) and som (*Machilus bombicina*) trees planed on the contour bunds across the steep slop (25-30%) with 50 x 80 cm spacing. Pineapple productivity was recorded highest in the understorey of *G. robusta*. On terrace risers, congo and guinea grasses were cultivated. After ninth year of plantation, *G. robusta* attained an average height and dbh of 11.88 m and 12.68 cm, respectively. Similarly, *M. bombicina* attained 12.30 m height and 18.72 cm dbh. The average productivity of congo and guinea grass was 25.9 and 27.5 t/ha.

## ARUNACHAL PRADESH

#### Evaluation of multipurpose trees (MPT's):

In the arboretum, out of 51 MPT species, during 1997-2001, 50 species established. Among 16 tree species established in 1997, *Pinus kesiya* attained maximum basal girth (666 cm) and canopy spread (6.28 cm x 5.96 cm) after seven year of planting. Highest plant height was recorded in *Ixonanthus khasiana* (8.72 m) followed by *Anthocephalus cadamba* (8.52) and *Michelia obtusifolia* (8.26). Chlorophyll content was found maximum in *Jacaranda mimosaeifolia* followed by *Ixonanthus khasiana* and *Mesua ferrea*. Highest light intensity in inter rows was recorded in *Livistonia jenkinsiana* (2,47,833 lux) followed by *Phoebe goalparensis*, *Kapur*, *Jacaranda mimosaeifolia* and *Gmelina arborea* and lowest in *Ixonanthus khasiana* (5000 lux). Among the 20 tree species planted in 1998, *Acacia mangium* attained maximum plant height (11.40 m), basal girth (78 cm) and maximum canopy spread (5.62 cm x 6.36) and lowest in *Taxus baccata*. Chlorophyll content was recorded highest in *Syningtonia populnea* followed by *Grevillea robusta* and *Pinus wallichiana*. Highest inter spacing light intensity was found in *Trema orientalis*



(1,53,550 lux) followed by *Bombax ceiba*, *Lagerstroemia speciosa*, *Bischofia javanica* and least in Penlow followed by *Machilus bombycina*, *Syzygium cuminii*, and *Pinus wallichiana*. Among six species established in 1999, *Aleurites montana* attained maximum plant height (8.05 m), basal girth (53.4 cm), breast girth (45 cm) canopy spread (4.06 x 4.36 cm) followed by *Manglietia insignis* and *Parkia roxburghii* during 2004. *Parkia roxburghii* contained maximum chlorophyll content followed by *Embllica officinalis* and *Papulaluk*. *Aleurites montana* showed maximum interspacing light intensity (1,35,284 lux) followed by *Engelhardtia spicata*, *Bauhinia purpurea*, *Manglietia insignis* and *Parkia roxburghii*. Among five species planted in 2000, maximum plant height (8.42 m), basal girth (52.6 cm), breast girth (44.5 cm) and canopy spread (5.82 cm x 5.43 cm) were attained by Blue Marble Tree (*Elaeocarpus sphaericus*) during 2004 followed by *Kobolakso*, *Sapindus mukrosoni* and *Aquilaria agallocha*.

Out of four species planted in 2001, *Roko* (*Litsea lacia*) had shown satisfactory growth followed by *Hiko* and *Empe*. Soil pH of 50 species reported ranged from 4.17 in *Cunninghamia lanceolata* to 4.16 in *Elaeocarpus sphaeriacus*.

Among 31 combinations of 51 species of MTP and five species of cane, *Alnus nepalensis* + *Takek* was reported as best in terms of vegetative growth and chlorophyll content followed by *inus kesiya* + *Tachin* and *Altingia excelsa* + *Tahar*.

Out of different combinations of 25 MPTs and turmeric, chlorophyll content of turmeric leaves was found more in the month of October than November almost for all combinations. During October, maximum chlorophyll content was recorded in turmeric with *Pinus kesiya* followed by *Machilus bombycina*, *Alnus nepalensis*, and *Altingia excelsa*. During November, turmeric leaves contained maximum chlorophyll under *Pinus kesiya* followed by *Alnus nepalensis*, *Symingtonia populnea* and *Dubanga grandiflora*.

#### Effects of tree densities on the growth performance of Gamhari (*Gmelina arborea*).

The spacing trial on gamhari was established in 1999. In fifth year of establishment, gamhari attained highest plant height of 6.71 m with basal circumference (49.8 cm) and circumference at

breast height (35.1 cm) at 3m x 4m followed by growth at spacing 2m x 4m and 4m x 6m .

## SIKKIM CENTRE

### Collection and Evaluation of Multipurpose tree species

#### Growth performance of MPTs

The growth performance of 17 year old arboretum comprising of 34 MPTs was carried out. Among these, *Alnus nepalensis* had maximum average height (29.0m) and dbh (83.0cm) followed by *Terminalia myrocarpa* (19.0 m) and (63.45 cm) height and dbh, respectively.

### Productivity of turmeric and ginger under the shade of MPTs

Under the shade of seven MPTs trees ginger variety *bhaise* and turmeric was sown. The maximum crop yield was obtained under the shade cover of *A. nepalensis* i.e. ginger (95q/ha), turmeric (85q/ha) as compared with control (without shade) 157q/h and 146q/ha.

### Lopping management studies of MPTs.

The biomass production in terms of leaf and fuel wood (on fresh weight basis) was recorded maximum in *F. cunia*, (45.0kg/tree), followed by *F. hookerii* (35.55 kg/tree).

### Development of suitable management practices for different agroforestry systems with special reference to their productivity and sustainability

#### Sikkim mandarin-based AFS

##### Inter cropping with Sikkim mandarin

The average yield of ginger maize mustard and soybean with tree combination was recorded as 85.53, 20.0, 2.65, 4.65 q/ha respectively. However, yield of sole crops (without tree) 165.5, 27.0, 5.5, and 6.0q/ha. Respectively, was higher in all the crops. The average fruit yield of mandarin was recorded as (28.0kg/tree).

#### Guava-based AFS

##### Inter cropping with Guava

The Av. yield was recorded in ginger (75.53q/ha), maize (19.0q/ha), mustard (3.51q/ha) and



soybean (4.00 q/ha) when these crops were sown as intercrop with guava. The sole yield was recorded 165.5, 27.0, 5.5, and 6.50q/ha, respectively. The average fruit yield of Guava was recorded (7.5kg/tree).

### TRIPURA CENTRE

Multipurpose tree species (MPTS) suitable for humid sub tropical climate were planted in RBD. MPTS are divided into 3 groups on the basis of planting geometry. The tree species planted in 2m x 2m spacing are (i) *Acacia auriculiformis* (ii) *Morus alba* (iii) *Leucaena leucocephala* (iv) *Dalbergia sisso*. The tree species planted in 3m x 3m spacing are (i) *Gliricidia maculata* (ii) *Azadirachta indica* (iii) *Michelia champaca* (iv) *Eucalyptus hybrid*. The tree species planted in 4m x 4m spacing are (i) *Tectona grandis* (ii) *Gmelina arborea* (iii) *Samania saman* (iv) *Albizia procera*. *Acacia auriculiformis* were clear felled and boundary plantation was only maintained.

The perusal of the data indicated that *E. hybrid* attained the maximum height of 22.73 m, basal girth of 102.8 cm and girth at breast height of 86.9 cm followed by *Garborea*, *A. procera*, *S. saman*, *M. champaca*, *T. grandis* etc. *E. hybrid* was found to produce 506 m<sup>3</sup> timber/ha after 17 years of tree planting.

It is indicated from the perusal of the data that the productivity of upland rice underwent a variation from 7.50 to 13.0 q/ha under the interspaces of MPTS. A reduction in grain yield varying from 28.6 to 58.8% over control was noted. The pineapple productivity varied from 3.13 to 12.63 t/ha with 19 to 80% reduction in fruit yield over control. The productivity of turmeric on grass plot basis showed a variation from 2.30 to 6.40 t/ha but on net plot basis the variation in turmeric yield was from 4.0 to 13.0 t/ha. The maximum productivity of turmeric was noted in *Morus alba* and the lowest was in *Tectona grandis* with 28.9% and 78.0% reduction over control, respectively.

#### Quality of pineapple

The physico-chemical assay of pineapple grown under the interspaces of MPTS, was evaluated. The total soluble solid of the fruit produced under MPTS was from 14.3 to 18.2 per cent thus indicating 0.7

to 28.2 per cent increase over the fruit of open space. The reducing sugar and total sugar content were found maximum (10.9 and 14.5%) in the fruit produced under the canopy of *M. champaca* and *L. leucocephala*, respectively. An increase of 21.9 per cent and decline of 0.68 per cent in reducing sugar and total sugar content over the fruit of open space were noted. Acidity of the fruit varied from 0.44 to 1.08 per cent thereby showing maximum decline of 31.3 per cent and increase of 68.8 per cent over the fruit of open space in pineapple grown under the canopy of *Tectona* and *Albizia*, respectively. TSS/acidity ratio which underwent a variation from 16.85 to 40.45 has been widely accepted as a measure of fruit palatability. The more the ratio, the more proportionate would be the sugar-acid blend. So the pineapple produced under the canopy of *Tectona*, *Azadirachda* and *Gliricidia* was of high palatability.

Results regarding cell wall composition of leaves of different tree species showed that *Tectona* possessed the highest NDF contents (65.87 percent) on DM basis while the lowest NDF value was observed in *Gmelina*. On an average, the ADF content was 31.55 per cent with the highest being in *Dalbergia* (38.83) and the lowest in *Leucaena* (19.15 per cent). ADF is composed of ligno-cellulosic matter. Overall cellulose concentration was averaged 17.57 per cent among different species. *Leucaena* exhibited the lowest lignin content (3.91 per cent) while *A. procera* showed the maximum level (24.23). The mean values of IVDMD and IVOMD values were found to be 46.88 and 48.76 per cent, respectively.

The highest *In vitro* DM and OM digestibility were observed in *Leucaena* (63.18 per cent) as against the lowest value of 35.98 per cent in *Tectona*. Generally, digestibility values are positively correlated with protein level and negatively with fibre fractions particularly ADF and lignin. The digestibility values are dependent mainly on chemical composition of the feed stuffs.

### MANIPUR CENTRE

#### Collection and evaluation of *Casuarina* species

Evaluation of five *Casuarina* species collected from Australia Tree Seed Centre and *C. equisetifolia* collected from the Deputy Conservator of Forest



(Genetics), Coimbatore was continued for the 12<sup>th</sup> year. Maximum plant height up to 23.8 m was recorded with *C. equisetifolia* followed by *C. glauca* (21.0 m) and *C. cunninghamiana* (17.5 m) and maximum plant girth up to 84.0 cm was recorded with *C. glauca* followed by *C. cunninghamiana* (77.6 cm) and *C. equisetifolia* (72.6 cm). Whereas maximum canopy was recorded with *C. glauca* (8.5 m) followed by *C. equisetifolia* (6.5 m) and *C. cunninghamiana* (5.6 m) respectively.

#### **Effect of stump sizes in the growth of *Gmelina arborea***

A trial to study the effect of stump sizes ( $T_1$  - 1.15 cm,  $T_2$  - 1.30 cm,  $T_3$  - 1.45 cm and  $T_4$  - 1.60 cm) in the growth performance of *Gmelina arborea* was established in May, 1996. Treatment  $T_2$  and  $T_3$  have been dominating since last six years by giving maximum height up to  $T_2$  (10.70 m) and  $T_3$  (9.93 m) against the mean height of 9.35 m. Collar height girth (CGH) was recorded maximum (47.33 cm) with  $T_3$ , closely followed by  $T_2$  (45.33 cm). Girth at the breast height (BHG) for all the treatments is almost same. Maximum BHG was recorded with  $T_2$  (33.67 cm) followed by  $T_3$  (32.67 cm) and  $T_1$  (30.00 cm) and  $T_4$  (29.33 cm).

#### **Provenance of *Parkia roxburghii***

Among fifteen provenances maximum plant growth (height, CHG and BHG) after twelve years of planting was recorded with provenance No. 4 (8.85 m, 52.2 cm and 41.6 cm, respectively) while minimum was recorded with provenance no. 13 (5.52 m, 30.1 cm and 23.5 cm, respectively). Provenance no. 9 had maximum number of branches (10.0). Maximum canopy of 5.1 m was recorded with provenance no. 7 while minimum (2.8 m) was recorded with provenance no. 13. The data reveals that after twelve years of planting the height attained is not very convincingly high as compared to what we find under valley conditions. This may be due to the fact that trees have been grown on eroded soil.

A trial on the effect of stem and root cutting of four years old *Parkia* plants were also carried out. After eight years of planting, maximum plant height up to 9.45 m was recorded with provenance collected from Ukhrul district followed by provenances from Churachandpur district (8.3 m)

and provenances from Bishnupur district (7.05 m). Maximum CHG was recorded with provenance from Ukhrul (46.4 cm) followed by Churachandpur (45.0 cm) and Bishnupur (44.1 cm).

Evaluation of different provenances for early fruiting/flowering was conducted by stump based budding, seed selection etc. Seed selection is found most successful in reducing the transition period of flowering/fruiting from 8 to 4 years. Stump cutting trial from 1 - 4 inches diameter and 1m lengths for vegetative propagation treated with IBA (1000 to 3000 ppm) indicated 2 inches diameter with 3000 ppm was most successful (53% survival). The flowering and fruiting through such propagation method is being attempted. However, such propagation method has not shown success in bearing fruit/flowers in a period of six years. Agro-techniques for cultivation of early flowering and shortening pre-bearing of varieties/provenances are underway.

Studies on growth performance of different multipurpose tree species (MPTS) in arboratum (4-5 years old)

After five years of planting, maximum plant height upto 6.34 m was recorded with *A. nepalensis* followed by *Aleurites fordii* (5.89 m) whereas maximum CHD (11.29 cm) was recorded with *Alnus nepalensis* closely followed by *Aleurites fordii* (11.01 cm). BHD cannot be recorded for *Coffea arabica* and *Cinnamomum tamala* due to bushy nature. Similarly, *Coffea arabica* had maximum branching (38/plant). Canopy of 4.92 m was recorded with *Aleurites fordii*.

#### **Studies on growth performances of MPTS *Aquilaria malaccensis*, *Maichelia champacca*, *Oroxylum indicum* and *Titocarpus assamica***

Maximum plant height, CHD and BHD up to 196cm, 1.96cm and 1.66cm, respectively was recorded with *M. champacca*. Number of branches was maximum up to 28.0 per plant in *Aquilaria malaccensis* closely followed by *M. champacca* (8.83/plant).

#### **Nursery raising**

Nursery was raised for *Alnus nepalensis*, *Schima wallichii*, *Gmelina arborea*, *Parkia roxburghii*, *Alenthus excelsa*, *Cinnamomum tamala*, *Large cardamom*, *Mesua ferrea*, *Passion fruit*, *Jatropha*



*curgas*, *Aleurites fordii*, citrus (Khasi mandarin, Kachai lemon) black pepper, kiwi fruit *etc.*

### Suitable management practices for different systems

#### Silvi-horti-pastoral system

Maximum plant height and CHG after twelve years of planting was recorded with *E. teriticornis* (21.10 m and 92.2 cm) followed by *E. citriodora* (19.3 m, 83.4cm), *A. auriculiformis* (17.45 m and 88.4 cm), *P. roxburghii* (13.61 m and 75.2 cm) *M. azadirachta* (12.52 m and 76.1cm), respectively. Whereas maximum canopy was recorded with *A. auriculiformis* (7.95 m) followed by *P. roxburghii* (7.35m), *M. azadirachta* (6.90 m) and *E. citriodora* (6.75 m) respectively. The branching was maximum with *E. teriticornis* (30.2 / plant) while rest of the tree species branching were only in the range of 13.2- 18.8 per plant. *Eucalyptus* spp. Recorded maximum bole height, 7.2m for *E. citriodora* and 5.4 m for *E. teriticornis*. Branching started from lowest height (1.4 m) in case of *B. variegata*.

On the terraces different medicinal plants viz. *Adhatoda vasica* (Nongmakha Angouba), *Alpinia galanga* (Kanghoo), *Artemesia parviflora* (Libakngou), *Azadirachta indica* (Neem), *Coix lacryma-jobi* (Changning), *Curcuma coesia* (Yaingam Amuba), *Blumea balsamifera* (Langthrei), *Dioscorea* spp. (Haa), Large cardamom and *Phlogacathus thyrsoflorus* (Nongmakha) were introduced for further study and fodder crop were planted at the raisers.

Maximum fodder yield (variety - *Panicum maximum*) upto 45.1 t/ha/year was recorded in combination with *L. Polyantha* followed by treatment No. 2 (42.3 t/ha/year) in combination with *P. roxburghii* in two cuttings

#### Agri-horti-pastoral system

Local banana (Leimakhong local) were introduced on the raiser bunds. Ten accessions were collected from Manipur (Imphal east, Imphal West and Ukhrul District) and Mizoram. Among the ten accessions, the growth of the Dwarf Cavandish and Robusta were found superior over other accessions. The performance of Dwarf Cavandish under foot hill condition is quite satisfactory though some of

the plants were affected with bunchy top. All other accessions were affected by Stem weevil and Panama wilt. Maximum degree of infection was recorded with Maringhei followed by Babupara and Bhimkol. Out of ten accessions only two i.e. Dwarf Cavandish and Robusta recorded early flowering (271 days) followed by Bhimkol (300 days). The highest bunch weight was recorded in Dwarf Cavandish (24.1 kg) followed by Robusta (17.49 kg). Flowering has not been observed in other accessions due to severe diseases and pseudostem weevil.

Groundnut (ICGS-76) was taken as test crop under agricultural component with 5 strains of *Rhizobium*. It yielded up to 25.52 q/ha and 30 q/ha under unlimed and limed conditions, respectively. Two different varieties of fodder viz., *Panicum maxicum* and *Pennisetum pedicellatum* were also grown. Three different cuttings were made during the period of report. Mean maximum cuttings up to 50.04, 51.38, 30.97 t/ha in the first, second and third cuttings were recorded in *P. maxicum* and 35.32, 32.95 and 10.83 t/ha in the first, second and third cuttings were recorded in *P. pedicellatum*.

#### Silvi-horticultural system

Maximum plant height upto 6.57 m was recorded with *A. nepalensis* followed by *A. lakoocha* (3.83 m). Maximum CHD was recorded with *A. nepalensis* (12.29 cm) followed by *A. lakoocha* (5.67 cm). Maximum canopy and number of branches was also recorded with *Alnus nepalensis*. *E. umbellata* being bushy in nature, mean number of branches could not be recorded.

Intercropping of passion fruit cv. purple under the partial shade of parkia roxburghii (10mx10m<sup>2</sup>) without irrigation increased the fruit yield by 28% over control. Intercropping of ginger var. thingpui with passion fruit in terraces gave an additional yield of 10.5 tonnes ginger/ha. Intercropping of turmeric germplasm (23 lines) (with spacing 25x40cm<sup>2</sup>) with Passion fruit and an additional yield of 8.3-10.1 t/ha of turmeric was obtained. This system provides not only additional yield but also helps in soil conservation as well as has a potential to generate employment too.

During the year being reported jatropha, dalchini and tejpatta plants have been transplanted in different arboratum. The performance of jatropha



is very encouraging. Flowering has been initiated in many plants in first year itself. *Jatropha* has attained the mean height of 0.62 m with collar height diameter (2.31 cm) without any branching. *C.zylenicum* though had the height of just 41 cm yet the average number of branches per plant has been recorded to be 2.6.

## VI. AGRICULTURAL ENGINEERING

### Evaluation of Management Practices for Biogas Generation from Pig Waste

A slurry ratio 1.5:1 and HRT of 45 days was utilized and biogas generation was measured during winter season. The biogas was analysed for its methane and carbon dioxide content using the gas chromatograph. The gas was found to contain 56-58 % methane. The digested slurry was found to have available N and P of 1.52 g and 846 mg per 100 g respectively.

### Evaluation of cropping sequences in low cost polyhouse

Five different cropping sequences were evaluated for their performance in the poly house for round the year vegetable cultivation. The cropping sequences such as Tomato-French Bean-Cabbage- Capsicum, Tomato-Brinjal-Cabbage-Pea, Capsicum-Brinjal-Capsicum-Cabbage, Capsicum-Brinjal- Cabbage -Pea and Tomato-Brinjal-Capsicum-French Bean were evaluated throughout the year. The cropping sequence Capsicum-Brinjal-Capsicum-Cabbage gave the highest profit (Rs. 32.98/ m<sup>2</sup> cultivated area) followed by capsicum-Brinjal-Cabbage-Pea (Rs. 29.37/ cultivated area).

### Cropping Sequence in Polyhouse for Higher Return

A low cost polyhouse of 161.8 m<sup>2</sup> floor area was designed, constructed and evaluated to overcome the the problems associated with undulating topography and to make the protected cultivation technology cost-effective. The off season crops such as tomato, capsicum, cabbage, and French bean were cultivated successfully with higher yield and lower level of insect incidence. Creeper crops such as bottle gourd, bitter gourd and cucumber were

grown on risers of the terrace. Five cropping sequences; tomato-french bean-cabbage-capsicum, tomato-brinjal-cabbage-pea, capsicum-brinjal-capsicum-cabbage, capsicum-brinjal-cabbage-pea, and tomato-brinjal- capsicum-french bean were evaluated for maximization of annual return from unit area of land. Capsicum-brinjal-capsicum-cabbage yielded highest net return with Rs 34.4 per m<sup>2</sup> area followed by capsicum-brinjal-cabbage-pea with net annual return of Rs 29.4 per m<sup>2</sup>.

### Fabrication of low cost poly house suitable for farmers' field

Three Low cost poly houses were promoted for farmer's field at Mawpun, Umdohbyrth and Umroi villages. The covered area of these constructed polyhouses were 147, 234 and \_\_\_ m<sup>2</sup>. The structure has been made with the help of bamboo and covering is done using 200 micron UV film. The basic structure was made by using the net of split bamboos with a grid of 9 x 12 inch. The roof of the green house was made in the form of hemispheres in such a manner that height of the roof from ground remains constant. Hemisphere was also made with grid of bamboo split supported on truss made of bamboo. The polythene was supported from both side using bamboo splits on roof to overcome the pressure generated by the heavy wind. The provision for natural ventilation was provided by opening the sides of green house through cross ventilation to avoid excess increase in temperature inside poly house.

### Proyotype Feasibility Testing and Front line Demonstration of improved agricultural Implements

The feasibility testing and front line demonstration of suitable agricultural implements/ tools were conducted for their popularization among the farmers of the region. The implements namely low land rice seeder, manual rice transplanter, hand operated winnower, Wet land Puddler and power tiller with plough and puddler attachment were tested and demonstrated on farmers' fields.

### Training on mechanization and manufacturing of Agricultural Implements for Officers and local village artisans:

In total 27 nos. of State Govt Officers of various Dept. also 29 nos. of local village artisans from



Manipur State were trained in various aspects of agricultural implements suitable for this region.

#### Quality of Surface Water as affected by various land uses in the watersheds

Surface water samples were collected from various land use systems during rainy season and analysed for various parameters were monitored periodically. The result of the water samples analysed is indicated in **Table 1**

#### Modelling of Runoff and Sediment Yield from Hillslope on Plot and Field Scale

A total number of 8 runoff plots of size 10x2m with an average slope of 65% were constructed by inserting galvanized iron sheet 20 cm below the ground and allowing 20 cm above the ground. The treatments for each runoff plot were bare fallow, grass cover, maize along and across the slope, maize intercropped with soybean and pigeon pea, upland paddy, topo – sequential strip cropping, and mixed cropping simulating the jhum crop. On field scale 4 micro watersheds with area ranging from 0.52 to 3.3 ha under different land use like agriculture, horticulture, shifting cultivation and undisturbed natural vegetation and different conservation measures like contour bund, bench terrace, contour

trench and half moon terrace were considered for the simulation of runoff and sediment yield.

The average value for simulated sediment yield per hectare per millimetre of rainfall was largest for micro watershed under shifting cultivation land use with a value of 36.6 kg and lowest for micro watershed under undisturbed natural vegetation with a value of 4.8 kg. The simulated sediment yield for micro watershed under agriculture with conservation measures and for micro watershed under horticulture (fruits and vegetable crops) with conservation measures was 8.6 and 5.6 kg per hectare per millimetre of rainfall, respectively.

#### Economic Analysis of Micro Irrigation for Winter Season vegetable production using harvested Rainwater in Mid Hills of Meghalaya

The economic feasibility of rainwater harvesting and recycling for irrigating winter season vegetable crops namely Cabbage (*Bio Samrat*), Cauliflower (*Himani*), Pea (*Arkel*) and Lettuce (*Green Rapid*) was worked out. The harvested rainwater was recycled back to field by sprinkler irrigation system to irrigate the crops. The average yield obtained was 426, 280, 44 and 120 q/ha, respectively. The Benefit-Cost ratio for the whole system for 1 ha vegetable cultivation area was worked out to be 2.7

**Table 1: Quality of surface water from different land uses and standards for drinking water**

Parameters	Forest	Low land Paddy	Fallow	Agriculture on Bench Terrace	Agriculture on Bun	Desirable limit
pH	6.4	5.8	6.1	5.3	5.7	6.5 – 8.5
Conductivity ( $\mu$ mhos/cm)	19.5	71.10	18.2	24.5	28.5	1500
Chloride (mg/l)	1.65	3.63	2.0	4.31	2.98	250
Turbidity (NTU)	6	16	10	12	16	5.00
Total dissolved salts (mg/l)	2.18	6.28	5.91	10.58	16.98	500
Total hardness (mg/l)	5.01	20.02	3.00	26.55	10.01	300
Calcium (mg/l)	1.49	1.18	2.06	1.04	2.52	200
Magnesium (mg/l)	1.23	1.00	-	1.21	1.10	200
Total alkalinity (mg/l)	12.0	16.5	23.0	14.5	13.2	200
Nitrate Nitrogen (mg/l)	8.8	20.16	3.84	11.32	9.04	45
Sulphate (mg/l)	2.0	3.0	2.0	4.0	3.0	200
Iron (mg/l)	0.12	0.64	0.36	0.42	0.64	0.3
Sodium (mg/l)	18.4	86.66	12.30	148.77	137.74	-
Potassium (mg/l)	72.6	57.3	44.0	24.9	66.8	-
Phosphorous (mg/l)	0.16	0.45	0.27	0.40	0.49	2 - 3
Faecal coliform (MPN/100ml)	4	75	9	54	41	Nil

(All the values presented in the table represent average over the monsoon season of 2004)



### Heat unit accumulation, biomass production and yield of mustard under different sowing dates

Mustard (M-27 and TS – 38) were sown at three different dates at ten days intervals starting from 20.10.2004. TS-38 recorded higher heat unit accumulation expressed in terms of degree-days as compared to M-27. The accumulated heat unit was found to be closely related with biomass production. Seed yield as well as biomass production reduced with the delay in sowing owing to unfavourable weather and moisture stress conditions. Heat use efficiency expressed as the ratio of accumulated heat unit corresponding to maximum biomass accumulation also reduced at the later sowing dates. The variety TS-38 germinated poorly in the 3<sup>rd</sup> sowing and no yield was obtained. However, germination of M-27 was marginally better with seed yield of 1.8 q/ha.

### Training rural population on Post Harvest handling

Altogether eleven training programmes on various Post Harvest Technologies (Table 2) were conducted under Jai Vigyan NATP Project on Household Food and Nutritional Security for Tribal Backward and Hilly Areas (Programme-5). Total 197 participants including farmers, self-help group members, housewives, students, self-employed persons attended the trainings. More than 200 participants learnt about the nutritional benefits of soybean and preparation of low cost nutritious recipes of soybean during the National Nutritional Week. During the year 30 metallic bins and 15 improved honey boxes were distributed to the farmers of identified villages and members of Jai Vigyan Honey Club (Fig. 1&2).

**Table 2: Trainings organized during the year.**

Sl. No.	Training Programme	Number of Programmes organized
1.	Processing of soybean for food uses	5
2.	Processing and Preservation of fruits and vegetables	4
3.	Household production of mushroom	1
4.	Household production and processing of honey.	1



**Fig. 1. Training on soy biscuits preparation**



**Fig. 2. Distribution of metallic bins & beehives to the farmers.**

### Commercialization of Farm Tools and Machinery for Hill Agriculture

During the year following agricultural tools and equipments were manufactured and sold to government/non-government organizations and farmers of this region (Table 3).

**Table 3: Agricultural tools and equipments manufactured and sold during the year.**

Sl. No.	Item	Quantity	Sl. No.	Item	Quantity
1.	Maize Sheller	1871	8.	Manual Trolley	12
2.	Garden Rake	221	9.	Metallic tip Dibbler	10
3.	Hand grass Slasher	161	10.	Groundnut Decorticator	7
4.	Hand fork	26	11.	Hand operated Winnower	4
5.	'U' Blade Weeder	21	12.	Wheel Hoe	3
6.	Metallic Seed bin	20	13.	Manual Seed drill	3
7.	Adjustable row Marker	14	14.	Pedal paddy Thresher	1

## VII. BIO-ORGANICS

### Development of the bio-organics from the weed and tree species for organic agriculture

#### Bioorganic for groundnut

One hundred and fifty eight different plant extracts were tested for their growth promotion and four preparations namely, RCHE 34L, RCHE78L, RCHE13L and RCHE 377L showed growth promoting attributes, (Table 1.)

In pot culture, groundnut seed treatment with 1.5% concentration of RCHE13L had resulted in five times more nodulation and 270% more pod yield over control of nodules (Fig. 1).

#### Bioorganic for French bean

Ninety six herbal preparations were tested in the frenchbean ( local bush type, var. Meghalaya local) and two preparations showed growth promoting attributes and RCHE 79L showed slight improvement of plant height (5.3 cm ) but good improvement of root length (5.2 cm) and secondary rootlets (14 nos.) (Fig. 2).

**Table1: Effect of herbal extract on Groundnut (15 Days after treatment in petridish)**

Treatment	Plant height (cm)	Root length (cm)	Secondary rootlets ( nos)	No. of pods/plant	No. of Nodules (For 10 cm of length)	Dry wt (g/plant)
RCHE 34	2.85	3.60	21.6	9.6	8	10.50
RCHE 78L	3.32	5.57	29.0	10.2	12	15.16
RCHE 13L	5.42	7.24	42.6	16.3	16	18.64
RCHE 377L	4.10	5.50	36.1	12.4	11	13.90
Control	1.25	2.35	11.75	6.0	2.5	08.41



**Fig. 1. Effect of herbal extract on root nodulation and yield**

## VIII. ANIMAL SCIENCES

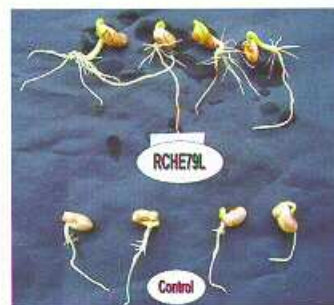
### PIG

#### Genetic improvement of Khasi local pigs crossed with Hampshire

#### Reproductive performance of different crossbred pigs

Different reproductive traits of 3 groups of crossbred pigs (Hampshire x Khasi Local) with 50%, 75% and 87.5% genetic inheritance were studied and data obtained are presented in Table 1 & 2. It was found that average age and weight at puberty increased significantly ( $P < 0.05$ ) with increasing level of genetic inheritance. Similarly, age at first conception and age at first farrowing were also significantly higher ( $P < 0.05$ ) in CB-75% and CB-87.5% than CB-50%. No significant difference was observed in inter-farrowing interval between different groups of crossbreds.

No significant difference was observed in groups CB-75% and 87.5% in terms of litter characteristics



**Fig. 2. Effect of herbal extract on root elongation**



of pig viz., litter size at birth and weaning, litter weight at birth and weaning, individual weight at birth and weaning and weaning percentage. However, these were significantly higher ( $P < 0.05$ ) than those of CB-50%.

**Table 1: Comparison of different reproductive traits of the crossbred (Hampshire x Khasi Local) pigs (Mean  $\pm$  SE)**

Reproductive traits	(CB-50%) (n=25)	(CB-75%) (n=25)	(CB-87.5%) (n=30)
Age at puberty (days)	256.18 $\pm 20.45^a$	279.42 $\pm 6.44^b$	298.65 $\pm 26.65^c$
Age at first conception (days)	298.48 $\pm 14.50^a$	321.36 $\pm 10.90^b$	349.48 $\pm 16.16^c$
Age at first farrowing (days)	413.64 $\pm 36.38^a$	436.89 $\pm 18.61^b$	463.80 $\pm 26.86^c$
Inter-farrowing interval (days)	204.35 $\pm 16.58$	208.84 $\pm 30.64$	214.89 $\pm 18.45$
Weight at puberty (Kg)	45.84 $\pm 6.78^a$	53.43 $\pm 12.39^b$	66.40 $\pm 10.05^c$

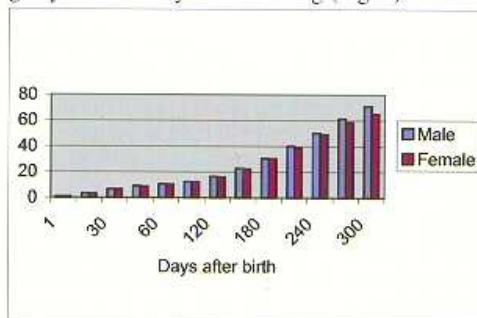
**Table 2: Comparison of various litter traits of the crossbred (HS X KL) pigs (Mean  $\pm$  SE)**

Litter traits	CB-50%	CB-75%	CB-87.5%
Litter size at birth	6.74 $\pm$ 0.49 <sup>a</sup>	7.85 $\pm$ 0.85 <sup>b</sup>	7.89 $\pm$ 0.63 <sup>b</sup>
Individual weight at birth (Kg)	0.80 $\pm$ 0.39 <sup>a</sup>	0.97 $\pm$ 0.32 <sup>b</sup>	0.99 $\pm$ 0.35 <sup>b</sup>
Litter weight at birth	5.39 $\pm$ 0.40 <sup>a</sup>	7.68 $\pm$ 0.93 <sup>b</sup>	7.75 $\pm$ 0.26 <sup>b</sup>
Litter size at weaning	5.14 $\pm$ 0.30 <sup>a</sup>	6.75 $\pm$ 0.29 <sup>b</sup>	6.78 $\pm$ 0.36 <sup>b</sup>
Individual weight at weaning	6.75 $\pm$ 0.89 <sup>a</sup>	8.09 $\pm$ 0.36 <sup>b</sup>	8.56 $\pm$ 0.97 <sup>b</sup>
Litter weight at weaning	34.69 $\pm$ 8.21 <sup>a</sup>	54.60 $\pm$ 3.49 <sup>b</sup>	58.03 $\pm$ 4.66 <sup>b</sup>
Weaning percentage	76.26 $\pm$ 2.48 <sup>a</sup>	85.98 $\pm$ 2.63 <sup>b</sup>	85.93 $\pm$ 4.60 <sup>b</sup>

### Pre and post weaning growth pattern of crossbred (87.5%) pigs

Pre weaning body weight of 100 crossbred (CB-87.5%) piglets (50 male and 50 females) at 15 days interval up to 60 days of age and post-weaning growth of 40 piglets (20 males and 20 females) at monthly interval up to the age of 10 months were recorded. Results indicated that average body weight of male at different age was higher than female but the difference was non-significant

( $p < 0.05$ ). Similar trends were also observed in daily body weight gain (g/day). Highest daily body weight gain was found to be in between 8 and 9 months. Weaning stress in piglets was observed from the daily weight gain difference of 112.67 g/day just before weaning and its reduction to 60.20 g/day immediately after weaning (Fig. 1).



**Fig. 1. Comparative body weight (kg) of crossbred pigs (87.5%)**

## II. Cryopreservation of boar semen

### Effect of temperature, rpm and duration of centrifugation on boar spermatozoa

Study was conducted to find out optimum temperature, rpm and duration of centrifugation for separation of seminal plasma. The optimum temperature of centrifugation was found to be 20-24°C at the rpm of 1500-2500 for 5-6 min for minimum damage of spermatozoa (Table 3-5).

**Table 3: Effect of temperature on sperm characteristics during 2000 rpm for 5 minutes centrifugation**

Temperature (°C)	Progressive motility	Live percentage	Abnormalities (%)
24	78.55 $\pm$ 1.20	80.25 $\pm$ 1.50	21.53 $\pm$ 1.27
20	75.75 <sup>a</sup> $\pm$ 1.25	76.25 <sup>a</sup> $\pm$ 1.25	22.64 <sup>a</sup> $\pm$ 1.36
15	70.65 <sup>b</sup> $\pm$ 1.50	75.35 <sup>b</sup> $\pm$ 1.35	23.60 <sup>b</sup> $\pm$ 1.46
10	60.45 <sup>c</sup> $\pm$ 1.35	60.45 <sup>c</sup> $\pm$ 1.30	24.42 <sup>c</sup> $\pm$ 1.50

Studies on replacement seminal plasma with Bestville Thawing solution (BTS) revealed that partial replacement (50-75%) of seminal plasma

with Beltsville Thawing Solution (BTS) after centrifugation of freshly ejaculated sperm rich fraction of semen has beneficial effect on motility and viability of spermatozoa during *in vitro* storage. Whereas, complete removal of seminal plasma has adverse effect on motility, and, membrane and acrosomal integrity.

**Table 4: Effect of rpm on sperm characteristics during centrifugation at 24°C for 5 minutes**

rpm	Observations	Progressive motility	Live %	Abnormalities (%)
1500	10	75.25 <sup>a</sup> ±1.50	81.25 <sup>a</sup> ±1.50	21.25 ±1.41
2000	10	75.75 <sup>a</sup> ±1.20	80.25 <sup>a</sup> ±1.25	22.20 ±1.06
2500	10	70.65 <sup>a</sup> ±1.30	65.45 <sup>a</sup> ±1.30	23.32 ±1.22
3000	10	60.45 <sup>b</sup> ±1.30	65.45 <sup>a</sup> ±1.30	23.45 ± 2.12
3500	10	55.65 <sup>b</sup> ±1.85	58.45 <sup>b</sup> ±1.30	24.10 ±2.20

**Table 5: Effect of duration on sperm characteristics during 2000 rpm centrifugation at 20°C**

Time (min.)	Observations	Progressive motility	Live %	Abnormalities (%)
2	10	77.55 <sup>a</sup> ±1.20	80.25 <sup>a</sup> ±1.50	20.75 <sup>a</sup> ±1.34
3	10	75.75 <sup>a</sup> ±1.25	78.65 <sup>a</sup> ±1.25	21.54 <sup>a</sup> ±1.23
4	10	75.65 <sup>a</sup> ±1.50	78.35 <sup>a</sup> ±1.35	22.43 <sup>a</sup> ±1.26
5	10	75.45 <sup>a</sup> ±1.35	77.45 <sup>a</sup> ±1.30	22.70 <sup>b</sup> ±1.52
6	10	72.65 <sup>a</sup> ±1.45	75.35 <sup>a</sup> ±1.40	24.15 <sup>b</sup> ±2.15
8	10	65.35 <sup>b</sup> ±1.65	67.25 <sup>b</sup> ±1.35	24.25 <sup>b</sup> ±2.65
10	10	40.50 <sup>b</sup> ±1.25	45.50 <sup>b</sup> ±1.40	24.76 <sup>b</sup> ±2.23

#### Assessment of DNA integrity

Boar spermatozoa preserved with BTS were subjected to comet assay for assessment of DNA

integrity. In this test, spermatozoa with damaged DNA appear as comet under fluorescence microscope. A total of 24 samples, 12 each from both Hampshire and crossbred boar were preserved with BTS at 18°C and assayed for comet appearance. At 0, 24, 48 and 72 hr, comet percentage for Hampshire and cross-bred were 2.75±0.22 and 2.78±0.22, 6.67±0.21 and 7.64±0.20, 9.81±0.21 and 10.19±0.22 and, 12.92±0.22 and 14.17±0.20, respectively. There was no significant difference for comet percentage between the breeds. But as the duration of preservation extended, the comet percentage increased significantly.

#### Hematology of Khasi local pig

The blood cytology of 30 khasi pigs of 6 different age groups were studied. The blood samples were collected from anterior venacava of apparently healthy pigs. The result (Table-6) revealed that haemoglobin concentration was lowest at day one which gradually increased up to 6 month of age. Similar trend was also found in total erythrocyte count (TEC) and total leukocyte count (TLC). Whereas, Neutrophil count was significantly higher at first day and gradually decreased with the advancement of age except at 2 month of age where it was lowest.

#### On farm trial on pig production technology in Meghalaya

Ten farmers provided training in pig production technology and received one unit (two females and one male) of upgraded pig. Pigs were being kept in low cost houses made of locally available materials

**Table 6: Hematological constituents of Khasi local pig**

Hematological parameters	Age of pig					
	1st day	15 day	1 month (Mean value ± SE)	2 month	4 months	6 months
Hb. (g.percent)	6.9± 0.17	8.5± 0.21	8.6± 0.10	10.1± 0.12	10.5± 0.12	12.5± 0.27
TEC (million /cmm)	3.81± 0.39	4.31± 0.83	4.85± .57	5.57± 0.27	6.21± 0.91	7.34± 0.81
PCV (%)	18.3± 0.69	22.5± 0.30	30.6± .87	43.6± 0.41	44.1± 0.64	45.5± 0.51
ESR (mm/hr.)	6.02± 0.29	4.00± 0.12	2.1± 0.31	2.0± 0.3	1.10± 0.18	0
TLC( thousands /cmm)	7.95± 1.28	8.45± 1.07	8.9± 0.91	11.95± 0.84	21.35± .31	22.25±1.52
Neutrophils (%)	52.67± 1.35	40.21± 1.68	39.28± .58	32.01± 0.38	42.0± 0.57	36.0± 1.62
Eosinophils (%)	2.09± 0.18	1.07± 0.49	2.09± 0.18	1.07± 0.49	1.07±0.49	1.07± 0.49
Lymphocytes (%)	42.50± 1.20	59.14± 0.21	60.00± .17	63.69± 1.44	55.9±1.80	60.40± 0.45
Monocytes (%)	2.09± 0.18	0	1.07± 0.49	2.73± 0.58	2.46± 0.18	1.07± 0.49
Basophils (%)	0	0	0.2± 0.07	0.2± 0.07	0	0.40± 0.05



and provided household produces as feed along with some feed additives (Fig. 2). Productive and reproductive performance such as litter size at birth and weaning, litter weight at birth and weaning, age at first heat, age at first conception and gestation period etc. of all piglets were recorded in the farmer's field. Litter size at birth and litter size at weaning was 6.5 and 5.8, respectively. Litter weight at birth and pre-weaning growth rate was found to be 6.25 kg and 120 g/day. Pre and post weaning mortality were found to be 4-5% and 8-9%, respectively. Age at 1st heat and 1st farrowing were recorded as 10.05±0.325 and 13.65±0.130 months, respectively.



Fig. 2. Upgraded sow and litters in farmer's sty.

#### Resource based feeding system for pig production in Meghalaya

Two experiments were conducted on post weaning and grower crossbred pig of 75% exotic inheritance of Hampshire x Khasi local to study the effect of corn and deoiled rice polish (DRP)

based feeding system. The results of growth performance, and nutrient digestibility indicated that corn-soy diets showed better performance in pigs at both stages of growth (Table 7). It emanates from the results that feeding of corn-soy based diet to pigs at post weaning and grower stages with supplementation of minerals and common salt is economical.

#### Effect of DL-Methionine and probiotics supplementation in pig feeding:

Supplementation of DL-Methionine with corn-soy based ration significantly increased the growth rate to the extent of 10.62% without any change in feeding cost and FCR values. Similarly, supplementation of probiotics (mixture of live bacteria, yeast and enzyme) on DRP-soy based ration significantly increased growth rate in pigs up to 81.87% with improvement in FCR values and feed cost (Table 8).

Table 8: Effect of DL-methionine and probiotics supplementation on the performance of pigs

Feeding Regime	Corn-Soy	Corn-Soy + DL-meth.	DRP-Soy	DRP-Soy + Live fungi	LSD±
Growth rate (g/d)	471 <sup>a</sup>	521 <sup>a</sup>	171 <sup>a</sup>	311 <sup>a</sup>	37.24**
DM Intake (g/d)	1355	1354	1366	1367	NS
FCR	2.88 <sup>a</sup>	2.60 <sup>a</sup>	7.99 <sup>a</sup>	4.41 <sup>a</sup>	0.69**
Feed cost/kg body weight gain (Rs.)	27.34 <sup>a</sup>	25.68 <sup>a</sup>	69.67 <sup>a</sup>	39.14 <sup>b</sup>	6.03**

Values having different superscripts within row differ significantly (P<0.01)\*\*

Table 7: Growth performance and nutrient digestibility of various rations, fed to pigs

Particulars	Treatment Means					
	Control Diet	Post weaning stage			Grower stage	
		Corn-Soy Diet	DRP-Soy Diet	Control Diet	Corn-Soy Diet	DRP-Soy Diet
Growth Performance:						
Growth rate (g/d)	165 <sup>b</sup>	175 <sup>b</sup>	140 <sup>a</sup>	376 <sup>b</sup>	390 <sup>b</sup>	191 <sup>a</sup>
Dry matter intake (g/d)	462	451	578	1365	1335	1375
Feed conversion ratio	2.80 <sup>a</sup>	2.58 <sup>a</sup>	4.12 <sup>b</sup>	3.63 <sup>a</sup>	3.42 <sup>a</sup>	7.19 <sup>b</sup>
Feed cost/kg gain (Rs.)	23.90 <sup>a</sup>	24.75 <sup>a</sup>	33.99 <sup>b</sup>	31.84 <sup>a</sup>	31.76 <sup>a</sup>	60.85 <sup>b</sup>
Digestibility Coefficient:						
Dry matter	76.3 <sup>ab</sup>	82.7 <sup>b</sup>	71.1 <sup>a</sup>	62.7 <sup>b</sup>	84.8 <sup>c</sup>	50.0 <sup>a</sup>
Protein	73.4 <sup>b</sup>	78.4 <sup>b</sup>	66.8 <sup>a</sup>	57.6 <sup>a</sup>	74.9 <sup>b</sup>	51.9 <sup>b</sup>

Values having different superscripts within row differ significantly (P<0.01) within experiment

Digestibility of DM and protein increased significantly due to supplementation of live fungi and enzymes on DRP based ration (Fig.3).

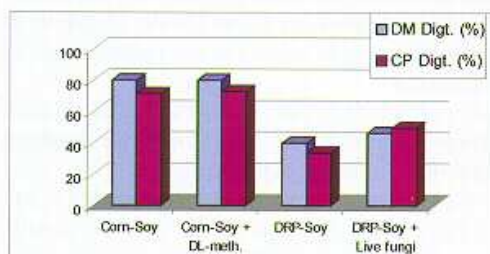


Fig. 3: Effect of DL-meth. and live fungi supplementation on DM/CP digestibility

#### Sweet potato based feeding system for swine production

Performance of crossbred (Hampshire X Khasi local) pigs at 10, 15 and 21 kg body weights were studied on sweet potato tuber (SPT) based feeding regime for the period of 35 days. The DM digestibility was not much affected due to SPT feeding. It was observed that protein digestibility decreased with the increased level of SPT feeding. It resulted 8-10% less growth rate during post weaning stage (10 and 15 kg body weights) at 40% level of SPT feeding. Similarly, pig attained 10% less growth rate at grower stage also (21 kg body weight) with the feeding of SPT at 70% level. The feeding cost and FCR value increased significantly ( $P < 0.01$ ) as the level of SPT feeding was increased (Table 9).

## RABBIT

### On farm trial on rabbit production technology in Meghalaya

Ten farmers were trained in rabbit husbandry, each received one unit of adult rabbit (two females and one male). They had maintained rabbits in outdoor hutch and battery system made of wood and bamboo (Fig 4). Rabbits were fed vegetables residue from kitchen garden, kitchen waste, local grasses, tree leaves, etc. The growth rate obtained was 12-13 g/day in field conditions. Litter size at birth and weaning was 6.7 and 6.0, respectively. Litter weight at birth was 369g, with an average Individual weight of 55.07g Pre and post weaning mortality was found to be 7- 8 and 2 - 3%, respectively.



Fig 4. Rearing of New Zealand white rabbits by the farmers

A study was conducted on growth performance of rabbit maintained on radish and carrot with 50% mash feed on DM basis (Table 10). Results revealed

Table 9: Feeding cost and FCR of sweet potato tubers fed to pigs of varied body weight

Average body weight (kg)	10.18±0.59			14.92±0.58			21.00±0.25	
Level of SPT feeding (% of total DM intake)	0	40	70	0	40	55	0	70
Growth rate (g/d)	238 <sup>b</sup>	226 <sup>b</sup>	111 <sup>a</sup>	339 <sup>c</sup>	277 <sup>b</sup>	218 <sup>a</sup>	473 <sup>d</sup>	425 <sup>c</sup>
FCR	2.39 <sup>a</sup>	3.02 <sup>b</sup>	4.39 <sup>c</sup>	2.79 <sup>a</sup>	3.33 <sup>b</sup>	3.66 <sup>b</sup>	2.87 <sup>a</sup>	3.43 <sup>b</sup>
Feed cost / kg Bd. Wt. Gain (Rs.)	30.06 <sup>a</sup>	33.20 <sup>b</sup>	51.75 <sup>b</sup>	35.07 <sup>a</sup>	39.76 <sup>b</sup>	42.58	36.10	37.12

Values having different superscripts within row differ significantly ( $P < 0.01$ ) within similar body weight group



that ADG (average daily gain per day) was 11.87, 13.29 and 17.09 g for radish, carrot and sole mash feeding, respectively. The corresponding FCR (feed conversion ratio) were 5.78, 5.43 and 3.9 respectively. The corresponding ADI per day (average daily intake) was 68.61, 72.16 and 66.82 g, respectively.

**Table 10: Proximate composition of feed stuff fed to rabbit (% DM basis)**

Nutrient	Radish with leaves	Carrot with leaves	Mash Feed
DM	10.38	12.70	93.04
CP	10.45	11.22	14.08
CF	20.89	33.48	11.64
EE	6.12	7.00	10.33
NFE	50.30	36.97	56.83
TA	12.24	11.33	7.12

#### Effect of mating system on reproductive performance of rabbit

An experiment was conducted with 60 female rabbits to find out the effect of single and double mating on reproductive and productive performance. The results revealed that there was a significant difference ( $P < 0.05$ ) in conception rate, litter size at birth (7.25 vs. 6.43), litter weight at birth (442.38 vs. 391.63) and litter size at weaning (6.18 vs. 5.21) in double and single mating. It was concluded that the double mating gives a better result in comparison to single mating.

#### Growth performance of rabbits on buckwheat-soy based ration along with soybean fodder

Nutritional evaluation of buckwheat at 36% and 78% level of incorporation with roasted full fat soybean grain was studied in grower rabbits for the period of 50 days and compared with control diet. The different mash diets were fed to rabbits of respective groups in *ad-libitum* in the morning and soybean fodder was provided *ad-libitum* in the evening hrs. The growth performances in terms of body weight gain, feed intake and FCR values did not differ significantly amongst various groups of rabbits (Table 11). However, significantly ( $P < 0.01$ ) higher DM and CF digestibility and DE of diets were recorded in rabbits fed on buckwheat-based ration (Table 12).

**Table 11: Growth performance of NZW rabbits on buckwheat-soy based ration**

Particulars	Control Diet	Buckwheat at 36%	Buckwheat at 78%
Initial Body Wts. (g)	780	788	775
Growth rate (g/d)	17.91	17.43	19.11
Total DM intake (g/d)	80.82	72.76	71.90
% DM intake from fodder	41.91	41.66	41.02
FCR	4.52	4.19	3.84

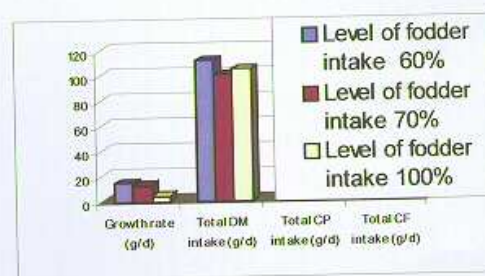
**Table 12: Nutrient digestibility in NZW rabbits fed on buckwheat-soy based ration**

Particulars	Control Diet	Buckwheat at 36%	Buckwheat at 78%
DM Digestibility (%)	55.27 <sup>a</sup>	69.91 <sup>b</sup>	69.00 <sup>b</sup>
CP Digestibility (%)	71.15	73.57	71.99
CF Digestibility (%)	28.48 <sup>a</sup>	29.96 <sup>a</sup>	34.59 <sup>b</sup>
DE (Kcal / kg)	2262 <sup>a</sup>	2431 <sup>b</sup>	2572 <sup>b</sup>

Values having different superscripts within row differ significantly ( $P < 0.01$ )

#### Soybean fodder as a sole feed for rabbit production

Soybean is a promising crop of the region as grain and fodder. An experiment on adult rabbits (90±5 days old, 1355±5.60g) was conducted for a period of 30 days to evaluate the level of soybean fodder feeding. The intake of total DM, CP and CF in rabbits was not affected even on sole feeding of fodder (Fig. 5). However, growth rate was



**Fig. 5. Performance adult rabbits fed on soybean fodder**



significantly reduced in rabbits kept on fodder as a sole feed. Maximum DM and CF digestibility were recorded in rabbits fed completely on fodder without any change in protein digestibility. Significantly ( $P < 0.01$ ) less DE value of soybean fodder as a sole ration was observed (Table 13).

**Table 13: Nutrient digestibility in NZW rabbits fed on soybean fodder as a sole feed**

Particulars	Level of soybean fodder intake on DM basis		
	60%	70%	100%
DM Digestibility (%) <sup>*</sup>	65.61 <sup>a</sup>	63.65 <sup>a</sup>	70.21 <sup>b</sup>
CP Digestibility (%)	69.41	67.30	71.88
CF Digestibility (%) <sup>**</sup>	37.70 <sup>a</sup>	32.94 <sup>a</sup>	48.90 <sup>b</sup>
DE (Kcal / kg) <sup>**</sup>	2401 <sup>a</sup>	2373 <sup>a</sup>	1999 <sup>a</sup>

Values having different superscripts within row differ significantly ( $P < 0.01$ )<sup>\*\*</sup> and ( $P < 0.05$ )<sup>\*</sup>

## DAIRY

### Dairy Farming

#### Broom grass as a potential green fodder for lean season feeding

An experiment was conducted to study the effect of feeding broom grass as green fodder to dairy cattle during lean (winter) season. Three animals were fed with paddy straw as sole source of roughage and other three animals were fed with 50% broom grass and 50% paddy straw. Average milk yield was 7.71 lit/day per animal in paddy straw fed (40% of total DM intake) group while it was 8.38 lit in the other group. This indicated that broom grass, which grows well in this region, could be used as potential alternative to maintain milk production in dairy cattle during lean season.

#### Effect of incorporating soybean meal (SBM) on milk yield and economics

The effect on milk yield and economics of incorporating SBM in dairy concentrate by partly replacing mustard oil cake (MOC) was studied. The average milk yield per animal per day increased by 80 ml due to incorporation of SBM at the level of 10% in dairy concentrate while the average cost incurred on concentrate feed per animal per day

increased by Rs. 12.95. The results indicated that cost of feeding increased significantly due to high cost of soybean meal making it uneconomical to be used in dairy cattle rations in this region.

## GOAT

### Effect of system of rearing on growth rate of goats

A 42-day trial was conducted in goats to study the effect of system of rearing on the growth pattern. A group of two male and 12 female goats were fed under stall fed condition with green cultivated fodder and 100g concentrate/head/day and another group of as many animals were grazed in the field for six hrs a day and provided 100g concentrate/head. Goats under stall-fed condition gained body weight @ 60g/day and those under grazing system gained @40.91g/day.

## POULTRY

### Collection and conservation of indigenous fowls of NE Region

Different types of indigenous fowls *viz.* Miri, Frizzle, Naked neck and Feathered shank were collected from Assam, Arunachal Pradesh and Meghalaya to study the performance under different systems of rearing (Fig 6). A wide range of variability in respect to physical characteristics within the same type of indigenous fowls were observed which might be due to unrestricted random mating in the village poultry flock. The other work on the subject is under progress.

#### Corn-soy based feeding of Kuroiler chicks:

Feeding experiment on the day-old Kuroiler chicks was conducted on corn-soy based rations at different levels of protein and energy with constant levels of Ca (1%) and P (0.5%). The birds kept on corn-soy based diets suffered from leg weakness, poor growth and listlessness from 2nd week onwards, suggesting nutrient imbalance in the diets and confirmed the earlier results recorded in broiler chicks. Thus, it can be inferred that corn-soy based ration needs to be fortified with major minerals and trace elements to balance the diet.





Naked Neck

Miri



Frizzle

Fig. 6. Different types of indigenous fowls of NE Region

#### Growth Performance of Vanaraja breed under intensive System:

Growth performance of vanaraja bird obtained from PDP, Hyderabad was studied under the climatic conditions of Meghalaya and the results are indicated in Table 14.

#### Performance of vanaraja under backyard system of rearing

After successful adoption of Vanaraja breed as indicated above, the birds were given to interested poultry growers to study their performance under backyard systems after raising these up to 6 weeks

at the Institute farm and the results obtained are given in Table 15. Birds reared up to 6 weeks and after their distribution are depicted in Fig. 7 and 8.

Table 14: Sex-wise performance of Vanaraja chicken under intensive system of rearing at agroclimatic conditions of Meghalaya

Age	Male	Female	Combined
4 <sup>th</sup> Day body weight (g)	56.97 ± 0.46	56.65 ± 0.45	56.81 ± 0.32
2 <sup>nd</sup> Week body weight (g)	163.87 ± 1.35 <sup>a</sup>	157.74 ± 1.54 <sup>b</sup>	160.73 ± 1.04
4 <sup>th</sup> Week body weight (g)	359.80 ± 3.59 <sup>a</sup>	335.04 ± 3.57 <sup>b</sup>	346.93 ± 2.59
6 <sup>th</sup> week body weight (g)	634.69 ± 5.97 <sup>a</sup>	586.96 ± 5.24 <sup>b</sup>	610.39 ± 4.12
8 <sup>th</sup> week body weight (g)	1022.46 ± 14.46 <sup>a</sup>	940.59 ± 9.63 <sup>b</sup>	964.89 ± 8.47
10 <sup>th</sup> week body weight (g)	1355.23 ± 23.52 <sup>a</sup>	1178.93 ± 11.39 <sup>b</sup>	1236.81 ± 12.34
12 <sup>th</sup> week body weight (g)	1703.89 ± 29.28 <sup>a</sup>	1481.42 ± 17.01 <sup>b</sup>	1553.15 ± 16.73
16 <sup>th</sup> week body weight (g)	2277.27 ± 41.96 <sup>a</sup>	1949.24 ± 26.14 <sup>b</sup>	2061.30 ± 25.48
18 <sup>th</sup> week body weight (g)	2462.98 ± 47.57 <sup>a</sup>	2144.88 ± 26.69 <sup>b</sup>	2241.84 ± 25.82
Daily G. R. (4 Day- 2 Weeks)	10.69	10.11	10.39
Daily G. R. (2 - 4 Weeks)	13.99	12.66	13.30
Daily G. R. (4 - 6 Weeks)	19.63	17.99	18.82
Daily G. R. (6 - 8 Weeks)	27.69	25.26	25.32
Daily G. R. (8 - 10 Weeks)	23.77	16.47	19.05
Daily G. R. (10 - 12 Weeks)	24.90	22.16	22.97
Daily G. R. (12 - 16 Weeks)	20.48	16.71	18.14
Daily G. R. (16 - 18 Weeks)	13.26	13.97	12.89
Daily G. R. (2 - 18 Weeks)	20.53	17.74	18.58



Fig. 7. Rearing of Vanaraja chicken under intensive system of management



**Table 15: Comparative performance of Vanaraja chicken under intensive system and backyard of farmers in agroclimatic conditions of Meghalaya**

Parameters	Intensive system (Institute farm)	Backyard system (Farmers field)
8 <sup>th</sup> week Body Weight (g)	964.89 ± 8.47 <sup>a</sup>	791.76 ± 9.39 <sup>b</sup>
10 <sup>th</sup> week Body Weight (g)	1231.56 ± 12.82 <sup>a</sup>	933.17 ± 13.35 <sup>b</sup>
12 <sup>th</sup> week Body Weight (g)	1553.15 ± 16.73 <sup>a</sup>	1115.36 ± 17.16 <sup>b</sup>
Weight gain (6-8 weeks) g	354.50	181.37
Weight gain (8-10 weeks) g	266.67	141.41
Weight gain (10-12 weeks) g	321.59	182.19
Weight gain (6-12 weeks) g	942.76	504.97
Daily G. R. (6-8 weeks) g	25.32	12.955
Daily G. R. (8-10 weeks) g	19.05	10.10
Daily G. R. (10-12 weeks) g	22.97	13.01
Daily G. R. (6-12 weeks) g	22.45	12.02
Mortality % (6-12 weeks)	Nil	3.17%

Figures bearing different superscript (row wise) differ significantly (P<0.01), G. R. - Growth rate.



**Fig. 8. A tribal woman with Vanaraja chicken in the backyard system**

**Effect of liver stimulants on growth performance and carcass characteristics of Vanaraja chicken at climatic conditions Meghalaya**

Effects of herbal liver stimulants like Liv-52 Protec (The Himalaya Drugs), Liver-Up (Sarabhai Zydus) and non-herbal Livozyme-Fe (Ashwini Pharmaceuticals) liquids on performance of Vanaraja chicken were investigated. A total of 450 straight run day old chicks of Vanaraja were wing banded and randomly distributed in to four groups. Group I, II and III were respectively given Liver-up, Livozyme-Fe and Liv-52 Protec @ of 10 ml/day/100 chicks in drinking water from day one to six weeks of age and group IV was served as control without any supplementation. All the groups were fed with the chick starter ration and were vaccinated against Ranikhet disease and infectious bursal disease. Significantly higher (P<0.05) body weight gain (0-6 weeks), ready to cook meat yield in groups treated with Livozyme-Fe and Liv-52 Protec and numerical improvement in Liver-up group was observed (Table 16). In groups II and III there was significant reduction (P<0.05) in relative weight of liver. Numerical improvement was observed in all treated groups for feed consumed/unit body weight gain and livability. Both herbal and non-herbal liver stimulants namely Liv-52 Protec and Livozyme-Fe enhanced the performance of Vanaraja chicken. No significant differences among herbal and non-herbal liver stimulants on the performance of Vanaraja chicken were observed.

**Table 16: Performance of Vanaraja chicken as influenced by various liver stimulants**

Parameters	Mean ± S.E			
	Liver-up	Livozyme-Fe	Live-52 Protec	Control
6 <sup>th</sup> week body weight (g)	714.79± 13.99 <sup>ab</sup>	735.97 ± 13.36 <sup>b</sup>	741.63 ± 12.24 <sup>a</sup>	694.37 ± 11.70 <sup>b</sup>
Weight gain (g) (0 - 6 Weeks)	677.27± 13.95 <sup>ab</sup>	699.37 ± 13.32 <sup>b</sup>	705.22 ± 12.18 <sup>a</sup>	657.18 ± 11.64 <sup>b</sup>
Feed/unit weight gain	2.46	2.42	2.41	2.57
Livability %	92.73	93.64	95.45	90.18
<b>Carcass Characteristics (% of live weight)</b>				
Ready to cook yield (Eviscerated+giblet)	69.84 ± 0.39 <sup>ab</sup>	70.99 ± 0.38 <sup>a</sup>	71.38 ± 0.65 <sup>a</sup>	69.16 ± 0.71 <sup>b</sup>
Liver	2.81 ± 0.07 <sup>ab</sup>	2.75 ± 0.06 <sup>b</sup>	2.74 ± 0.08 <sup>b</sup>	3.03 ± 0.08 <sup>b</sup>
Bursa	0.35 ± 0.01 <sup>a</sup>	0.36 ± 0.03 <sup>a</sup>	0.29 ± 0.01 <sup>a</sup>	0.36 ± 0.04 <sup>a</sup>
Spleen	0.31 ± 0.03 <sup>a</sup>	0.21 ± 0.03 <sup>a</sup>	0.24 ± 0.02 <sup>a</sup>	0.23 ± 0.02 <sup>a</sup>

Note: Figures bearing at least one common superscript (row wise) do not differ significantly. (P<0.05).



## Feed, fodder and nutritional profile

### Biomass yield from soybean for livestock feeding

Fodder and grain yield of soybean, an important feed staff, was evaluated and the results are given in Table 17 and 18.

**Table 17: Fodder and grain yield from soybean**

Particulars	Fodder Yield (t/h)	DM Yield (t/h)	Grain Yield (t/h)	Protein Yield (t/h)
Without cut	-	-	19.33 ±2.40	7.78 ±0.97
With one cutting	13.97 ±0.92	2.77 ±0.18	10.57 ±0.58	9.81 ±0.36
With two cuttings	20.07 ±0.29	4.11 ±0.05	2.19 ±0.15	9.56 ±0.07

**Table 18: Soil characteristics of soybean plot**

Particulars	pH	Organic matter (%)	Total N (%)	P (ppm)
Initial	5.52	9.56	0.195	45.31
After FYM & Lime addition	6.02	9.81	0.198	55.19
After Soybean Harvest	5.97	9.93	0.226	32.75

### Nutritional Profile of Unconventional foods consumed by the tribals in Meghalaya

#### Fermented foods

Fermented products like soybean (tungrymbai), bamboo (lungsiej) and fish (tungtap) have been evaluated for nutritional value. Tungtap is found to be a good source of protein (40.6 g %), calcium (5040 mg %), phosphorus (1930 mg %), sodium (6.26 mg %) and potassium (53.18 mg %). Tungrymbai contains high amounts of protein (45.9 g %), fat (30.2 g %), fibre (12.8 g %), vitamin A (70.9 IU %) and folic acid (200 µg %). Lungsiej was found to be of better nutritive value in terms of protein (8.5 g %), fat content (4.7 g %) and iron (1 mg % on fresh weight basis). Fermented foods are typical of the region and exhibited unique flavour and texture that may not be palatable to all.

#### Traditional snacks:

Eight varieties of traditional rice-based snacks like *Pumaloi*, *Pudoh*, *Jashulia*, *Putharo*, *Pukhleln*, *Pusaw*, *Pusla* and *Putyndong* from Shillong and villages in the Ri-Bhoi district eaten by the Khasi tribe of Meghalaya were evaluated for the processing methods (Fig 9) and for their nutritional contents. Markets in and around Meghalaya were surveyed for local rice-based snacks. Processing generally involved steaming and /or roasting of rice flour, which was made from special varieties of sticky rice. The nutritional content in terms of dry matter, protein, fat, fibre, mineral content, Ca and P of these snacks were also studied. The nutritive value of *Jashulia* was superior in terms of high amounts of protein, fibre, Ca and P and low amounts of fat. All other snacks were also superior in terms of the low amount of fat used in their preparation in comparison to other Indian snacks. However, consumption of these snacks is decreasing due to the availability of convenience snacks. The method of preparation of traditional snacks is also being lost due to the reduction in demand. It is necessary to retain these traditional snacks in the inherent culture by popularizing it so that a larger majority can enjoy its tastes and textures.



Jashulia Pusaw Pusla

**Fig. 9. Traditional snacks consumed by the Khasi tribals**

#### Dried fishes

Dried fishes (Fig 10) are very nutritious as they are rich in protein and fat. Macronutrient analysis revealed that the protein content ranged from 49.7 g % in *Sciaena* sp to 66.3 g % in *Salmostonia bacilla* and fat was from 5.6 g % in *Macrospinosa cuja* to 30.5 g % in *Salmostonia bacilla*. Since the fishes were eaten in a dried form they had high dry matter content and nutrient contents. Another important contribution was that of calcium and phosphorus not considered in other flesh foods. Level of calcium was between 2770 mg % in *S. bacilla* and 6630 mg % in *M. vittatus* and phosphorus content was in between 1470 mg % in *M. cuja* and 2250 mg %



in *S. bacilla*. *Sciaena* sp. showed high levels of vitamin A (93.9 IU %) followed by *Macrospinosaja* (90.9 IU %).



Fig. 10. Unconventional dried trash fish consumed in Meghalaya

#### Nutritive value, anti-nutritional factors and domestication potential of selected wild edibles of Meghalaya

Twelve wild edibles namely *Plantago major*, *Commelina benghalensis*, *Polygonum alatum*, *Spilanthes acmella*, *Fagopyrum cymosum*, *Alternanthera philoxeroides*, *Centella asiatica*, *Oxalis corniculata*, *Hottynia cordata*, *Sonchus oleoraceus*, *Vernonia altissimifolia* and *Emilia sonchifolia* were procured from the nearby forests of Ri-Bhoi district and transplanted into the institutes farm in the month of June. They were harvested in the month of October. The survival rate of the wild edibles varied between 73% in *S.acmella* to 100% in *C. benghalensis*, *C. asiatica*, and *O. corniculata*. The content of anti-nutritional factors in terms of tannins, phenolics and oxalic acid were evaluated in these plants. Phenolics (mg%) ranged from  $63.31 \pm 6.5$  in *O.corniculata* to  $192.14 \pm 0.0$  in *P.alatum*. Similarly, the tannin content (mg%) varied from  $1.0 \pm 0.14$  in *A. philoxeroides* to  $5.7 \pm 0.14$  in *P. alatum*. Oxalic acid content (mg% on fresh weight basis) ranged from  $3.17 \pm 0.26$  in *V. altissimifolia* to  $6.09 \pm 0.2$  in *A. philoxeroides*.

## ANIMAL HEALTH

### I. Surveillance and monitoring of important diseases in NE Region:

#### Seroprevalence of brucellosis in man and animals:

A total of 318 sera comprising of 60 cattle, 61 buffaloes, 121 goats, 44 sheep and 100 human beings were collected and screened for brucellosis by using *Brueclla abortus* plain antigen obtained from IVRI, Izatnagar (U. P.). The seroprevalence was 10%, 10%, 3.2% and 7.43% for human, cattle, buffalo and goats, respectively. The overall prevalence was 7.36%. All the sheep were found to be free from brucellosis.

#### Occurrence of avian influenza (bird flu):

A total of 69 serum samples and 85 throat swabs of poultry were collected from different villages of Meghalaya and Mizoram bordering Bangladesh and Myanmar were screened for the presence of avian influenza virus (AIV) at High Security Animal Disease Laboratory, Bhopal. All the samples were found to be negative for the presence of AIV. The findings indicated that the region is free from avian influenza (bird flu).

#### Prevalence of leptospirosis in man and animals

A total of 59 serum and whole blood samples collected from human (32), cattle (18), dogs (11) and pigs (9) were screened for the presence of *Leptospira* using ELISA kit obtained from Defence Research and Development Establishment (DRDE), Gwalior. Five of 9 pigs, 12 of 18 bovine, 20 of 32 human and 5 of 11 dog samples were found to be positive for leptospirosis. The overall incidence was found to be 71.19%. The data obtained indicated that the incidence of leptospirosis is very high in the region.

#### Toxoplasmosis in man and animals

Toxoplasmosis is one of the important zoonotic diseases causing abortion in women. The cat is a definite host and a number of livestock species are known to harbor the organism as secondary hosts to complete the life cycle. Seroprevalence of



toxoplasmosis was studied in sheep and goats and human beings by latex agglutination test and ELISA kits, respectively. Out of 26 sera sample comprising goats (21) and sheep (5), 3 sera sample were found to be positive for antibodies against *T. gondii*. Of the 241 sera of human, 23 sera (9.54%) were found to be positive for *T. gondii*. The prevalence was slightly higher in female (9.92%) than the male (9.09%). However, the difference was not statistically significant (Table 19).

**Table 19: Age and sex- wise distribution of *T. gondii* antibodies in human beings**

Age group (years)	Male	Female	Total Number Tested/ Positive
	Tested/ Positive	Tested/ Positive	
11—20	2/0	13/1	15/1
21—30	17/2	71/5	88/7
31—40	59/4	40/7	99/11
41—50	26/4	6/0	32/4
50-60	6/0	1/0	7/0
<b>Total</b>	<b>110/10 (9.09)</b>	<b>131/13 (9.92)</b>	<b>241/23 (9.54)</b>

Figures in parentheses indicate percentage

#### Outbreak of pasteurellosis in ducklings:

An outbreak of suspected pasteurellosis among ducklings in a Duck farm with high mortality in Tripura was investigated. About 90% mortality was reported in the farm having 2500 ducklings (Fig 11). Based on the clinical manifestation, necropsy findings, isolation and identification of *Pasteurella anatipestifer* and with the non-involvement of duck hepatitis virus and, aflatoxins and ochratoxin, the outbreak was confirmed as pasteurellosis associated with *P. anatipestifer*.

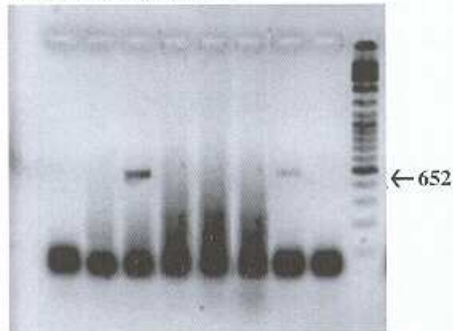


**Fig. 11. Outbreak of *Pasteurella anatipestifera* infection in ducklings**

## II. Development of PCR based diagnosis of livestock and poultry diseases

### Development of RT\_PCR for classical swine fever (CSF)

A CSFV specific Reverse Transcriptase PCR (RT\_PCR) using primers specific for E2 gene of CSFV was standardized and carried out for screening clinical samples of pigs suffering from CSF. The samples that gave rise to 652 bp segment in E2 gene were confirmed as CSF (Fig 12). The results of this study demonstrate the potential application of PCR in the diagnosis of CSF in pigs of the region. Application of PCR will greatly improve accuracy and will reduce laboratory response time for diagnosis of CSF and will facilitate rational deployment of resources for controlling the disease.



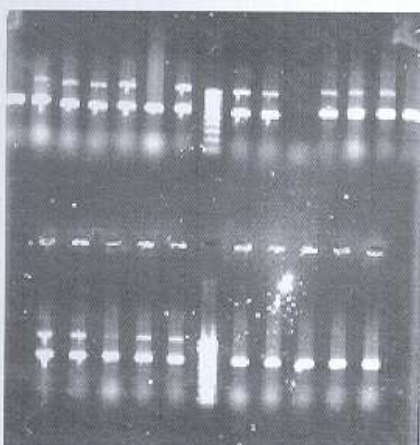
**Fig. 12. Detection of (E2) gene of swine fever virus by PCR**

### Development of RT\_PCR for rotavirus infection:

A rotavirus specific reverse transcriptase PCR (RT\_PCR) using its primers was standardized and carried out for the detection of rotavirus from the faecal samples. Extracted RNA from faecal samples was amplified using three sets of primers (A<sub>1</sub>, A<sub>2</sub>, A<sub>4</sub>, B<sub>1</sub>, B<sub>3</sub>, B<sub>4</sub> and C<sub>1</sub>, C<sub>3</sub>, C<sub>4</sub>) encoding for the specific gene sequences for three types of rotaviruses A, B and C. The RT\_PCR was carried out with the help of RT-PCR kit after standardizing the optimum PCR conditions. Rotavirus Type A could be identified from the faecal samples of calves suffering from diarrhoea. The results demonstrated the potential application of RT\_PCR for accurate and rapid laboratory diagnosis of rotaviral infection in the region and will help in controlling this disease.

**Detection of virulence genes of *Escherichia coli* and *Salmonella* by multiplex PCR (mPCR):**

Two different multiplex PCR (mPCR) protocols (one for *elt* and *est* genes and other for *hly*, *stx1* and *stx2* genes) were standardized using their specific primers and used to study the occurrence of these virulence genes in 160 strains of *E. coli* associated with diarrhea in man and animals. All isolates were found to be negative for the presence of *elt* gene encoding for thermo-labile enterotoxin (LT). Only one isolate each from calf showed the presence of *est* and *stx1* gene. Three isolates from calves were found to harbour *hly* gene.

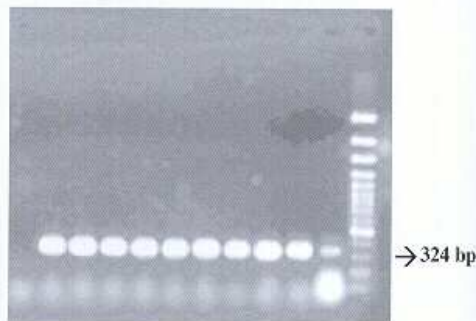


**Fig. 13. Multiplex PCR for detection of *sefC* and *pefA* genes in *Salmonella*. Lanes : 2-5, 7, 9, 10, 12-14, 17-20 positive for both *sefC* and *pefA*. Lanes: 1, 6, 10, 15, 23-27 positive for *pefA*. Lane: 28 negative control (*E. coli*)**

Multiplex PCR (mPCR) protocols for detection of 7 virulence genes, viz., *sm*, *sefC*, *pefA*, *invA*, *fimA*, *sopE* and *sopB* were standardized using their specific primers and used to detect the occurrence of these virulence genes in 85 strains of *Salmonella enterica* belonging to different serovars (Fig 17). The *sm*, *invA*, *fimA* and *sopB* genes were found to be present in all isolates indicated that these genes are widely distributed among *Salmonella* irrespective of their serovars and source of isolation. On the contrary only 38, 60 and 51 isolates were found to be positive for *sefC*, *pefA* and *sopE* genes, respectively (Table 21).

**Molecular typing and subtyping of *Clostridium perfringens*:**

A total of 40 strains of *Clostridium perfringens* recovered from case of gastroenteritis in livestock and poultry and 3 from healthy cattle were subjected to molecular typing and subtyping by multiplex PCR (mPCR) using primers specific for *cpa*, *cpb*, *etx*, *iA*, *cpe*, and *cpb2* genes. All the *C. perfringens* strains amplified only the primer specific for *cpa* (324 bp) indicating the presence of the alpha toxin gene (Fig 14). None were found to be positive for other genes. PCR results indicated that all the 43 *C. perfringens* isolates from the clinical cases of myonecrosis and gastroenteritis belong to genotype A.



**Fig. 14. Detection of virulence genes of *C. perfringens* type A by PCR. All the isolates are positive for alpha toxin (*cpa*, 324 bp fragment) gene**

**Molecular typing and subtyping of *Bordetella bronchiseptica*:**

A total of 47 *Bordetella bronchiseptica* isolated from respiratory infection in pigs were confirmed by PCR using *bvgS* primers specific for *Bordetella* genus which flank 600 bp DNA fragment encompassing the linker-encoding and transmitter-encoding sequences (Fig 15). Similarly, PCR was also carried out by using the primers specific for *shaB* and *shaC* toxin genes which are considered as the dominant attachment and/ adherence factors in *B. bronchiseptica*. In addition, another PCR was carried out using primers designed in the laboratory, which flank 599 bp segment in the *dnt* toxin gene, codes the dermonecrotic toxin in *B. bronchiseptica* (Fig 16). All the *B. bronchiseptica* isolates were found to harbour *dnt*, *shaB* and *shaC* toxin genes.



The polypeptide profiles of *B. bronchiseptica* isolates were carried out in 5 – 12.5% polyacrylamide gel. A total of 21 – 24 polypeptides were observed in the molecular weight range of 20 – 120 kDa in all the isolates. All the 47 isolates were found to harbour either one (25.53%) or two (80.85%) plasmids. The size of the plasmids was within the range of 25 – 26 and 14 – 16 kb.



Fig. 15. *Bordetella bronchiseptica* isolates showing positive for *BvgAS* gene. Lanes 1 – 15: *B. bronchiseptica* isolates, M : DNA ladder.

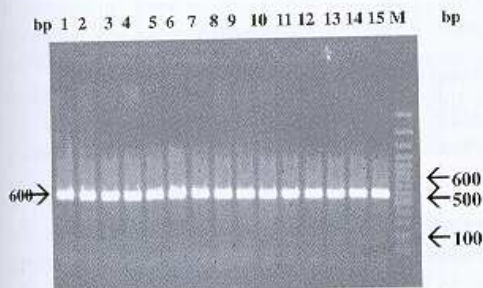


Fig. 16. Detection of *dnt* toxin gene of *B. bronchiseptica* isolates by PCR. lane 1-15: *B. bronchiseptica* isolates positive for *dnt* gene (599 bp), M: DNA ladder.

Twenty different restriction enzymes were used for the digestion of chromosomal DNA of *B. bronchiseptica*. *HinfI* or *DdeI* restriction endonucleases were found useful for discriminating *B. bronchiseptica* isolates by generating comparable fingerprints. The results obtained revealed that 90% isolates found to have similarity index in the range of 90% - 100%, while 10% were having similarity index in the range of 50% - 70%.

#### Genotyping of mesophilic *Aeromonas* isolates from meat:

A total of 27 *Aeromonas* isolates were screened for the presence of haemolysin/aerolysin genes by multiplex PCR employing the primers specific to *A. hydrophila* extracellular gene (*ahh1*), *A. hydrophila* aerolysin gene (*AH-aerA*) and *A. sobria* haemolysin (*asa1*) gene as these are considered to be potent virulence markers for *Aeromonas* sp. The isolates carrying only *ahh1* gene, *asa1* gene, both the *ahh1* and *asa1* genes, *ahh1* and *AH-aerA* genes belong to genotype 1, 2, 3 and 4, respectively and isolates without haemolysin gene belong to genotype 5. All the 27 *A. hydrophila* isolates were found to carry the *ahh1*, where as *AH-aerA* gene was found in 14 of them. Two *A. sobria* were found to carry *asa1* gene. On the basis of genotyping, 6 isolates found to be type 1; 2 to type 2; 14 to type 4 and 1 to type 5 (Fig 17).

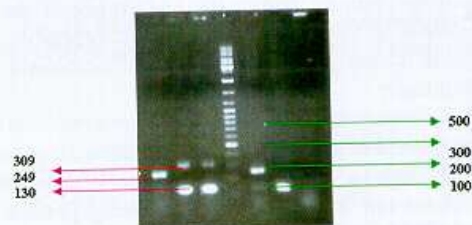


Fig. 17. PCR analysis of *ahh1*, *ah-aerA* and *asa* genes of Mesophilic *Aeromonas*. Lanes 1, 2, 3, 4 & 5 - Positive cultures, 6-negative, M is the marker (Fermentus)

#### III. Development and evaluation of *Salmonella* toxoid vaccine

*Salmonella* enterotoxin (Stn) was prepared from enterotoxigenic strains of *S. enterica* serovars Typhimurium and Enteritidis for development of the toxoid vaccine. Stn was partially purified by ammonium sulphate precipitation (60% saturation) and successive dialysis. Toxin was inactivated by different doses of Gamma radiation and the toxicity was determined by CHO cell assay. Loss of toxicity was observed for the irradiated toxin on cell culture assay. However, the irradiated toxin was found to be highly immunogenic as it induced high titre of



antibody on its inoculation into rabbits as detected by agar gel precipitation test (AGPT) and enzyme linked immunosorbent assay (ELISA). Further studies on the antibody production in the poultry are in progress.

#### IV. Development of weather based disease forecasting system

Agrometeorological and disease incidence/prevalence data for all the states of northeastern region for 10 years was collected, analysed and deposited in the database maintained at the PD\_ADMAS. The cumulative data was analyzed using NADRES (National Animal Disease Reporting Expert System) and a national and regional disease forecasting system was launched through BSNL for major infectious diseases prevalent in the country. Presently 16 important livestock and poultry diseases can be predicted at least two months before the occurrence of the outbreak in the region. The disease forecasting system is under validation at different locations in the country.

#### Prevalence of gastrointestinal parasites in pigs in Meghalaya

A total of 241 faecal samples from pigs were collected from various places of Meghalaya during the year 2004-05 and screened for the presence of different parasites. Out of these, 88 (33.5%) were found to be positive for one or other parasites (Table 22). The prevalence of gastrointestinal parasitic infection was found to be more in Jowai area (54.2%) than Kyrdemkulai area (11.1%) indicating areawise variation in the infestation.

#### Prevalence of different parasites in goats slaughtered for human consumption in Meghalaya

A total of 65 stomach and intestine of goats slaughtered for human consumption were collected from local unorganised slaughter places located in and around Shillong and examined for the presence of different parasites. The goats were brought from places of different altitudes of Meghalaya. Out of 65 viscera examined, 58 (89.23%) were positive for one or other parasites (Table 20).

**Table 20: Prevalence of parasitic infection in goat in Meghalaya**

No. of intestine examined	No. +ve for parasites (%)	Parasite recovered (%)
65	58 (89.23)	<i>O. venulosum</i> (86.20) <i>O. columbianum</i> (79.31) <i>Haemonchus(A)</i> sp. (72.41) <i>Haemonchus(R)</i> sp. (79.31) <i>Trichuris</i> sp. (68.96) <i>Trichostrongylus</i> sp. (63.79) <i>Moniezia</i> sp. (51.72) <i>Bunostomum</i> sp. (17.24) <i>Amphistome</i> sp. (18.96) <i>Gaigaria pachysalis</i> (10.34)

#### Prevalence of gastrointestinal parasites in cattle in Meghalaya

Out of 405 faecal samples of cattle collected and examined 223 (55.06 %) were found to be positive for various parasites (Table 21).

**Table 21: Prevalence of different parasites among cattle of Meghalaya**

Place	No. examined	No. positive (%)
Upper Shillong	197	93 (47.2)
Kyrdemkulai	89	48 (53.9)
Jowai	119	82 (68.9)
Total	405	223 (55.06)

#### Isolation and identification of immunogenic fraction of *Oesophagostomum* and *Bunostomum* sp. by SDS-PAGE and Western blotting

*Oesophagostomum* and *Bunostomum* parasites were triturated and centrifuged (50,000 rpm, 4°C, 10 min) and supernatants were collected. The supernatants thus obtained were then concentrated to 10 times. The concentrated proteins (20 µl) were analysed in SDS-PAGE by using precast gel (4 - 20%). In each run, a protein molecular weight standard was included. Duplicate gels were run for each sample. One gel was stained with Coomassie brilliant blue while the other one was used for immunoblotting. The separated protein bands were transferred on to nitrocellulose membrane using transblot apparatus and probed with antisera from naturally infected goats and cattle with *Oesophagostomum* and *Bunostomum*. Crude extract



of *Oesophagostomum* sp. revealed 15 protein bands within the range of molecular weight between 16 to 124 kDa, while that of *Bunostomum* sp. showed 15 protein bands within the range of 20 to 152 kDa. Most of the peptides in both the parasitic antigens were similar (Fig 18).

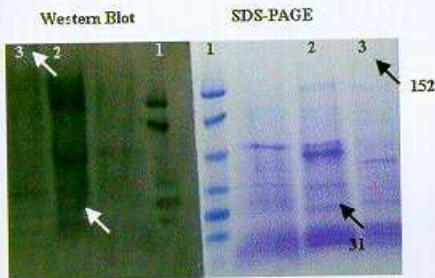


Fig. 18. SDS-PAGE and Western blot analysis of crude proteins of *Oesophagostomum* and *Bunostomum* sp. Lane 1: Molecular Marker; Lane 2: Antigen of *Oesophagostomum* sp.; Lane 3: Antigen of *Bunostomum* sp.

Western blotting indicated that 152 kDa and 31 kDa proteins were immunogenic and specifically reacted with *Bunostomum* and *Oesophagostomum* antisera, respectively. Rest of the immunogenic proteins was common in both the parasites.

After identification of immunogenic proteins, unstained gel were cut into small pieces and put

directly into electroelutor for protein elution. The eluted proteins were concentrated. The immunogenic fractions (152 kDa and 31 kDa) were again subjected to SDS-PAGE gel to know the purity of the proteins. SDS-PAGE analysis of eluted protein revealed a single band indicated its purity (Fig 19B). These purified immunogenic protein fractions were used for developing Dot-ELISA for detection of antibody to *Oesophagostomum* and *Bunostomum* sp. in naturally infected goat and cattle.

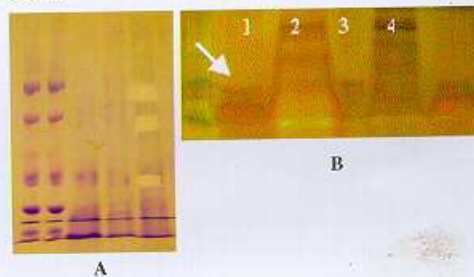


Fig. 19. Elution of immunogenic proteins from SDS-PAGE gel and SDS-PAGE profile of crude (A) and eluted protein (B)

#### Development of Dot-ELISA kit for detection of parasitic antibody in naturally infected goats and cattle

Dot-ELISA was standardized and was used for detection of parasite specific antibody in naturally infected goat and cattle.

#### A. Goat serum samples

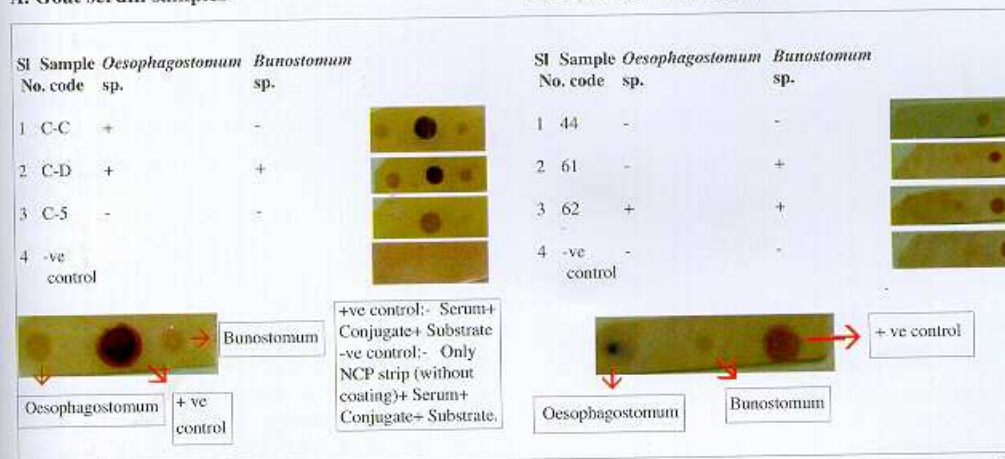


Fig. 20. Monitoring of serum samples from goat and cattle for identification of *Oesophagostomum* and *Bunostomum* sp. using Dot-ELISA kit. A. Goat serum samples, B. Cattle serum samples

## FISHERIES

### Captive breeding and larval rearing of chocolate mahseer, *Neolissocheilus hexagonolepis*

A captive breeding trial was conducted on chocolate mahseer, *Neolissocheilus hexagonolepis* (Fig 21). The source of broodstock was Umiam river. The female brood fish weighed 200-300g, while the males were of 50-100g size. Breeding was done by the process of stripping of male and female fishes. Incubation was done in enamel trays with mild aeration and the incubation period ranged from 80-84 hours. Percentage of hatching was 85. The yolk-sac absorption in larvae was completed in 6 days after hatching and the larvae were subsequently maintained on planktonic diet for a period of one month. The fry were subsequently reared in cement cisterns up to fingerling size. They were fed with rice bran and mustard oil cake in addition to a mixed culture of plankton.



Fig. 21. Different stages in the breeding process of chocolate mahseer

### Native ornamental fish of Nagaland and their conservation status

The State of Nagaland is gifted with a wide group of fishes having a good potential as aquarium fish in global fish market due to their diversified ornamental value. From the State, 71 ornamental fish species have been recorded which belonged to 38 genera under 17 families and 4 orders. At present, most of the species are threatened and rarely occurring. The conservation status of the native ornamental fish were studied (Fig 22).

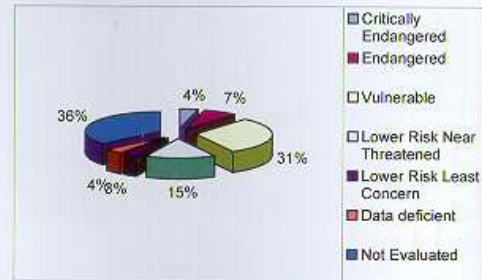


Fig. 22. Conservation status of the native ornamental fish of Nagaland

### Native ornamental fishes of Sikkim - An evaluation

Some of the native ornamental fish of Sikkim collected are shown in Fig. 23. The conservation status of the different fish species of the state is Endangered 4 (13.79%), Vulnerable 10 (34.48%), Lower Risk Near Threatened 5 (17.24%) and Not Evaluated 10 (34.48%).

### Studies on the native ornamental *Garra* species of NEH States with a note on their conservation

*Garra* form an important group of Indian Ornamental Fish having good demand due to their attractive appearance, suckers, hardiness and compatibility (Fig 24). The eight North Eastern Hill States harbour as many as 12 *Garra* species, which belong to a single genus *Garra* under the family Cyprinidae. All the 12 *Garra* species of northeast are found to possess ornamental value and are popular among the traders and hobbyists. Although the trade is not organized, these fishes are being collected from the natural habitat by local fish collectors and are sent to Kolkata by some traders. Almost all the species are declining from their natural habitat due to degradation of water





*Pseudechenis sulcatus*

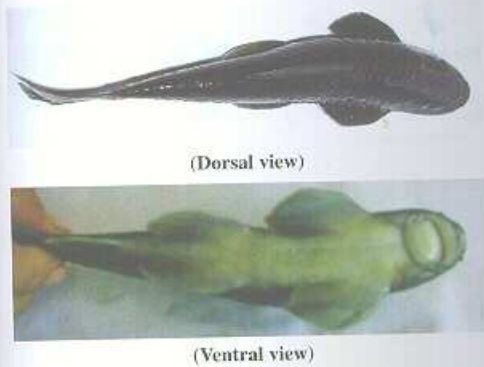


*Barilius bendelisis*

*Lepicephalus guntea*

Fig. 23. Promising ornamental fishes of Sikkim

bodies, pollution, poisoning, dynamiting and over fishing of broods and juveniles. The conservation status of the *Garra* species of north eastern states show that out of the total recorded 12 species, 02 are Critically Endangered and 05 are Vulnerable.



(Dorsal view)

(Ventral view)

Fig 24. Native ornamental *Garra* Sp.

### Fecundity of Zebra danio, *Brachydanio rerio* (Hamilton)

Fecundity of zebra danio, *Brachydanio rerio* (Fig 29) varied between 215 and 4004 in the fishes of length and weight ranging from 29 to 81 mm and 0.2 to 6.74 g, respectively. The number of mature eggs per gram of body weight ranged from 602.44 to 2560.42 with an average of 1277.45. The relationship of fecundity to body length, body weight and ovary weight have been determined which shows a linear pattern (Fig. 26-28). The correlation co-efficient were found to be positive and were significant at 1% level. Fecundity was more closely related to body length than body weight and ovary weight of zebra danio. Fecundity value was dependent on length by more than 85% whereas about 74% dependency of fecundity was observed on body weight and ovary weight. However, the three variables *viz.*, body length, body weight and ovary weight altogether contributed about 91% for the fecundity variable.



Fig. 25. Zebra danio, *Brachydanio rerio*

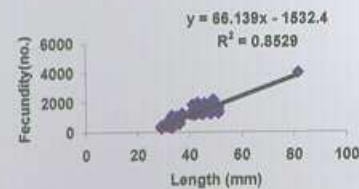


Fig. 26. Relationship between body length and fecundity of *Brachydanio rerio*

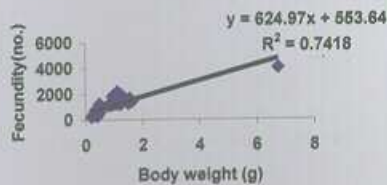


Fig. 27. Relationship between body weight and fecundity of *Brachydanio rerio*

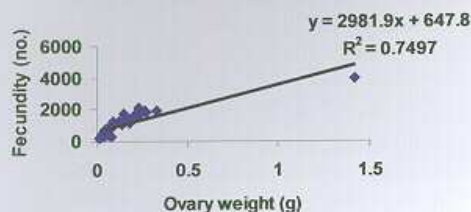


Fig. 28. Relationship between ovary weight and fecundity of *Brachydanio rerio*

#### Studies on qualitative and quantitative plankton production using duck droppings

Two different doses of duck droppings i.e. 0.25g/lit and 0.5g/lit were applied. On computation of the results, it has been found that, a dose of 0.5g/lit was ideal for both phytoplankton and zooplankton production. Among the phytoplankton, *Spirogyra* sp. and *Euglena* sp. and among the zooplankton, *Brachionus* sp. and *Lepadeta* sp. were found dominating. The quantitative analysis revealed a phytoplankton population of 1229 nos./50 lit and a zooplankton population of 2225 nos./50 lit on the 30<sup>th</sup> day (Fig 29). On the 60<sup>th</sup> day, phytoplankton population was 2404 nos./50 lit and zooplankton population was 13810 nos./50 lit (Fig 30). The study revealed that duck droppings can be used as manure for mixed culture of plankton, which in turn can serve as important feed for the fishes.

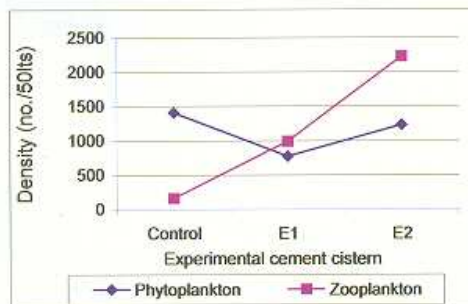


Fig. 29. Phytoplankton and zooplankton densities on the 30<sup>th</sup> day

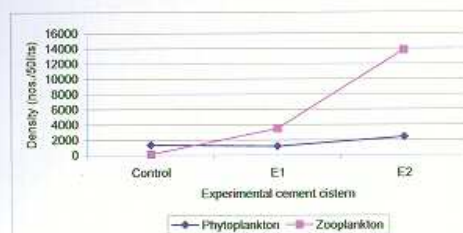


Fig. 30. Phytoplankton and zooplankton densities on the 60<sup>th</sup> day

#### Growth performance of Red Tilapia fed with different livestock excreta under mid-hill micro-situation of Meghalaya

A study was conducted to establish the effect of different livestock excreta on the growth performance of Red Tilapia (Fig 31). The fish were fed with five different livestock excreta viz. duck, pig, poultry, cow dung and rabbit. The fish fed with rice polish served as control. The experiment was conducted for 90 days. Analysis of the result showed that, among the five tested livestock excreta, duck excreta helped in achieving the highest total weight gain (TWG) of 0.43g/fish. The order of growth performance of Red Tilapia fed with different livestock excreta was duck excreta (TWG, 0.43g/fish) > pig excreta (TWG, 0.39g/fish) > cow dung (TWG, 0.30g/fish) > poultry excreta (TWG, 0.25g/fish) > rabbit excreta (TWG, 0.11g/fish). The absolute growth, growth increment and specific growth rate (SGR) were also found to be the best in fishes fed with duck excreta, when compared to other livestock excreta (Table 22). The mean weight increment over a period of 3 months is shown in Fig 32.

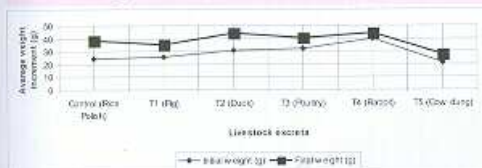


Fig. 31. Farm raised Red Tilapia



**Table 22: Growth performance of red tilapia fed with different livestock excreta**

Treatments	Initial weight (g) ±S.D	Final weight (g) ±S.D	Absolute growth (g) ±S.D	Growth increment (g/fish/day)	SGR (%)	TWG (g/fish)
Control (Rice Polish)	24.25±7.51	38.66±7.77	14.41±0.26	0.16	0.22	0.59
T1 (Pig)	25.33±4.24	35.23±7.71	9.93±3.47	0.11	0.15	0.39
T2 (Duck)	30.69±10.47	44.16±8.21	13.47±2.26	0.14	0.17	0.43
T3 (Poultry)	32.20±4.15	40.25±7.14	8.05±2.99	0.08	0.10	0.25
T4 (Rabbit)	39.50±10.55	44.08±13.09	4.58±2.54	0.05	0.05	0.11
T5 (Cow dung)	21.25±2.73	27.66±5.17	6.41±2.44	0.07	0.12	0.30



**Fig. 32. Mean weight increment of red tilapia over a period of 3 months**

**Integrated weed management for production of grass carp, *Ctenopharyngodon idella* (Val.)**

The weeds like *Ageratum conyzoides* L., *Bidens pilosa* L., *Galinsoga parviflora* Cav. and *Crassocephalum crepidioides* (Benth) (Fig 33) were fed to the grass carp, *Ctenopharyngodon idella* (Val.). Among the four tested weeds, *G. parviflora* was found to be the most preferred feed and the



*Galinsoga parviflora*

*Bidens pilosa*



*Ageratum conyzoides*

*Crassocephalum crepidioides*

**Fig. 33. Weeds as feed for grass carp**

order of feed preference was *G. parviflora* > *C. crepidioides* > *A. conyzoides* > *B. pilosa*. The weight gain (72.53%) and FCR (36.66) were also high with *G. parviflora*. The weight gain with *C. crepidioides*, *A. conyzoides* and *B. pilosa* were 47.34%, 19.83% and 10.06%, respectively, while the FCR were 48.46, 75.26 and 144.61 for the same (Tables 23, 24). The results indicated that *G. parviflora* is an excellent feed for the grass carp among the 4 evaluated weeds.

**Table 23: Growth and survival of grass carp fed on different terrestrial weeds**

Parameters	Weeds			
	A. conyzoides (T <sub>1</sub> )	B. pilosa (T <sub>2</sub> )	G. parviflora (T <sub>3</sub> )	C. crepidioides (T <sub>4</sub> )
No. of fish	10	10	10	10
Duration (days)	90	90	90	90
Initial weight (g) <sup>a</sup>	29.30	31.60	30.73	31.56
	± 1.48	± 1.10	± 1.68	± 1.43
Final weight (g) <sup>a</sup>	35.11	34.78	53.02	46.50
	± 1.65	± 1.76	± 1.25	± 1.80
Weight gain (g) <sup>a</sup>	5.81	3.18	22.29	14.94
	± 0.17 <sup>a</sup>	± 0.66 <sup>b</sup>	± 0.43 <sup>b</sup>	± 0.37 <sup>b</sup>
Percentage weight gain	19.83	10.06	72.53	47.34
Average growth (g/day/fish)	0.0646 <sup>a</sup>	0.0354 <sup>b</sup>	0.2476 <sup>c</sup>	0.166 <sup>d</sup>
Survival (%)	100	100	100	100

\* Average wet weight/individual  
 Values having different superscripts (a, b, c, d) differ significantly (P<0.01)  
 C.D. at 1% for weight gain = 3.3893  
 C.D. at 1% for average growth = 0.00743

**Table 24: Feed utilization and food conversion ratio of grass carp fed on different terrestrial weeds**

Weeds	Food consumed (g)	Parameters Wet Weight gain (g)	FCR
<i>A. conyzoides</i> (T <sub>1</sub> )	437.30 <sup>a</sup>	5.81 ± 0.17 <sup>a</sup>	75.26 <sup>a</sup>
<i>B. pilosa</i> (T <sub>2</sub> )	459.89 <sup>a</sup>	3.18 ± 0.66 <sup>a</sup>	144.61 <sup>a</sup>
<i>G. parviflora</i> (T <sub>3</sub> )	817.19 <sup>c</sup>	22.29 ± 0.43 <sup>b</sup>	36.66 <sup>c</sup>
<i>C. crepidioides</i> (T <sub>4</sub> )	724.14 <sup>d</sup>	14.94 ± 0.37 <sup>c</sup>	48.46 <sup>d</sup>

Values in each column having different superscripts (a, b, c, d) differ significantly (P < 0.01)

C.D. at 1% for food consumption = 13.5735

C.D. at 1% for weight gain = 3.3893

C.D. at 1% for FCR = 4.7927

#### Performance of composite fish culture in Ri-Bhoi district of Meghalaya

Carp culture technology was disseminated to a total of 24 fish farmers who belonged to seven different villages of Ri-Bhoi district of Meghalaya. On-farm interactive demonstrations were conducted on various steps involved in fish culture like weed clearance, eradication of weed and predatory fishes, application of manure and lime, stocking, administration of feed and prophylactic measures (Fig 34). The growth of fishes were found to be



Netting to check the growth of fish



A haul of a good crop

Fig. 34. Activities in the farmer's field

significantly good with catla attaining an average growth of 550-700g, rohu 350-500g, mrigal 250-400g, silver carp 700-950g, grass carp 750-900g, common carp 550-700g, java puthi 200-320g and gonius 200-310g. The fish biomass production ranged from 1265 to 2106 kg/ha after 9 months of culture.

## IX. TRANSFER OF TECHNOLOGY

### Role of Self-Help Groups in mobilizing tribal Youths of Meghalaya for Entrepreneurship

Six SHGs working in Ri-Bhoi district were studied and results indicated that most of the members (61.66%) belong to 18 to 25 year age group, have primary level of education and were almost equally distributed in an annual income group of rupee 10-15 thousands. The SHGs had a very good linkage with training organizations and appear to be most interested (50 percent) in livestock production technology. Data on income generation from identified enterprises revealed that almost all the members (57 nos.) did earn certain income from different enterprises. Livestock production was found most remunerative followed by manufacturing of tools and implements. The study also revealed that certain constraints like storage and marketing facilities are adversely affecting the efficiency of SHGs.

### TRAINING

During the period under report in total, nineteen training programmes were conducted. Details of various activities and technologies transferred to the user groups are detailed in Table 1.

Table 1: Training programmes conducted during 2004 - 05

Name of the training	No. of participants	Category
Nursery preparation of Paddy	15	Farmers
Pig production technology	24	- do -



Application of insecticide in maize	10	- do -
Piglet care	10	-do-
Poultry production	12	SHG
Pig production technology	49	Retd. Army officials
Horticultural technologies	49	Farmers
Dairy Farming	49	Farmers
Rabbit farming	49	Farmers
Mushroom production technology	49	Farmers
Vermicompost	49	Farmers
Soybean processing	14	Farmers
Nursery preparation for tomato	20	Farmers
Nursery preparation for tomato	25	Farmers
Nursery preparation for capsicum	15	Farmers
Training-cum-visit	140	Farmers
Nursery raising of tomato and capsicum	18	Farmers
Integrated disease management in tomato	25	Farmers
Integrated pest management in tomato	25	Farmers

#### Summer School

The division has successfully conducted a summer school on Organic Food Production at this institute during 5<sup>th</sup> to 25<sup>th</sup> August 2005. Altogether 25 participants of different SAUs, CAU, KVKs and ICAR Institutes from all over India participated. The course covered various aspects of organic farming production, certification, accreditation, marketing and role of financial institutions as well as APEDA in popularizing organic farming in N.E. India. The participants were shown fields of the farmers of Meghalaya where organic farming is being practiced.

#### Other Extension activities

Under transfer of technology programme the division has adopted three villages for agricultural development through scientific agriculture and animal rearing. After conducting PRA exercises,

farmers have been selected for different technological interventions like introduction of HYVs of rice, vegetables, improved breeds of pig and poultry. All the interventions have been regularly monitored with respect to benefit attained by the farmers. Moreover, cooperative society and self-help group have also been formed to help farmers to run their enterprises. Besides this, the division has also organized the following events as a part of TOT programme.

1. **Farmers' fair:** A farmers' fair was organized on 29<sup>th</sup> October 2004 at Barapani to display the technologies developed by the institute. Farmers-Scientists interaction session was also organized for getting feedback of different problems faced by farmers in agriculture, animal husbandry, fishery, horticulture and all other allied areas. Scientists of selected disciplines answered the queries. It was attended by 300 farmers from all over the state. The fair was inaugurated by Hon'ble Minister of Agriculture, Govt. of Meghalaya, Shri H.D.R. Lyngdoh, in the presence of Shri S.W. Rymbai, MLA of the area and Director, Heads of Divisions/sections and other staff of the institute.
2. **Field Day:** A field day on Rice was organized at Nongthymmai (Kyrdem) village of Ri-Bhoi district to exhibit the success of high yielding as well as aromatic rice varieties in the village. The field day was attended by more than 100 farmers of the neighboring villages. Farmers were made acquainted with improved varieties and management practices for rice cultivation.
3. **Exhibition:** An exhibition was held at Basic Agriculture Training Centre, Upper Shillong. Institute's rice varieties were displayed and suitability of different varieties to different agro-ecosystem was explained to farmers. The institute also participated in a State Level Exhibition held at Shillong w.e.f. 21<sup>st</sup> -24<sup>th</sup> January 2005 in commensuration with the celebration of Meghalaya Day. The stall exhibited various activities of the institute and displayed the technologies generated by the institute.
4. **Visit.** Thirtynine dignitaries including Prof. Swaminathan, Deputy Director General from Krishi Bhavan, Vice-Chancellors, Secretaries of



Senior level from centre and North Eastern States 267 students across the region, more than 500 farmers of this region, 73 entrepreneurs under the banner of self-help groups visited the institute.

### **INSTITUTION VILLAGE LINKAGE PROGRAMME**

With the implementation of this project the cropping intensity has increased to 200 percent with the introduction of vegetable cultivation in Rabi season. The farmers used to harvest an average yield of 1856 kg/ha from the local variety of paddy but with the adoption of high yielding varieties both in upland and lowland situations, the farmers are getting an average yield of 3600 kg/ha resulting a net profit of Rs. 14,000/ha. Similarly, in maize, the profit has been recorded as high as Rs. 20,000/ha by the adoption of improved varieties. In the case of commercial vegetable cultivation of tomato and capsicum both in Kharif and Rabi season, per hectare profit gained was Rs. 69,000 and Rs. 89,000, respectively. In livestock sector also farmers could gain an average profit of Rs. 1600/pig within a period of one year.

Another impact of the project observed in the adjoining villages revealed that 248 farmers have adopted all the technologies and 468 farmers have adopted a few number of technologies like vegetable cultivation and pig rearing at their own without getting assistance from the project. This is most encouraging indication that the project will go a long way in changing the aptitude of the farmers.

### **NAGALAND CENTRE**

#### **Constraints faced by the tribal farmers in adopting improved agricultural and livestock technologies**

A survey was conducted in five villages and information was collected from 75 farmers each having both the enterprises (agriculture and livestock). The constraints faced were grouped in five categories viz. socio-economic, production technology, infrastructure, information technology and marketing.

Major constraints felt by the farmers having both the enterprise were less information available in

local languages (96.0%), high cost of animals (90.6%) and lack of understanding of the scientific terms explained by specialists (80.0 %)

Nearly three fourth of the respondents mentioned their difficulties as high cost of veterinary medicines and low sale price of produce (77.3%), poor economic condition (76.0%), non-availability of improved animal breed (73.3%) and market competition (72.0%).

More than fifty but less than seventy per cent of the respondents mentioned following constraints for non-adoption of technology. Non-availability of storage facilities (68.0 %), lack of labours for farm work (64.0 %), lack of veterinary hospital facilities (60.0%), less knowledge of television programmes on agriculture/livestock etc. (57.3%), lack of scientific and technical knowledge for growing crops and animals (56.0%) and contagious diseases in poultry and dairy animals (54.6%).

#### **Analysis of the problems in respect of agricultural and allied aspects.**

The Participatory Rural Appraisal (PRA) techniques such as social maps, resource maps, transect analysis, seasonal analysis, livelihood analysis, agro-ecosystem maps, and Venn diagrammes were applied in Bade and Vidima villages. The most impact of modern technologies on villagers' life was from ICAR (43%) followed by State Departments (26%) and Self Help Groups (11%).

### **NATIONAL WATERSHED DEVELOPMENT PROJECT FOR RAINFED AREAS**

Under NWDPR, Centre is developing two model farms one each at Peren and Jalukie for implementation of sustainable, eco-friendly, economically viable agricultural production systems. The activities are enumerated as below:

#### **Soil and water management**

Eight training programmes were conducted to improve the technical skill of farmers with respect to preparation of farm layout, making of contour bunds and water harvesting structures, raising of fruit trees and vegetables. Waterways were constructed for safe passage of excess runoff to the farm pond; to reduce the soil erosion, cultural operations were carried out across the slope and



along the contour line; to reduce soil erosion, biological hedges along the contour bunds were raised. Alder trees were planted as live fence in the upper reaches. In the middle part fruit trees such as tree tomato, sweet orange, Assam lemon, banana and pomegranate were planted. Development work was also initiated under Jalukie Watershed Project.

## TECHNOLOGY MISSION

### Technology refinement and imparting trainings under Technology Mission (Hort.).

Seeds of improved varieties of tomato and cabbage were distributed to the farmers of three villages viz Bade, Naga United and Tenyiphe-I in Dimapur district for on farm testing.

Six trainings on "Nursery raising and production technologies were also organized.

### Farmers visit to Demonstration

Total 380 nos. of farmers from different adopted villages and Self Help Groups have visited the demonstration farm. During their visit farmers problems were discussed with the resource persons and solutions were suggested. Crops grown in the

demonstration farm were exhibited to farmers (Table 2).

### Linkages with Line departments and NGOs

KVK has linkage with different line departments of state like Agriculture, Horticulture, Animal Science, Veterinary & Fishery, Govt. of Nagaland and NRC on Mithun for organizing training programmes. Linkages with different NGO's in the state viz. DAN (Development of Agriculture in Nagaland), World Vision, AIDA (Agency for Integrated Development Action), Prodigal Home, RADA (Rural Agricultural Development Agency) and DBVTC (Don Bosco Vocational Training Centre) have also been established to transfer of technology through these agencies.

## TRIPURA CENTRE

Training on different aspects were conducted for practicing farmers, farm women & rural youth of different villages like Birchandra, West Manu, East Manu, Salhang Manu, Bagafa, Matar Bari Block were participants (Table 3).

Table 2: Performance of different crops at demonstration farm

Crops	Varieties	Av. Yield (q/ha)	Crops	Varieties	Av. Yield (q/ha)
<b>Vegetables</b>			<b>Spices</b>		
Okra	P.Kranti	226.0	Turmeric	Megha-1	644.0
	Najnka (F-1 Hyb.)	310.0			
	Okra-10 (F-1 Hyb.)	295.0	<b>Fruit crops</b>		
Chilli	Pusa Jwala	150.0	Orange	Khasi Mandarin	66.60
Cowpea	Aspargas BlackBean	65.0	Guava	Allahabad Safeda	200.0
Bottle gourd	F-1 Hyb	120.0	<b>Oilseed crop</b>		
Cucumber	F-1 Hyb	156.0	Toria	TS-38	8.75
Ridge gourd	AAU, Sel.1	125.0		M-27	7.25
Sponge gourd	Pusa Chikni	120.0			
Bitter gourd	F-1 Hyb.	70.0			
French bean	S-9	75.0			
Radish	J.White	235.0			
Spinach	All green	53.0			
Pea	Azad P-1	132.0 green pod			
Tomato	F-1 Hyb.	284.0			
Cabbage	PO1	250.0			
	Rare Ball (F-1 Hyb.)	421.0			
Cauliflower	Ageti	235.0			
Knol khol	White Viena	325.0			
Tomato	F-1 Hyb	294.0			

**Table 3: Details of Traing programmes**

Discipline	No. of Courses	No. of Trainees		
		SC/ST	Others	Total
Crop Production	05	34	46	80
Agril. Engg.	05	68	61	129
Horticulture	02	12	16	28
Plant Pathology	01	09	15	24
Total Courses :	13	Grand Total :		261

**Impact of Training :-**

Framers, after the training programmes had reported an increased agricultural production (12–15%) in their fields by adoption of improved package of practices

F.L.D. on oilseed & pulses were organised at village, Bagafa, East Manu, West Manu, Salthang Manu, Takma, Birchandra, Arhar (UPAS-120) FLD was conducted in 10 sites with an yield of 10.5 q/ha. Similarly, groundnut (ICCV-86590) was demonstrated at 28 sites (4 hectare) and an yield of 12.5 q/ha was obtained. In the rabi season mustard (B-9) was demonstrated in 9 hectare area in 21 sites and 10.7 q/ha yield was obtained. Rabi rajmash (PDR-14) at 15 sites covering 4 hectare area was demonstrated with an yield of 13.4 q/ha. The impact of different FLDs in South Tripura is evident as area under oilseeds and pulses has increased resulting in 7% increase in production.

**(3) On Campus Demonstration**

Demonstration (on campus) on different oilseeds viz. sesamum (BS-18-5-6), groundnut (ICGS-44) and Toria (B-9) were conducted which yielded 7.2, 18.0 and 9.4q/ha, respectively.

**(b) Flower seedling nursery**

For hybrid marigold, Petunia, Salvia and Gozania a seasonal flower garden was raised and sown to farmers and the general public. Awareness programmes were arranged through farmers visit to flower nurseries for their acquaintance with the package of practices.

**(c) Demonstration of farm implements, tools/ Soil and water conservation measures:**

Improved farm tools and implements were demonstrated to the practicing farmers. Watershed catchment treatment like check dam/ gully plug in

the gully line for soil and water conservation was demonstrated to the farmers (Fig.1).



**Fig. 1. Demonstration to farmers**

**(4) Extension activities.**

The extension activities conducted by K.V.K. during 2004 – 05 are given in Table 4.

**Table 4:Extension activities undertaken**

Sl. No	Activity	No. of Beneficiaries			
		Number	SC/ST	Others	Total
1.	Field days	01	16	19	35
2.	Visit of farmers field	15	33	65	97
3.	Farmers /Students visit to KVK	10	24	127	151
4.	Exposure visit	01	19	23	42
5.	Ex – trainees meeting	03	28	48	76
6.	Observation of National Science Day	01	12	21	33
7.	Soil Conservation Week	01	10	15	25
8.	Farm's Club	13	-	-	-
9.	Observation of ICAR Foundation day	01	-	-	-

**MANIPUR CENTRE**

**Training programmes organized / arranged**

- Two days Training programme on Breeding of Magur was organised. The function was inaugurated by Sri N. Mangi Singh, Honbl'e Minister of Fisheries, Govt. of Manipur



- Training on, "Breeding of *Clarias batrachus* (Magur)" held from 12th to 13th, January 2005 at the Center in collaboration with CIFA, Bhubaneswar.
- Training on, "Production of fish waste based ensilage for cattle feed" held from 18th to 19th February 2005 organized by CIFT, Cochin in collaboration with the Centre.
- Training on, "Breeding and culture of Carps, Prawn and Ornamental fishes" held from 23rd to 26th, February 2005 organized by CIFE, Mumbai in collaboration with the Centre at Manipur State Fisheries Training Center, Imphal.
- Awareness camp on, "Responsible fishing" held on 15th March 2005 organized by CIFT, Cochin in collaboration with the Center at District Fisheries Office, Imphal East.
- Seven training programmes were organized during the period on Vanaraja as backyard poultry venture for the needy personnel viz. educated un-employed rural farmers.

## MIZORAM CENTRE

### Trainings:

Six trainings were conducted on scientific pig farming with emphasis on housing, feeding and management practices for improving the productivity of pigs. Folders in both English and Mizo languages were distributed to the farmers to know the details.

### Technology Mission, MM-I, CSS (Hort.) "Integrated development of horticulture in North Eastern states"

Under the programme I which includes production of nucleus seed/planting materials of citrus (khasi mandarin), banana (Giant Cavendish) and passion fruit (Purple) following progress has been made:

- 3000 seedlings of one year old Khasi mandarin were distributed to farmers through Horticulture Department, Govt. of Mizoram.
- 500 suckers of Banana (Giant Cavendish) have been supplied to Directorate of Agriculture, Mizoram.

- 1000 seedlings of passion fruit (var. purple) have been distributed to farmers through village council president, Venglai unit, Kolasib District, Kolasib, Mizoram.
- Planted 220 nos. of Khasi mandarin seedlings at ICAR farm, of which 200 have survived.

### Standardization of production and protection technologies (Programme II)

#### Varietal evaluation on Banana:

Three varieties viz. Giant Cavendish, Dwarf Cavendish and Poovan were evaluated for their growth, yield and quality. The observation recorded up to 280 days after planting revealed that the Poovan attained the maximum height of 2.59 m followed by Giant Cavendish (1.59 m) and minimum height was recorded in Dwarf Cavendish (1.38 m). Pseudostem girth was recorded to be maximum of 71 cm in Poovan followed by Dwarf Cavendish (52.6 cm) and Giant Cavendish (50.3 cm), respectively. Leaf area was recorded to be maximum in Giant Cavendish (8.6 m<sup>2</sup>) followed by Dwarf Cavendish (7.7 m<sup>2</sup>) and Poovan (7.4 m<sup>2</sup>). Shooting was first noticed in Dwarf Cavendish.

### Standardization of production and protection technologies (Programme II)

#### Varietal evaluation on Passion fruit

Five varieties of passion fruit viz. purple type, yellow (oval type), yellow (round type), small fruited (wild type) and Kaveri were evaluated. The seedlings were planted in field in the month of June, 2004. The observation recorded at 180 days after planting revealed that the plant height was maximum in purple type (3.23 m) followed by small (wild type 2.3 m) and the minimum was recorded in yellow (round type 1.8 m). Purple type recorded the maximum stem girth of 1.8 cm followed by yellow (oval type 0.61 cm) and the least in yellow (round type 0.50 cm). Small (wild type) recorded the maximum nos. of primary vines (9.8) and minimum was recorded by yellow (oval type 3.0). Secondary vines were recorded to be maximum of 55.8 in small (wild type) variety and the minimum was recorded in yellow (oval type 13.2).

The performance of Kaveri was relatively very poor and only one plant survived out of eleven plants.



### Technology refinement and imparting training (Programme III)

Two declining Khasi Mandarin orchards were selected for rejuvenation. Growth, yield and quality parameters were recorded one year after rejuvenation in both orchards. Orchard-1 in Thingdawl Block recorded average plant height (3.9 m), trunk girth (30.1 cm) and nos. of fruits (37.3). Analysis of the fruits was done and the average TSS of 10.00%, titrable acidity (0.47%) and total sugar (7.16%) was observed whereas orchard-2 in Thingdawl Block recorded average plant height of 6.3 m, trunk girth (41.7 cm) and nos. of fruits (37.1). Average TSS was recorded to be 9.72%, titrable acidity (0.51%) and total sugar (6.77%).



Fig. 2. Orchard 1 in Thingdawl block under rejuvenation



Fig. 2. Orchard 1 in Thingdawl block under rejuvenation

## X. AGRICULTURAL ECONOMICS

### Projection of Foodgrains Production and Requirement in North Eastern States

Projection study on production and requirement of foodgrains in north eastern states was carried out to estimate the demand-supply gap of foodgrains. State-wise compound growth rates (CGR) of foodgrains production (includes rice, wheat, maize and pulses) were estimated by using time series data for a period of 1984-85 to 1997-98 (Basic Statistics for NER, 2002). Requirement of foodgrains was estimated by multiplying the recommended amount of per capita foodgrains with the population base (which was estimated through CGR).

Mizoram showed highest CGR for foodgrains production (10.37 %), followed by Nagaland (6.57 %), Assam (2.58 %), Tripura (2.25 %), Manipur (1.96 %), Arunachal Pradesh (1.30 %) and Meghalaya (1.19 %). The CGR of Mizoram was observed to be abnormally high (10.37 %) and raised serious doubt, thus, was excluded from the present study. The foodgrains production for the region was estimated to be 7471, 8549, 9817 and 11315 thousand tons for the year 2010, 2015, 2020 and 2025, respectively. Requirement of foodgrains were projected to be 8269, 9165, 10178 and 11326 thousand tones for the year 2010, 2015, 2020 and 2025, respectively (Table 1). Assam was the main contributing state (more than 70 %) to bridge the gap between supply and demand (with a 2.58 % production growth and 1.73 % population growth), followed by Nagaland and Tripura.

### ICAR and Agricultural Development in Meghalaya with special reference to Ri-Bhoi district

District-wise analysis of Gross Domestic Product (GDP) of Meghalaya during the period of 1994-95 to 2003-04, based on different sources of published secondary data indicated that Ri-Bhoi district achieved highest increment (10 %) in agricultural contribution to primary sector's GDP (includes agriculture, forestry & logging, fishing and mining & quarrying) followed by South Garo (more than 6 %) and East Garo (nearly 6 %) (Table 2). Ri-Bhoi is leading in terms of positive change



**Table 1: Projections of foodgrains production and requirement in North eastern states**

States			Production*					Requirement*				
	CGR (Prod.)	CGR (Popl.)	2005	2010	2015	2020	2025	2005	2010	2015	2020	2025
Arunachal Pradesh	1.30	2.33	217	231	246	263	280	220	246	276	310	348
Assam	2.58	1.73	4733	5375	6105	6934	7876	5234	5703	6214	6770	7377
Manipur	1.96	2.63	416	459	505	557	613	486	554	630	718	817
Meghalaya	1.19	2.62	215	229	243	257	273	469	534	608	692	787
Mizoram	10.37	2.56	-	-	-	-	-	-	-	-	-	-
Nagaland	6.57	4.97	381	524	720	990	1360	443	565	720	917	1169
Tripura	2.25	1.46	584	653	730	816	911	620	667	717	771	829
All	-	-	6546	7471	8549	9817	11315	7473	8269	9165	10178	11326

\* 1000 tons

**Table 2: Contribution of agriculture to GDP of primary sector vis-à-vis districts' total GDP**

Districts	Contribution to GDP (at 1993-94 constant prices)					
	Share to primary sector (%)			Share to districts' total GDP (%)		
	1994-95	1999-2000	Change (%)	1994-95	1999-2000	Change (%)
Jaintia	30.91	32.26	1.35	15.84	16.62	0.78
East Khasi	88.53	92.63	4.10	15.14	14.63	-0.51
West Khasi	75.33	75.44	-0.09	26.33	24.93	-1.39
Ri-Bhoi	80.77	90.82	10.05	26.73	33.71	6.97
East Garo	86.30	92.22	5.92	31.61	37.11	5.50
West Garo	91.71	94.79	3.08	34.42	37.01	2.59
South Garo	42.34	48.70	6.36	26.20	30.35	4.14
Meghalaya	67.45	71.21	3.76	22.10	23.70	1.59

Source: Directorate of Economics and Statistics, Govt. of Meghalaya, 2003.

in contribution of agriculture to district's total GDP, followed by East Garo (more than 5 %) and South Garo (nearly 4 %). But, West Khasi district is showing negative change (- 1.39 %) indicating the agriculture's contribution to district's GDP is declining. The change in per capita income over the same period of time (1994-95 to 1999-2000) indicated that West Khasi District showed highest improvement (more than 49 %) followed by East Garo (32 %), South Garo (31 %), West Garo (30 %) and Ri-Bhoi district (26 %) (Table 3). This result indicates that in Ri-Bhoi district even though agriculture contributes significantly in state's GDP but failed to increase the per capita income, as compared to other districts, like, West Khasi district, in which the change in contribution of agriculture

to district's GDP was negative, but increase in per capita income was highest. This revealed one of the core issues, perhaps the labour force employed in agriculture are either not gainfully employed (may be due to low productivity) or working at sub-optimal level due to technological and geographical backwardness. However, this improvement in income needs further scrutiny because the increase in per capita income has direct bearing with the population growth. District-wise change in population base indicating that Ri-Bhoi district having highest population growth (23 %) followed by West Khasi (16 %) and Jaintia district (15 %). So, Ri-Bhoi district is not only contributing positively to the district's GDP, but also improving the per capita income moderately (26 %) carrying

**Table 3: District-wise change in per capita income vis-à-vis change population**

Districts	Per capita income			Population (000)		
	(in Rs at 1993-94 constant prices)			1994-95	1999-2000	Change (%)
	1994-95	1999-2000	Change (%)			
Jaintia	10515	13092	24.51	245	283	15.51
East Khasi	10352	13013	25.71	579	642	10.88
West Khasi	4748	7097	49.47	244	283	15.98
Ri-bhoi	6708	8465	26.19	148	182	22.97
East Garo	5567	7354	32.10	208	238	14.42
West Garo	6027	7815	29.67	440	498	13.18
South Garo	10483	13696	30.65	85	96	12.94
Meghalaya	8038	10156	26.35	1949	2222	14.01

Source: Directorate of Economics and Statistics, Govt. of Meghalaya, 2003.

a greater population mass with high growth rate (23%), and should be taken as the model district for the development of Meghalaya. The encouraging agricultural development in Ri-Bhoi district can be attributed to several factors, such as, road & market linkages, watershed development programme and the presence of ICAR Research Complex in this district.

#### Constraints in improving productivity of Paddy in Meghalaya

Farm level socio-economic survey was conducted in East and west Khasi Hills covering both the mid and high altitude areas of Meghalaya during the year 2004-05 to focus the appropriate technology that is needed to increase the productivity of rice through improved varieties. The result indicated that average productivity of rice in the mid altitude areas were ranging between 500 to 2500 kg/ha during 2004-05 (Table 4). The wide variability may partly be explained by the extreme diversity in rice ecosystem. In spite of prevailing increasing return to scale (+0.6035) the productivity of paddy can be increased if input intensive programme is implemented, but the main difficulty of implementation is the complex and diverse socio-economic conditions of the farmers. Major constraints identified are: (i) average level of chemical fertilizer application in rice field is very low (maximum 24 kg/ha) and in some cases it is nil. (ii) highest level of achievable (9 %) yield is explained mainly by management factors and partly

**Table 4: Exploration of the potential productivity (Kg/ha) gap of paddy in mid- altitude areas of East Khasi Hills of Meghalaya during 2004-05.**

Ranges of Productivity	Average Yield ( Kg/ha)	Potential Gap	% of farm households
500-699	642 (13.3)	1904	11
700-999	876 (13.3)	1670	7
1000-1199	1156 (7.66)	1390	13
1200-1700	1377 (18.24)	1169	24
1701-2000	1733 (20.02)	813	22
2001-2200	2167 (14.26)	379	7
2201-2500	2383 (13.75)	163	7
2501-3000	2546 (5.65)	-	9

Figures in parentheses show Coefficient of Variation (in %)

by the biotic and abiotic constraint, calls for the target oriented holistic approach both at scientific level and at policy level. At the strategic level, it is possible to bring at least another 14 % farmers among the highest yield group; (iii) in high altitude area farmers preferred to grow local landraces than high yielding varieties. Among the local varieties, *Nonglowai* is mostly preferred (Table 5) even though its productivity (940 kg/ha) was low as compared to other local landraces. The highly differentiated yield rate fluctuation along and across the local landraces is directly reflected by the estimated value of the coefficient of variation (9 to 46 %); (iv) the yield gap between local rice varieties and *Megha I & II* variety is around 563 kg/ha



**Table 5: Variations of productivity and fertilizer application of the local rice varieties in high altitude of East Khasi Hills area of Meghalaya**

Varieties	Number of observation	Average Yield (in Kg/ha)	Variation of productivity*	Average fertilizer application (in Kg/ha)
<i>Thaka</i>	5	1380	13.94	24 (40.07)
<i>Thangsaw</i>	19	880	18.67	17 (16.11)
<i>Nonglowai</i>	27	920	9.09	18 (15.21)
<i>Ethai</i>	6	1320	46.22	21 (42.59)
<i>Leit kynsaw</i>	9	940	22.06	14 (29.09)
<b>Megha I&amp;II</b>	7	1522	27.08	22 (47.13)

\* and Figures in parentheses show Coefficient of Variation in %

whereas at potential level it is around 321 kg/ha (Table 6). But the coefficient of variation is relatively high in case of Megha I & II variety (27.08) than the mostly used local variety (9.09) i.e., *Nonglowai*. This variation may be explained due to adaptability and stability of the local variety. In case of high yielding rice variety like *Megha I & II*, farmers' unwillingness to accept these varieties is not fulfilling their taste. In other words, in the high altitude area, socio-economic reasons are more dominating for low yield and hindering the productivity growth than in mid altitude and valley area where biotic factors plays a major role for the same. For example, even after 12 years of releasing the *Megha I & II* variety, the rate of adoption is only 27 %, calls for participatory mode of breeding programme in new varieties for high hills. Farmers rely mainly on traditional varieties, which are low yielding but seem to be tolerant to some of the

stresses that characterize rainfed ecosystems. Farmers indicate a clean preference for traditional varieties because of characteristics such as cooking quality, aroma, taste, keeping quality of steamed rice and suitability of use as food other than steamed rice.

#### Marketing of Tomato: A case of Ri-Bhoi district

Summer Tomato is widely grown in Ri-Bhoi because of its suitability in Paddy-based cropping system. The Umsning block is largest producer in Ri-Bhoi district and Shillong is major primary market, where bulk of the quantity is disposed off. Small quantities are being sold in local weekly markets. To examine the producer share in consumer rupees primary data from 30 farmers through PRA/Focus Group Discussion and personal interview were collected during 2004. Producers share in consumer rupee was worked out to be 58.65%, which found to be higher than ginger crop (21- 48%) observed during last three years. The marketing cost paid by the farmers was calculated to be 11 % (Rs. 227/q). The gross intermediaries' margin was observed to be 30 %, which includes the total cost paid by intermediaries and margin, retain by intermediaries.

#### Marketing of Pineapple: A case study of Nongpoh market (Ri-Bhoi)

A study was conducted on the production system and the product distribution channel to the ultimate consumers. Three classes of people were interviewed and these were producers, retailers, and the consumers. And many places nearby Nongpoh has been visited specially villages for producers.

**Table 6: Exploration of the Range of potential productivity (Kg/ha) gap of paddy in High altitude area of East Khasi Hills of Meghalaya during 2004-05**

Locally used variety		Megha I & II		Gap	
Range of Productivity	Average (Kg/ha)	Range of Productivity	Average (Kg/ha)	Actual (Kg/ha)	Potential (Kg/ha)
200-400	325	600-1100	783	458	692
401-600	573	1100-1400	1164	591	311
601-800	750	1401-1500	1388	638	87
801-900	900	1501-1700	1475	575	0
<b>Average</b>	<b>591</b>		<b>1154</b>	<b>563</b>	<b>321</b>
<b>C.V</b>	<b>34.52</b>		<b>25.65</b>		



Sample was constituted with 20 producers, 20 retailers, and 30 consumers. Study revealed that the producers who do not have retail shop (65 %) prefer to sell their pineapple produces directly at the wholesale market during market days at Nongpoh. The producers who are also retailers (35 %) have their shops besides the Highway and their target consumers are basically the vehicles plying on the highway. And the rest (10 %) of the producers sell their pineapple produces both at the wholesale market as well as in the retail shops. It has been observed that largely, producers (40 %) prefer Auto for transportation. And nearly 20 % of the producers prefer Jeep for the transportation. And Tempo prefer for transportation by 15 % of the producers. The rest of the producers prefer both Auto and Jeep. The average transportation cost paid for Auto is Rs.11/*kuri* (1 *Kuri* equals 20 pineapples), Jeep Rs.10/*kuri*, Tempo Rs.13/*Kuri* and the rest of the producers pay an average of Rs.10/*Kuri*. More than half of the producers (60 %) considered for survey, sell pineapple up to the worth of Rs 200-400 daily and the average price received by them is Rs17/piece. One-fourth of the sample producers (25 %) sell up to Rs 500 daily and the average price received by them is Rs 17/piece and the rest of the producers (15 %) sell up to Rs 600 daily and the average price received by them is Rs 15/piece. Regarding pre and post harvest losses accrued by the producers, were, non-availability of buyers (30 %), rat infestation (10 %), heat and down market (low price). Mostly the producers (50 %) are facing losses because of not a single reason but of multiple reasons, such as no buyers plus rats, rats plus heat, rats plus down market and no buyers plus down

market. The following observations were made on Pineapple marketing (i) farmers are producing in a very primitive/traditional method as grown as mixed crop with other crops; (ii) efforts made on improved cultivation of pineapple are not satisfactory, necessitates more research on evolving modern production technologies to reduce pre & post harvest losses; (iii) marketing of Pineapple is highly unorganized and mostly sold through small scale and price fluctuation is quite high; (iv) major marketing channels identified were, (a) producer – retailer – consumer (b) producer – wholesaler–retailer–consumer and (c) producer–retailer. (v) Consumers are highly satisfied with the taste and quality of pineapple produced locally. (vi) Government should encourage private entrepreneurship to expand the utilization of Pineapple with more innovative diversification, such as, producing Pineapple Juice with the brand name of ‘Organic Pineapple Juice’ or utilization of leaves to produce fiber etc.

#### Financial viability of agri-horti-silvi-pastoral vis-à-vis shifting cultivation

Three different situations were simulated to resemble progressive farming (Situation I), semi-progressive farming (Situation II) and subsistence farming (Situation III) with several relevant assumptions. Financial viability of the agri-horti-silvi-pastoral farming system model as well as existing shifting cultivation was estimated by using discounted methods, namely, Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) (Table 7). The initial investment amount under the agri-horti-silvi-pastoral system

**Table 7: Financial feasibility of agri-horti-silvi-pastoral farming system model vis-a-vis shifting cultivation**

Situations	NPV (in Rs)		BCR		IRR (in %)	
	WLIV	WOLIV	WLIV	WOLIV	WLIV	WOLIV
Situation I	53833	37024	1.32	1.20	46	37
Situation II	24092	11270	1.21	1.10	30	22
Situation III	12953	1747	1.16	1.02	24	15
Shifting cultivation	1265	-	1.07	-	16	-

WLIV and WOLIV represents with livestock and without livestock component, respectively



calculated (at 2004-05 current prices) to Rs. 29040 per ha (includes 488 man-days labour) for land development and terracing (half-moon terrace, contour bunding and bench terrace) activities. Results show that NPV was found to be favourable under all the Situations including shifting cultivation. But the magnitude of profitability was substantially higher (Rs. 37024 per ha) under Situation I as compared to other Situations (Rs. 11270, Rs. 1747 and Rs. 1265 under Situation II, III and shifting cultivation, respectively). Similarly, other criteria, namely, BCR and IRR also indicate that the present farming system under study (agri-horti-silvi-pastoral) farming system is a financially viable option for investment activity. Again the magnitude of profitability varies in different Situations, such as, BCR were 1.20, 1.10 and 1.02 under Situation I, II and III, respectively. Benefit cost ratio under shifting cultivation (1.07) shows that the investment is just viable and similar to Situation II. Financial feasibility criteria, IRR depicts that all the investment made in different Situations as well as under shifting cultivation are viable option with varying range of profitability. All the IRR values (37, 22, 15 and 16 % under Situation I, II, III and shifting cultivation, respectively) were observed to be higher than the discount rate (14 %) suggesting the viability of investment. The feasibility study indicated that the agri-horti-silvi-pastoral farming system model is definitely a viable option for investment activity under different Situation if the availability of capital (particularly initial investment) not a constraint. However, financial feasibility study also reveals that shifting cultivation cannot be termed as an absolutely non-viable option for investment considering the low economic status and poor resource base endowment with the *jhum* cultivators, as it requires low investment. So, the farming system research should be focused on improvement of shifting cultivation rather than complete weaning it out. Financial feasibility study also investigates the change in profitability due to incorporation of livestock component in the farming system model. Result depicts that magnitude of all the investment criteria (NPV, BCR and IRR) improves substantially due to livestock component, irrespective of Situations under consideration. This re-confirms the importance of livestock component in the farming system models.

#### **Dynamic change in Bovine Population in Meghalaya in last two decades**

In last two decades w.e.f. 1983-84 to 2002-03 there is dynamic change in bovine population in Meghalaya. The population of milch crossbred cows increased from 8.4 thousand to 15.4 thousand numbers. There is increasing trend in the population of indigenous (158.2 thousand to 212 thousand) but not so rapid as compared to crossbred cows. Buffaloes population decline from 10.1 thousand numbers in 1983-84 to 5.3 thousand numbers in 2002-03. Milk production in Meghalaya increased from 40.2 thousands tons in 1983-84 to 67.6 thousands tons in 2002-03, mainly due to increase in crossbred cows population. The contribution of crossbred cows increased from 38.61% to 59.32% in last two decades. There is a decline in milk production contribution from indigenous cows and buffaloes. The contribution of indigenous cows milk production decreased from 51.49% to 38.17% w.e.f. 1983-84 to 2002-03. The contribution of milk production from buffaloes decreased from 9.70% to 2.51% during the period 1983-84 to 2002-03. This decrease is mainly due to the decrease in buffaloes population. Maximum increase in milk production was 68.16% in 2002-03 and minimum increase in milk production was 1.74% in the year 1987-88 as compared to base year 1983-84. In last two decades milk production from crossbred cows increased @ 5.19% and milk production in buffaloes declined @ 3.71%. The increase in indigenous cow milk production was only 0.67%. In this During 1993-84 to 2002-03, milk production in crossbred cows increased at the rate of 5.79% per annum where as buffaloes milk production declined at the rate of 6.40% per year. There was 30.53% variability in milk production from crossbred cows and 25.74% variability in buffalo's milk production w.e.f 1983-84 to 2002-03. The variability is mainly due to change in population of crossbred cows and buffaloes. Total variability in milk production was 15.44%.

#### **Growth Pattern of Egg Production in Meghalaya: An Empirical Analysis**

In 1986-87 increase in *desi* population was 7.63% as compared to 1985-86 in which increase in number was 13.35%. In 1989-90 increase in number was 9.53% as compared to previous years



1988-89 in which increase was 13.98%. Again in 1991-92 increase in number was 13.77% as compared to 1990-91 in which increase was 13.98%. After 1991-92 there was increase in population of *desi* fowls and maximum increase was 58.26% in 2002-03. During the analysis period from 1983-84 to 2002-03, the production, number and yield of poultry shows a positive growth trend (Table 8). Instability in Poultry production, number and yield were analyzed through coefficient of variation and it was observed that instability in egg production was highest for improved poultry with 38.13% variation. Total variation in egg production was 16.78%.

**Table 8: Compound growth rates in production, number and yield of poultry**

Particulars	Desi	Improved	Total
Production	2.43**	7.18**	2.91**
Fowls (no)	2.24**	6.91**	6.48**
Ducks (no)	-0.56	-7.42*	-1.09
Fowls & Ducks (no)	2.54**	7.22**	2.79**
Yield	-0.06**	-0.07**	0.09**

\*Significant at 5% level of significance  
\*\* Significant at 1% level of significance

## XI. INTEGRATED MODEL WATERSHED DEVELOPMENT IN NORTH EASTERN REGION

### GENERAL DESCRIPTION:

A project for development of three integrated model watersheds in the North Eastern Region was initiated with a total planned budget of Rs.90.00 lakhs. Wah Umroi watershed in Meghalaya, Peren-Jalukie watershed in Nagaland and Sajung watershed in Sikkim was selected for development as a model watershed. A total sum of Rs 20.15 lakhs was released for all the three model watersheds in the financial year 2003 – 04 and 2004 – 05.

### PHYSICAL PROGRESS OF WORKS

#### Wah Umroi Model Watershed (Meghalaya)

Location of the model watershed is in between longitude 25° 41' 5" and 25° 45' N and latitude 91° 55' 5" E to 91° 59' 7" E in RiBhoi Dist. of Meghalaya encompassing an area of 1612.5 ha. Within the watershed, development works were taken up in five different sub watersheds – Umroi (235ha), Mawthai (60 ha), Umeit (22.5 ha), Mawpun –I (77.5 ha) and Mawpun –II (137.5 ha).

Progress made till the end of year 2004-05 is as follows:

- Basic investigatory works for proper planning of Wah Umroi watershed has been completed.
- Altogether 11 nos. of Self Help Groups (SHGs) were formed to activate the people participations in the development process of the watershed.
- A CC water storage tank of 7000 litre capacity for harnessing the spring water for domestic and livestock consumption was constructed at Umeit village as an Entry Point Activity (EPA) programme.
- Two training programmes on fruit preservation, household decoration, Soya milk production etc have been conducted for farmwomen of Umroi and Umeit village.
- A cowshed for housing a unit milch cow has been constructed and milch animal provided to beneficiary at Mawpun.
- Seven hectare of land was developed by constructing contour bunds and halfmoon terraces for horticulture and agroforestry plantations in Mawpun sub watershed.
- A state level training programme was conducted as part of the capacity building of the functionaries engaged in the watershed programmes in the region.
- Contour bunding as soil conservation measure was done in 3 hectare land for gradual development of terraces for crop production.
- Drainage line treatments were undertaken. Construction of stone sausage dam, retaining wall and rectangular weir has been completed.



- A bamboo – framed poly house for the purpose of production of seedlings/nursery have been constructed at Mawpun.
- Three water harvesting ponds at Mawthei are in progress.

Various activities undertaken under Mawpun and Umroi are depicted in figures (1-9)



Fig. 1. Check dam -Gabion (Mawpun)



Fig. 2. Stone masonry and gabion retaining wall (Mawpun)



Fig. 3. Rectangular weir cum diversion wall (Mawpun)



Fig. 5. Plastic lined pond at hilltop (Mawpun)



Fig. 6. Earth dam and masonry chute spillway (Mawpun)



Fig. 7. Fishery pond at Mawpun

#### Jaluki – Paren Model Watershed in Nagaland

The Jaluki -perern Model Watershed is located in the Jaluki/Peren District of Nagaland. The development activities were undertaken at two locations (i) Peren (50 ha) and (ii) Jaluki (450 ha).





**Fig. 8. Pond water utilisation through Sprinkler**



**Fig. 9. Watershed at Umroi**

The land in Peren is on hill slope while Jaluki lies in the foothills. The basic activities and investigations for formulation of development process according to the action plan laid out are partly completed.

Progress made during the last two years is detailed below:-

- Five training programmes and visits were conducted for the beneficiaries.
- Contour bunding, landlevelling, preparing drainage channels and laying out of plots were completed in the hills at Peren (3.4 ha) and in the foot hills at Jaluki (7.4 ha).
- Pit digging for planting horticulture saplings are completed. Soybean and maize etc were grown as agronomical crops.
- Different horticulture crops/plants planted at both the sites were:

Assam lemon	= 250 nos ( Jaluki site)
( Assam lemon variety)	
Round lemon	= 250 nos ( „ )
(Rangpur lime variety )	
Pineapple	= 19,000 ( „ )
( Kew- 900 nos & suckers	
Queen – 1000 nos )	
Banana	= 350 ( Peren site)
( Dwarf Cavandis – Jahaji)	
Sweet orange	= 300 nos ( „ )

- In addition to above plantations of horticultural plants like Passion fruit ( 1000 nos), Lichi ( 50 nos) , Banana ( 1000 nos ) Papaya ( 800 nos) etc are in progress at Jaluki ( Nagaland)

The progress made at the site is depicted in figures (10-12)



**Fig. 10. Fishery-cum-duckery demonstration in Jaluki watershed**



**Fig. 11. Piggery unit in Jaluki watershed**





Fig. 12. Pineapple plantation in Jaluki watershed

#### Sajung Model Watershed at Sikkim

The land and socio- economic survey of the watershed area is in progress. Self Help Group was formed at Sajung village and efforts to form more are being made. Three farmers training programme were conducted in collaboration with KVK Sikkim to enhance the skill and knowledge of the farmers for growing improved varieties of field and horticultural crops. A temporary small office cum goodown facility has been created at the watershed site.

Soil conservation measures and land shaping works are planned. Input support to farmers of the watershed for growing crops like potato, mustard, field pea were provided to the farmers in the watershed. Cultivation of passion fruit is encouraged by supplying planting material.

#### Financial requirement:

The financial requirement for basic activities and development works in the three model watersheds were met from fund available under NWDPRP funded by Ministry of Agriculture, Department of Agriculture and Cooperation, New Delhi. However, from next financial year funds may be required from Institute budget to take up the developmental activities in the above three model watersheds. Six water harvesting structures, contour bunding and bench terracing, horticultural and agroforestry plantations and inputs to the crop productions are planned in the next financial year.

#### Mawlangkhar, West Khasi Hills, Meghalaya

**Implementing Agency:** ICAR Research Complex for NEH Region, Meghalaya.

**Location:** Mawlangkhar, Nongstoin, West Khasi Hills.  
(25°32' 14. 6" N & 91°21' 55.5" E).

**Year of Initiation:** 21.10,2003

**Date of completion:** December 2008.

**Watershed Size:** -

**Area** : About 20 ha.

**No of families involved:** 50 families.

#### Objectives:

1. To assess the technology developed by the institute
2. To introduce improved technologies for improvement in crops, fruits, vegetables, fish and animal production, and
3. To develop technological skills of the local manpower in participatory mode.

#### Initial Status:

- Wasteland, wetland and rainfed farming systems
- Monocropping and use of low yielding local cultivars
- *Bun* and *Jhum* cultivation,
- Absence of HYV vegetables
- Low productivity, unemployment and low income.

#### Interventions made:

- Detailed survey of the area for watershed development, based on the land capability.
- Diagnostic and socioeconomic survey to assess socio economic condition of the farmers in the watershed.
- Water harvesting structures in community land were constructed while two farmers ponds were renovated
- Construction of bench and half moon terraces.
- Introduction of HYV crops
- Introduction of sub-tropical temperate fruits,
- Introduction of improved pigs and rabbits
- Composite fish culture.

- Interface meeting with NABARD, state agricultural officials, ICAR scientists and farmers were arranged.

#### Major Achievements:

**1. Water harvesting ponds:** Two ponds in community land were developed.

The main pond of the watershed (Pond.1) has the following components: -

- Pond dimension: 49 m x 26 m x 1.80 m
- Capacity: 2.293 million liters.
- Dyke made of stones and soil.
- Stone pitching on the dyke slopes from inside to stabilize the dyke
- Retaining wall / toe wall made of stone, cement and sand to hold the pressure of the dyke soil and stones in inner side of the dyke.
- Pitching the top of the dyke with grass blocks
- A spill way to drain excess water (0.9 m x 1.0 m)
- An emergency spill way to drain water during flooding (Fig.13)



Fig. 13. Main water harvesting pond of Mawlangkhar watershed

- A drainage pipe with valve in the dyke bottom to drain water with gravitational flow for irrigation, fishing etc. and
- Two diversion channels in both sides of the pond to reduce excess pressure of water load to pond during heavy rains.

The pond No. 2 on the upper ridge of the main pond is relatively smaller and shallower.

- The most significant point in the construction and renovation of all the watershed pond is that local farmers actively participated in the construction and development process (Fig. 14).



Fig. 14. Newly constructed terraces at the Watershed site, Mawlangkhar

#### 2. Analysis of soil samples:

Soil samples were collected from different locations of watershed and analyzed for various parameter. Soil reaction was highly acidic in nature and the pH of soil ranged between 4.87 and 4.91. Organic carbon varied from 1.48 to 1.70 %, whereas available N, P, K, ranged between 170 to 220; 1.3 to 2.6 and 290 to 390 kg/ha, respectively.

#### 3. Cultivation of potato:

Seven quintals of potato (variety Kufri Jyoti) in 2004 to 35 farmers and eight quintals (Kufri Jyoti, Kufri Megha and Kufri Giriraj) to 40 farmers in 2005 were distributed. Encouraging results were obtained especially in first year ( 20-25 t/ha as compared to 13-15 t/ha obtained with local varieties) .

The farmers of the watershed showed keen interest in growing both the high yielding potato cultivars i.e., K. Jyoti and K. Giriraj.

#### 4. Cultivation of vegetables:

- Efforts are on to introduce and intensify tomato hybrid Avinash-2 , capsicum variety California Wonder was introduced and sweet potato variety Sonipat-2 in farmers field. Sweet potato performed very well (25 t/ha).



## 5. Rice Cultivation:

Following interventions were made:

- Line planting introduced (20 x 15 cm) to get optimum population and for better intercultural operations.
- Along with farmers' practice of applying low dose of manure (5 t FYM/ha), low dose of NPK (40; 30; 20 Kg /ha) was advocated depending upon the resources available with the farmers.

Four rice cultivars (Megha rice 1 & 2, Vivek Dhan 82 and RCPL 1-87-8) was tried in farmers field in 2004. Megha 1 & 2 (2.3- 2.5 t/ha) gave at par yield with local varieties. Among these varieties, Vivek Dhan 82 has potential if planted earlier as it has produced good growth and yield attributes, however grain filling was poor.

## 6. Fruits:

- 3 pear varieties i.e. William, Fertility, Lagun and 3 varieties plum i.e. Santarosa, Japanese plum and Davis plum planted,
- 2 peach varieties planted i.e. Shan-e- Punjab and TA 170.
- 2 passion fruit varieties (Kaveri hybrid and Meghalaya local) were introduced.

## 7. Composite fish culture:

- Composite fish culture involving surface feeder 40% (Catla, silver carp and puntius/java punti), Column feeder 30% (Grass carp and rohu), and bottom feeder 30% (mrigal, common carp and goni) were adapted both in community pond and farmers pond.
- Around 2000 fingerlings were released in 2004 @ 1 fingerling/sq.m.
- The institute supplied concentrate feed.
- Feeding technique was (e.g. Feed tray, quantity and timing of feeding etc.) was given by the scientists.
- After 10 months of stocking it was observed that grass carp attained maximum average weight (370 g/fish) followed by common carp. The performance of exotic carp was good especially the grass carp mainly because of availability of grasses to fish from pond as well as from outside. The growth of other fishes were not up to the mark mainly because of improper feeding.

## 8. Animal husbandry.

### (i) Rabbits:

- One unit each (two female and one male) of rabbit (New Zealand White) were distributed to two farmers.
- The second unit was returned back from first farmers and given to another farmers.
- The farmers already started marketing the rabbits and there is good local demand.
- The farmers made the housing of their own with locally available materials. Design was given by the scientists of ICAR. Growth was found to be about 14g/day.
- In four kindling litter size at birth and at weaning was 6.50 and 6 respectively.

### (ii) Pigs:

- Five unit (Two female and one male constitute one unit) upgraded pig having 75% Hampshire and 25% Meghalaya local inheritance was given to the farmers.
- The farmers made excellent housing with concrete and tin roof by taking design guidance from scientists.
- They are using local grasses, vegetables viz., carrots, raddish, squash, mash feed of rice bran, rice polish, kitchen waste, salt and mineral mixtures etc. as pig feed.
- Average growth was found to be 110 g/day weight at birth was 4.5kg.

## 9. Distribution of farm implements:

Two paddy thresher and ten maize shellers were distributed to the villagers.

## 10. ITK identified:

The following ITK's were identified

(i) *Grass block pitching* on terrace risers and embankments: Farmers practice of grass block pitching on terrace risers and embankments to strengthen their stability and also reduce soil erosion. The cubes of grass blocks are artistically arranged in layers similar to masonry works.

(ii) *Thonglong or soil piling in rice field*: Crop residues and weed biomass are put in a heap and covered by slicing the top soil of the field and left for 3-4 weeks as such. After that the soil is again spread uniformly over the field and rice is

cultivated. It is found to be a good practice as it allows better decomposition of organic matter and improve soil physical parameters due to exposure to sun. It may also reduce the problems of pest and diseases in rice.

**(iii) Locally available two non-traditional fodder for feeding cattle, pig and rabbits.**

- *Chloris barbata* (DM: 66.25 %, CP: 14.07%, CF: 23.20%, EE: 9.93%, TA: 7.35 % & NEE: 45.45 %).
- *Erianthus rufipilus* (DM: 41.16 %, CP: 10.49 %, CF: 33.38 %, EE: 1.77 %, TA: 10.37 % & NEE: 43.99 %).

**Financial details of the project at Mawlangkhar : (2004 - 05)**

Sl. No	Particulars	Amount (Rs.)
1.	Construction and renovation of watershed ponds (4 nos.)	2,17,425.00
2.	Construction of terraces	30,000.00
3.	Economic and diagnostic survey	7,600.00
4.	Animal/fish supplied to the farmers/ watershed	28,636.00
5.	Field demonstrations (crops/fruits/vegetables)	32,380.00
6.	Vehicle charges (hired)	21,023.00
7.	Contractual services for supervision @Rs.2000/month	34,000.00
8.	Miscellaneous (Stake holder meeting/boards etc.)	17,705.00
	<b>Total</b>	<b>3,88,769.00</b>



## 4. NUMBER OF PUBLICATIONS

Divisions/Centres	Research Papers	Popular articles	Technical Bulletins	Technical Folders	Books Chapters	Books	Abstracts
Agronomy	3	1	-	-	-	-	3
Soil Science	15	2	-	-	2	-	11
Plant Breeding	5	-	-	-	2	-	-
Horticulture	11	6	-	-	-	1	4
Water Management	1	-	-	2	-	-	4
Agril Extension	6	-	-	-	-	-	8
Agril Economics	9	-	-	-	-	-	2
Agril Engg	6	3	2	-	10	1	8
Entomology	2	2	1	1	2	-	8
Plant Pathology	4	-	-	-	1	-	3
Animal Production	18	1	-	-	2	-	8
Animal Nutrition	8	-	-	-	1	-	6
Vet. Parasitology	5	-	-	1	-	-	2
Animal Health	14	4	-	0	6	1	17
Fishery	8	-	-	-	1	-	2
Agroforestry	10	-	2	-	1	-	13
<b>Centres</b>							
Arunachal	3	-	1	-	2	1	2
Manipur	16	6	-	-	4	1	7
Mizoram	2	2	-	8	1	-	5
Nagaland	2	4	-	-	1	-	2
Sikkim	8	1	1	1	1	-	13
Tripura	9	18	1	5	2	1	19
<b>Total</b>	<b>165</b>	<b>50</b>	<b>8</b>	<b>18</b>	<b>39</b>	<b>6</b>	<b>145</b>

## 5. DISTINGUISHED VISITORS

### Umiam, Meghalaya (HQ)

1. Prof V.L. Chopra, Ex D.G. ICAR, Dr. Panjab Singh, Ex D.G. ICAR and Prof. R.B. Singh, Ex. Chairman ASRB visited the institute on 23<sup>rd</sup> April 2004.
2. Dr. R.K. Samanta, Director, NAARM, Hyderabad visited the institute on 19<sup>th</sup> August 2004.
3. Dr. S.S. Baghel, V.C., A.A.U., Jorhat visited the institute on 25<sup>th</sup> August 2004.
4. Dr. H.S. Gupta, Director, VPKS, Alroma visited the institute on 5<sup>th</sup> October 2004.
5. Shri H.Donkumar Roy, Agriculture Minister Govt. Meghalaya visited the institute to inaugurate the Kishan Mela on 29<sup>th</sup> October 2004.
6. Dr. M.S. Swaminathan, Chairman NCF visited the institute on 22<sup>nd</sup> November 2004.

### Mizoram centre

1. Pu. H. Rammawi, Hon'ble Minister for Agriculture, Govt. of Mizoram visited the centre on 8.12.2004 and appreciated the work carried out by the scientists of the centre.

### Tripura centre

1. Dr. P. Rai, Director, National Research Centre for Agroforestry, Jhansi, visited the centre on 28-29 April 2004.
2. Dr. R.P. Singh, Director, Project Directorate on Poultry, Rajendranagar, Hyderabad visited the centre on 30<sup>th</sup> April 2004.
3. Dr. N.S. Talekar, Entomologist, Asian Vegetables and Rapeseed Development Centre (AVRDC), Taiwan visited the centre on 19<sup>th</sup> August 2004.
4. Dr. S.N. Shukla, ADG (Food & Fodder Crops), ICAR, New Delhi visited the centre on 23<sup>rd</sup> August 2004.
6. His Excellency, Governor of Tripura, Shri Dinesh Nandan Sahaya visited the centre on 6<sup>th</sup> September 2004.
7. Dr. G.L. Kaul, Chairman, Technology Mission (Hort), Govt. of India, New Delhi visited the centre on 19<sup>th</sup> November 2004.
8. Shri Manik Sarkar, Hon'ble Chief Minister, Govt. of Tripura visited the centre on 15<sup>th</sup> December 2004.
9. Smt. Elizabeth Kerkhoff, ICIMOD, Khumaltar, Kathmandu visited the centre on 13<sup>th</sup> January 2005.
10. Dr. Mathura Rai, Director, IIVR, Varanasi visited the centre on 28<sup>th</sup> February 2005.
11. Dr. R.P. Tiwari, Director, National Research Centre for Mushroom, Solan visited the centre on 29<sup>th</sup> March 2005.



### **Nagaland centre**

1. Dr. sarath Illangantileke, Regional Leader, International Potato Research Centre, South West and Central Asia visited the centre on 21<sup>st</sup> July 2004.
2. Dr. William Thrope, Regional Representative for Asia, International Livestock Research Institute (ILRI) visited the centre on 21<sup>st</sup> July 2004.
3. Dr. Kirti Singh, Ex-Chairman, ASRB (ICAR) visited the centre on 14<sup>th</sup> November 2004.
4. Dr. S.P. Ghosh, Ex-DDG (Hort) visited the centre on 14<sup>th</sup> November 2004.
5. Dr. K.R. Solanki, ADG (AF), ICAR, New Delhi visited the centre on 19<sup>th</sup> February 2005.

### **Sikkim Centre**

1. Dr. Mangala rai, Secretary, DARE & Director General, ICAR visited the centre on 27<sup>th</sup> November 2004.
2. Dr. J.S. Samra, DDG (NRM), ICAR visited the centre on 27-28 November 2004.
3. Dr. G. Kaloo, DDG (Hort), ICAR visited the centre on 27<sup>th</sup> November 2004.
4. Dr. S. Ayyapan, DDG (Fisheries), ICAR visited the centre on 27<sup>th</sup> November 2004.
5. Dr. Sushil Kumar, ADG (An. Science), ICAR visited the centre on 26<sup>th</sup> November 2004.
6. Ms. Kerrilee Lepointe Neepawa, Agronomist, Monkiba, Canada visited the centre on 2<sup>nd</sup> February 2005.

## 6. CONTRIBUTORS

**Dr. K.M.Bujarbaruah, Director**

### HEAD QUARTERS -MEGHALAYA

Dr. Y.P.Sharma, Joint Director

### AGRONOMY

Dr. G.C.Munda, PS  
Dr. D.C.Saxena, Sr.Sc  
Dr. U.K.Hazarika, Sr.Sc  
Dr. A.S.Panwar, Sr.Sc  
Dr. D.P.Patel, Scientist (SS)  
Dr. Rajesh Kumar, Scientist(SS)  
Dr. Anup Das, Scientist

### AGRICULTURE EXTENSION

Dr. N.Prakash Sr. Sc.  
Dr. P.P.Pal, Sr.Sc  
Dr. Rajesh Kumar, Sr.Sc

### AGRICULTURAL ENGINEERING

Dr. K.K.Satapathy, PS  
Sri M.B.Tamanhkar, Scientist (SG)  
Er. K.N.Agarwal, Scientist(SS)  
Er. R.K.Singh, Scientist(SS)  
Dr. U.S.Saikia, Scientist  
Er. Arvind Kumar, Scientist  
Dr. M.M.Selvan, Scientist  
Dr. T.D.Lama, Scientist  
Dr. B.K.Rao, Scientist

### SOIL SCIENCE

Dr. Patiram, PS  
Dr. Kailash Kumar, Sr.Sc

Dr. Vinay Kumar Mishra, Sr.Sc  
Dr. B. Majumdar, Scientist(SS)  
Dr. K.Laxminarayana, Scientist(SS)  
Dr. M.S.Venkatesh, Scientist(SS)  
Dr. R.Saha, Scientist

### HORTICULTURE

Dr. D.S.Yadav, PS  
Dr. N.Rai, Sr.Sc  
Dr. K.Dinesh Babu, Scientist  
Dr. R.K.Yadav, Scientist  
Dr. Satish Sanwal, Scientist  
Dr. R.K.Patel, Scientist  
Dr. Rajeev Kumar, Scientist  
Shri Akath Singh, Scientist

### PLANT BREEDING

Dr. K.R.Dhiman, PS  
Dr. A.Pattanayak, Sr.Sc  
Dr. Jibon Mitra, Sr.Sc  
Dr. S.Gupta, Sr.Sc  
Dr. D.K.Verma, Scientist(SS)  
Dr.(Mrs) Promila Devi, Scientist(SS)  
Dr.(Mrs) Alpana Das, Scientist(SS)  
Dr. Annadurai, Scientist  
Smt. Rajkumari, Scientist

### PLANT PATHOLOGY

Dr. A.K.Singh, PS  
Dr. Satish Chandra, PS  
Dr. Pankaj Baiswar, Scientist



#### **AGRICULTURE ECONOMICS AND STATISTICS**

Dr. K.K.Dutta, PS  
Dr. A.K.Tripathy, Sr.Sc  
Sri Med Ram Verma, Scientist  
Dr. S.Mandal, Scientist

#### **AGROFORESTRY**

Dr. B.P.Bhatt, Sr.Sc  
Dr. J.M.S. Tomar, Scientist

#### **ENTOMOLOGY**

Dr. N.S.Azad Thakur, PS  
Dr. A.N.Shylesha, Sr.Sc  
Dr.A.Kalaishekhar, Scientist  
Sri Sachin Suroshe, Scientist  
Sri Kanchan Saikia, Scientist  
Dr. M.H.Kodandaram, Scientist

#### **ANIMAL NUTRITION**

Dr. B.P.S. Yadav, PS  
Dr. J.J.Gupta, Sr.Sc  
Dr.Dipika Murugkar, Scientist (SS)  
Dr. S.Doley, Scientist  
Dr. P.Baswareddy, Scientist

#### **FISH AND FISHERIES SCIENCE**

Dr. B.K.Mandal, PS  
Dr. B.K.Mahapatra, Sr.Sc  
Dr.Vinod .K., Scientist (SS)  
Dr. Sulip Kumar Majhi, Scientist

#### **VETY.PUBLIC HEALTH**

Dr. H.Rahman, PS  
Dr. Ashok Kumar, Sr.Sc  
Dr. B.R.Shome, Sr.Sc  
Dr.(Mrs) R.Shome, Sr.Sc  
Dr. H.V.Murugkar, Sr.Sc  
Dr. I.Shakuntala, Scientist

#### **VETY.PARASITOLOGY**

Dr. S.Bandopadhyay, Sr.Sc

#### **POULTRY SCIENCE**

Dr. S.C.Saxena, PS  
Sri Santosh Hounshi, Scientist

#### **ANIMAL REPRODUCTION**

Dr. Anubrata Das, PS  
Dr. R.K.Bordoloi, PS  
Dr. S.K.Das, Sr.Sc  
Dr. Shyamal Naskar, Sr.Sc  
Dr. M.H.Khan, Scientist

#### **CENTRE**

#### **ARUNACHAL PRADESH**

Dr. L.C.De, Sr.Sc, Incharge Joint Director  
Dr. S.K.Sarangi, Scientist (Agronomy)

#### **MANIPUR**

Dr. S.V.Ngachan, Joint Director  
Dr.(Mrs) Mausumi Roy Choudhury, Sr.Sc  
Dr. S.Raychoudhury, Sr.Sc (Soil Chem)  
Dr. B.Narsimha Rao, Sr.Sc (Hort)  
Sri I.M.Singh, Scientist (Seed Tech)  
Dr.S.Basant Singh, Scientist(Agril.Econ)  
Dr. B.B.Panda, Scientist (Agro)  
Dr. Vijay Pal, Scientist (Pl.Breeding)  
Sri C.L.Ramalu, Scientist (VPH)  
Dr. B.K.Behra, Scientist (Fishery)  
Dr. Anjani Kumar Jha, Scientist (Hort)

## **MIZORAM**

Dr. K.A.Pathak, Joint Director  
Dr.Kamta Prasad, Scientist,SS (Agril. Extn)  
Dr.A.Kumaresan,Scientist (An. Repr)  
Dr. A.K.Vishawkarma, Scientist (Agro)  
Dr. Kundan Kishore, Scientist (Hort)  
Dr. Brajendra, Scientist (Soil Chem)

## **NAGALAND**

Dr. C.Rajkhowa, Joint Director  
Dr. Naresh Babu, Sr.Sc (Hort)  
Dr. H.D.Karmkar, Scientist(Vety. Micro)  
Dr. S.S.Ghadge, Scientist (Agrl.Extn)  
Dr. S.S.Rathore, Scientist (Agro)  
Dr. S.Dilli Rao, Scientist (Agrl.Ento)  
Dr. M.Karunakaran, Scientist (An.Reprod)

## **SIKKIM**

Dr. L.S.Srivastava, Joint Director  
Dr. R.K.Awasthe, Sr.Sc (Soil Sc)  
Dr. Nazrul Haque, Sr.Sc (An. Nutrition)  
Dr. Ramesh Singh, Sr.Sc (Hort)  
Dr.(Smt) S. Toppo, Sr. Sc (An. Nutrition)  
Dr. Ramesh Chandra, Scientist(SS) LPM  
Sri Matvar Singh, Scientist (AF)  
Sri R.Kuruppaiyan, Scientist (PB)  
Sri K.Ramesh, Scientist (Agril.Ento)  
Dr. P.K.Panda, Scientist (Agro)  
Dr. Z.B.Dubbal, Scientist (VPH)  
Dr. Ashok Kumar, Scientist (Hort)

## **TRIPURA**

Dr. N.P.Singh, Joint Director  
Dr. M.Dutta, PS (Soil Sci)  
Dr. Subrata Biswas, Sr.Sc(Pl. Path)  
Dr. T.K.Sengupta, Scientist SG (Pl.Path)  
Dr. S.K.Ghosh, Scientist SS (An.Repr)  
Dr. B.Santosh, Scientist (Fishery)  
Dr. C.Dutt, SS (AN)  
Dr. Jai Prakash, Scientist (Hort)  
Dr. M.Sankaran,Scientist (Hort)  
Sri D. Ram Gopal, Scientist (PB)  
Dr. S.Pandian, Scientist (Agrl.Extn)  
Dr. M.Niranjan, Scientist (Poul.Sci)  
Dr. S.P.Das, Scientist (PB)



## 7. कार्यकारी-सारांश

प्रतिवेदित अवधि के दौरान संस्थान के 136 वैज्ञानिकों ने 206 शोध परियोजनाओं, 40 राष्ट्रीय कृषि अनुसंधान परियोजनाओं व नौ तदर्थ एवं अखिल भारतीय समन्वित परियोजनाओं पर कार्य किया। इसके अतिरिक्त किसानों के खेतों पर कृषि पद्यातियों के तकनीकी मान्यकरण के लिए 18 परियोजनाएं चलाई गईं।

फसलों पर आधारित शोध कार्यों में मणिपुर केन्द्र द्वारा निचली भूमि के लिए उपयुक्त प्रसाद x आईआर 24 से व्युत्पन्न धान की किस्म आरसीएम-10 का विमोचन किया गया जिसकी उपज 6 टन/हेक्टेयर है। यह प्रध्वंश प्रतिरोधी किस्म, किसानों के खेतों पर चलाए जा रहे कार्यक्रम के अन्तर्गत भी, 6 टन/हेक्टेयर की उपज दे रही है। संस्थान के सभी केन्द्रों ने उपयुक्त प्रजातियों का परीक्षण कर, शस्य पैकेज के साथ, संबंधित राज्य सरकारों को प्रयोग के लिए दी हैं। त्रिपुरा केन्द्र ने टीआरसी 87-25 और वन्दना किस्म से तैयार की गई संकरण प्रजाति टीआरसी-2000-36-1-1 का सफलतापूर्वक मूल्यांकन करने के साथ-साथ उच्चभूमि संकरणों (एफ-5) की उन्नत पीढ़ी भी उत्पन्न की। इसके अतिरिक्त 14 स्थानीय झूम वंशक्रमों और 5 सुगंधित वंशक्रमों के मूल्यांकन के अलावा स्थानीय सुगंधित वंशक्रम, कालीखासा, का शुद्धिकरण भी किया गया है। बड़ापानी (मेघालय) में 42 में से 16 उन्नत पीढ़ियों का चुनाव उच्चभूमि के लिए किया गया जिनका भविष्य में, झूम-भूमि में, परीक्षण किया जाएगा। इसी क्रम में पराग संवर्धित वंशक्रमों डीएच 18 और डीएच 239 का चुनाव फार्म में मूल्यांकन हेतु किया गया। निचली भूमि के लिए 11 जीनप्रारूपों का परीक्षण किया गया। मणीपुर और नागालैंड के 38 स्थानीय कृषिजोपजातियों (कल्टीवर) का, पोषण-गुणों की जानकारी के लिए, विश्लेषण किया गया।

बड़ापानी (मेघालय) में विकसित cry/A(c) जीन वाले सभी चार ट्रांसजेनिक वंशक्रमों में सक्रिय जीन की सिंगल कापी का समावेश था। लम्बी अवधि वाले जंगली धान के एक पूर्वजकों (क्लोन्स) के इन्विट्रो संरक्षण के लिए एक प्राटोकाल विकसित किया गया। स्थानीय खरपतवारों से प्राप्त दो बायोआर्गनिक की 2% सान्द्रता के घोल से उपचारित धान की जड़ों की वर्षद्धि के परिणाम अत्यन्त उत्साहवर्धक (185 और 225% वर्षद्धि) रहे। गोबर की खाद की विभक्त मात्राओं का एन.पी.के. के साथ प्रयोग करने से उच्चभूमि धान की आर.सी.पी.एल 1-29 किस्म की अच्छी उपज (26.5 क्विंटल/हेक्टेयर) प्राप्त हुई। जैविक उर्वरकों के प्रयोग के बाद भी सूक्ष्म जैविक समष्टि वानस्पतिक खाद (विशेषकर चीड़ की पत्तियों) के प्रयोग से पोषण अंतग्रहण क्षमता और अवशिष्ट मष्दा उर्वरता में वर्षद्धि हुई। धान के खेतों से लिए गए मिट्टी के नमूने प्रकृषति में अत्यधिक अम्लीय थे तथा उनमें फॉस्फोरस और जिंक की मात्रा कम, पोटेशियम की मध्यम तथा जैविक तत्व अधिक पाए गए।

धान के रोगों और नाशकीटों के रासायनिक एवं जैविक माध्यमों से प्रबन्धन संबंधी उपलब्धियों से धान उत्पादन की प्रक्रियाओं के लिए एक पूर्ण पैकेज विकसित किया जा रहा है।

मक्का, जो दूसरी मुख्य खाद्यान फसल है, की उपयुक्त प्रजातियों की पहचान करके, उनमें से सर्वोत्तम किस्मों को खरीफ तथा रबी मौसम के लिए लोकप्रिय बनाने के प्रयास भी किए जा रहे हैं। बेबी कॉर्न (आर.सी.बी.सी.) पॉप कॉर्न (आर.सी.पी.सी.) एवं स्वीट कॉर्न (आर.सी.एस.सी.) के विकसित वंशक्रमों के मूल्यांकन तथा निदर्शन का कार्य भी किया जा रहा है। मक्का की सात प्रविष्टियों को सौर-माह के पांचवे दिन बुआई करके, वर्षभर मक्का उत्पादन की सम्भावनाओं पर प्रयोग किए गए। किसानों के खेतों पर, नाशकीटों

एवं व्याधियों के प्रबंधन के पैकेज के प्रयोग सहित, अग्र पंक्ति निदर्शन कार्यक्रम किए गए। भुट्टा बेधक के पूर्ण नियंत्रण के लिए 15 अप्रैल को मक्का की बुआई करना लाभदायक पाया गया। जिंक (6 कि. ग्रा/हेक्टेयर) का गोबर की खाद और चूने के साथ प्रयोग करने से अधिकतम उपज (53 क्विंटल/हेक्टेयर) प्राप्त हुई।

दलहनों के कार्यक्षेत्र में पहले से चिन्हित किए गए प्रकाश-संवेदी और प्रकाश-असंवेदी वंशक्रमों के चार संकरणों का मूल्यांकन पुष्पण-अनुक्रिया के लिए, खरीफ-पूर्व मौसम में, किया गया। राइसबीन के दो आशाजनक जीनप्रारूपों की भी पहचान की गई।

दलहन जैव-तकनीक कार्यक्रम के अन्तर्गत कर्षण जीवाणुओं की मध्यस्थता रूपान्तरण विधि द्वारा यिक पी की प्रारोह-कालिका और बीजपत्र-व्युत्पन्न कैलाई को रूपान्तरित करने के प्रयास किए गए। डीएनए फिंगर प्रिन्टिंग एवं विविधता विश्लेषण कार्यक्रम के तहत राइसबीन जनन-द्रव्यों के 50 कोर जीन-प्रारूपों की विविधता विश्लेषणता पर प्रयोग भी किए गए। राइसबीन जीनों में से सूक्ष्म-सैटेलाइट वाले अनुक्रमों के पथक्करण के भी प्रयास किए गए। इसी प्रकार के प्रयोग अन्य केन्द्रों पर भी उड़द, मूंग, फ्रेंचबीन और लोबिया आदि दलहनों पर किए गए।

तिलहनों के जननद्रव्य मूल्यांकन कार्यक्रमों के अन्तर्गत सोयाबीन के 167 जननद्रव्य वंशक्रमों का परीक्षण किया गया जिनमें से 10 जीनप्रारूप आशाजनक पाए गए। तीन रासायनिक दो वानस्पतिक और एक जैव-नियंत्रण कारक का परीक्षण सोयाबीन के किट्ट रोग का नियंत्रण करने के लिए किया गया और फलियों की अंगमारी व्याधि संबंधी परीक्षण भी किए गए। मूंगफली के 43 गुच्छ-प्रारूपों और 35 विस्तारण-प्रारूपों का भी मूल्यांकन किया गया।

तोरिया पर जैविक स्त्रोतों के वानस्पतिक पोषको के प्रभाव के अध्ययन के लिए किए प्रयोगों के अन्तर्गत एन.पी.के के साथ अजोला कम्पोस्ट के प्रयोग (2.5 टन/हेक्टेयर) से अधिकतम (12.7 क्विंटल/हेक्टेयर) पैदावार हुई। संस्थान के सभी केन्द्रों पर तिलहन फसलों पर समन्वित पोषण प्रबंधन, जैव उर्वरकों के

प्रभाव, रोग एवं नाशकीटों के प्रबंधन और उपजातियों के परीक्षण का कार्य किया जा रहा है। अम्लीय मृदा सहायता के लिए सरसों की किस्म पर किए परीक्षणों से पता चला कि खूड़ों में चूने का प्रयोग, सरसों उगाने के लिए लाभदायक है। सरसों के एफिड के नियंत्रण के लिए कीटनाशकों और वानस्पतिकों के प्रभाव का भी अध्ययन किया गया।

बागवानी के क्षेत्र में मुख्य फलों जैसे खासी मैन्डारिन, लैमन, अमरुद, आड़ू, पैशनफ्रूट आदि पर शोध कार्य किए गए। खासी मैन्डारिन के 11 उद्गम स्थानों में से सी.आर.एस -3 और सीआरएस -5 के पौधों की ऊंचाई तथा व्यास अधिकतम था। पॉली हाउस में “साफ्ट वुड ग्राफिटिंग” विधि सफलतम पाई गई। खासी मैन्डारिन की प्रजातियों *सी.जम्बीरी*, *नाइटी जम्बीर* एवं *सी.लेटीपस* के प्रकंद सर्वोत्तम पाए गए जिनकी सफलता प्रतिशत 82-92 के बीच रही। मादा जननेद्रियों से निकाले गए अशोधित फेरोमोन प्रयोगशाला (60%) और फील्ड परिस्थितियों (40%) में नर बीटल को आकर्षित करने में प्रभावी सिद्ध हुए। विभिन्न लैमन प्रजातियों की वृद्धि निष्पादन क्षमता की तुलना की गई। सभी केन्द्रों ने अपने-अपने क्षेत्रों की आवश्यकतानुसार विभिन्न फलों की किस्मों का परीक्षण तथा उनके प्रबंधन के लिए उपयोगी कृषि तकनीकों का विकास किया।

मिजोरम केन्द्र पर विभिन्न फलों जैसे केला, पैशनफ्रूट, अमरुद और अनन्नास आदि के लिए उर्वरकों और खादों के साथ जैव कारकों जैसे *एजोस्पाइरिलम* एवं फास्फोरस में विलेयशील रोगाणुओं की मात्रा का मानकीकरण किया। त्रिपुरा केन्द्र में अनन्नास के उत्तम फलों के उत्पादन के लिए रोपण किए जाने वाले पौधों की गुणवत्ता तथा रोपण सधनता का मानकीकरण किया।

शाक सुधार कार्यक्रम के अन्तर्गत बैंगन के बीस लम्बे और पांच गोल प्रारूपों और टमाटर की चार म्लानि रोग प्रतिरोधी आशाजनक किस्मों के जनन सुधार कार्य पर शोध शुरू किया गया। मेघालय एवं त्रिपुरा में बैंगन के तना एवं फल-बेधक के नियंत्रण के लिए समाकलित कीट प्रबंधन तकनीकों का, किसानों के खेतों पर, निदर्शन किया गया।



अखिल भारतीय समन्वित अनुसंधान योजना के तहत इस क्षेत्र के लिए उपयुक्त एक फ्रेंचबीन वंशकम, (SeI-35), भारतीय बीन (आरसीडीएल-115) के बारह वंशकम और लोबिया की एक किस्म (आरसीसीपी -1) पर बहु स्थानिक परीक्षण आरम्भ किए गए हैं।

पशुपालन शोध कार्यों के अन्तर्गत कायोप्रीजरवेशन के दौरान सूअर के शुक में शुक्राणुओं की जीवन-क्षमता को प्रभावित करने वाले भौतिक एवं रासायनिक प्राचलों का पता चला। परिरक्षण के दौरान सूअर के शुक्राणुओं की डी.एन.ए. अखंडता का मूल्यांकन करने के लिए “कॉमेट एसे” (Comet Assay) का प्रयोग किया गया। किसानों के यहां तथा संस्थान में सूअर एवं खरगोश उत्पादन तकनीकों पर आधारित प्रयोग किए गए। इन प्रयोगों में जानवरों के स्वास्थ्य की देखरेख और पौषणिक पहलुओं जैसे सूअरों के लिए कॉर्न-सॉइ एवं शकरकन्द आधारित पद्यतियां एवं बकव्हीट-सॉइ आधारित भोजन या केवल सोयाबीन आदि खिलाने के प्रयोग भी शामिल थे। इन प्रयोगों के उत्पादकता और जनन संबंधी परिणाम किसानों के यहां और संस्थान स्तर पर अभिलिखित किए गए। स्रोत आधारित भोजन पद्यति के परिणामों से सिद्ध हुआ कि कॉर्न-सॉइ आधारित भोजन, सूअरों के लिए, ब्याँत के बाद तथा विकास की अवस्था के लिए, किफायती होता है। डीएल-मेथ और कवक मिश्रित डीआरपी-सॉइ में कॉर्न-सॉइ का अनुपूरण लाभदायक होता है। कोइलर चूजों के लिए कॉर्न-सॉइ आधारित भोजन पद्यति का मुख्य खनिजों एवं सूक्ष्म मात्रिक तत्वों से प्रबलीकरण करना चाहिए। वनराजा प्रजाति के सफल रवीकरण के बाद इनकी उत्पादकता के अध्ययन के लिए इन्हे किसानों को दिया गया। शाकीय एवं अशाकीय यकृत उत्तेजकों ने वनराजा कुक्कुट की उत्पादकता में वृद्धि की।

आण्विक तकनीकों जैसे आरटीपीसीआर द्वारा क्लासिकल स्वेन बुखार और रोटावायरस संक्रमण की पहचान, पीसीआर द्वारा *एश्चेरिकिआ कोलाई* एवं *सालमोनेला* की उग्रजीनों की पहचान, *क्लॉस्ट्रीडियम परफ्रिजेन्स* और *बोर्डेटेला ब्रॉकीसेप्टिका* का आण्विक प्रारूपण और उप-प्रारूपण, *ईसोफेगोस्टोम* और *व्यूनोस्टोम* परजीवियों के प्रतिरक्षाजनी अंशों का

SDA-PAGE द्वारा पथ्यकरण एवं पहचान का कार्य और इन परजीवियों का पता लगाने के लिए “वेस्टन ब्लाटिंग” और “डॉट एलीजा” आदि का मानकीकरण करके प्रयोग किया गया।

मत्स्य पालन के क्षेत्र में नागालैंड से 38 वंशों के 17 कुलों और 4 गणों की 71 सजावटी मछलियां अभिलिखित की गई हैं। चाकॉलेट महाशीर के प्रयोगशाला में प्रजनन और लारवा के पालन-पोषण संबंधित प्रयोग सफलतापूर्वक किए गए। जेब्रा डेनिओ पर किए गए अध्ययन से पता चलाता है कि इसकी जनन-क्षमता परिवर्तनशीलता में शरीर के वजन, लम्बाई और अंडाशय के वजन की लगभग 91% की भागीदारी है। प्लवक (प्लैक्टॉन) के मिश्रित संवर्धन के लिए खाद के रूप में प्रयोग किए जाने वाला बतख का मल मछलियों का मुख्य भोजन होता है। लाल टाइलैपिया के भोजन के लिए बतख का मलमूत्र अन्य पशुओं के मलमूत्र की अपेक्षा बेहतर पाया गया। मूल्यांकित की गई चार खरपतवारों में से *जी.परवीफ्लोरा* ग्रास कार्प के लिए बहुत अच्छा भोजन है। मेघालय के सात गावों के चौबीस मछलीपालने वाले किसानों को कार्प मछली के संवर्धन की तकनीकी जानकारियां दी गई जहां इन मछलियों की उत्पादकता के अच्छे परिणाम मिल रहे हैं।

कृषि-बागवानी फसलों- मत्स्य-पशुधन के विवेकपूर्ण संयोजन से 6 विभिन्न सघन समाकलित खेती पद्यति मॉडल विकसित किए गए हैं। इन खेती पद्यतियों में उत्पादकता, एकल कृषि पद्यतियों की अपेक्षा, 10 गुनी अधिक थी जो परिवारिक स्तर के लिए भोजन उपलब्धता और पौषणिक सुरक्षा के लिए उपयुक्त है। यह सभी पद्यतियां पारिस्थितिकता की दृष्टि से उपयुक्त एवं किफायती है। सघन खेती पद्यति की फसल-मत्स्य -दुग्धशाला-मशरूम-वर्मीकल्चर, इकाई से सबसे अधिक आर्थिक लाभ (1:1.76) हुआ और द्वितीय स्थान पर कुक्कुट-फसल-मत्स्य -बतख-बागवानी (1:1.58) ईकाई रही। गहन खेती पद्यतियों के जैविक स्वरूप को बनाए रखने के लिए वर्मी कम्पोस्टिंग के द्वारा सारे फसल अवशेषों, फसल उपोत्पादों और खरपतवारों का इसी पद्यति में पुनःवकरण किया गया।

नांगपोह (मेघालय) और झालुकी (नागालैंड) में किसानों के खेतों पर समाकलित खेती पद्धति मॉडल विकसित किए गए जिनमें अन्न फसलों, मछलियों, पशुधन और बागवानी फसलों का समाकलन था। सूअर और मछलियों के समाकलन से मछलियों की उत्पादकता 30.0 क्विंटल/हेक्टेयर रही। किसानों के खेतों पर पाले जाने वाले पशुधन में वनराजा, बकरी, खरगोश, बतख और दूध देने वाले पशु शामिल थे। संस्थान द्वारा उच्चभूमि के लिए विकसित धान

की किस्मों की, किसानों के खेतों पर, उत्पादकता (30.0 क्विंटल/हेक्टेयर) अच्छी रही।

उपयुक्त कार्य-कलापों के अतिरिक्त संस्थान में क्षेत्रीय एवं राष्ट्रीय स्तर पर गोष्ठियों, विचार-गोष्ठियों/कार्यशालाओं का आयोजन करने के साथ-साथ विभिन्न विभागों के कर्मचारियों और किसानों के लिए अनेकों प्रशिक्षण कार्यक्रम भी किए गए। इस क्षेत्र के सभी राज्यों के सरकारी विभागों के साथ इंटरफेस बैठकों का भी आयोजन किया गया जिनका उद्देश्य अनुसंधानयोग्य मुद्दों की पहचान करना था।



