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ANNUAL REPORT

भाकृअनुप
ICAR

ANNUAL REPORT

2009-10

भाकृअनुप-कृषि
ICAR-RC-NEH

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

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PREFACE

ICAR Research Complex for NEH Region, a premier institute under the Natural Resources Management division of Indian Council of Agricultural Research, has been promoting and conducting research, extension and human resource development activities in agriculture and allied sectors for hilly and mountain ecosystem of North Eastern Hill Region. The institute has been striving hard through activities in its various divisions to maximize the needed output aimed at fulfilling its goals.

It gives me immense pleasure in presenting the Annual Report 2009 – 2010 of the institute. The report depicts the research achievements and other significant activities during the period. The institute conducted research, extension and training in various branches of Agriculture, Animal Sciences, Fisheries and Agricultural Engineering. Major accomplishments in natural resources management, watershed management, farming system research, crop sciences, animal sciences, fisheries, technology transfer are included in the report. The institute initiated various new studies / projects during the year under NAIP, DBT and Institute funded projects.

The report has been compiled through collective efforts of HODs, scientists and technical staff of the institute. I wish to express my sincere appreciation to all of them for their whole hearted support and cooperation in carrying out various functions and activities of the institute.

I sincerely thank the Editorial Committee for compiling, editing and bringing out the report.

I hope this publication will be of use and informative for the scientific fraternity engaged in hill agricultural research of National Agricultural Research System.

(S. V. Ngachan)
DIRECTOR

CONTENTS

1. EXECUTIVE SUMMARY

Research work conducted during 2009-10 at Head Quarters Meghalaya and its six regional centres are summarized below:

Under crop production, rice genotypes RCPL 1-115 and RCPL 1-116 yielded 3.87and 2.39 t/ha respectively compared to check Bhalum 1(1.86 t/ ha) under upland ecology. Genotypes Aaha, N-861, Chankimaso, IORO epyo, Megilai, Kulu fiirii, COL 4 etc. were found suitable for bioprospecting. Total crude protein contents in 29 test cultivars ranged from 5.24% to 13.85% and amylose content from 4.04 to 29.71%. Phosphate use efficiency was double in RCPL-1-160 compared to Shahsarang and Ngoba. One hundred seventy-nine entries were found to be resistant against rice blast disease. Field monitoring of virulence of *Pyricularia oryzae* was done. The highest tryptophan content was recorded in Maize cv. 'CML-172' with 0.76%. Higher productivity of maize was achieved by the application of paper mill sludge and lime (10% LR) in acid soils organic amendments. When applied without lime; FYM, poultry manure and weed biomass significantly improved soil hydro-physical properties. Twenty-nine maize genotypes were found resistant to Turcicum leaf blight; variety Vivek Maize Hybrid-15 recorded the lowest stem borer infestation (5.83%).Maize cv. Local yellow showed minimum cob borer infestation (4.13%). Pea lines VRP 373, VRP 316, VRP 281 and EC 881123 were found resistant to pea rust and powdery mildew. Thiamethoxam 25%WG @ 0.2 ml/l showed 66.49 % reduction over control against pod boring weevil (*Apion clavipes*) in pigeon pea. Biny and M-27 genotypes recorded very less incidence of aphids, *Pieris brassicae*, painted bug and saw flies. The application of lime and organic manure were equally effective in increasing the productivity of soybean and groundnut as compared to recommended dose of fertilizer. Estimated yield losses ranged 17 to 73% due to soybean rust disease among genotypes. Soybean genotypes MAUS 417 and DBS 2 were identified as high yielding and low yielding resistant genotypes respectively. In Bio-technology, a grafting method was standardized for establishment of putative transformed shoots of gram. Microsatellite markers for rice bean were developed.

In fruit crops, the maximum graft success (80%) was through wedge and tongue grafting in an under utilized fruit Sohiong (*Prunus nepalensis*). Physical and biochemical studies of *Sohiong* fruit were under taken. Protocols for ready to serve *Sohiong* and passion fruit beverage, *Sohiong* jam and tooty-fruity from Chow- chow were developed. *Khasi* mandarin showed maximum plant height (2.75 m) and rootstock diameter (5.3 cm) in grafted plant on *C. reshni* rootstock. Spray of Bavistin @2g/liter of water reduced scab disease up to 93%. Nisarga @ 6 g/l recorded 61% reduction in citrus scab disease. A survey was conducted in citrus orchards of Government and progressive farmers of Meghalaya; Tinsukia district of Assam and Lohit district of Arunachal Pradesh to assess *Phytophthora* diseases. Imidaclopid (0.075%) treated plants recorded the lowest numbers of larvae /twig in case of citrus leaf miner (*Phyllocnistis citrella*). Among the botanicals, karanjin (2%) recorded the lowest number of larvae. Seven districts of Meghalaya were surveyed for disease problems of Arecanut. Red palm weevil (*Rhynchophorus ferrugineus*) infestation was recorded for the first time on Arecanut. In vegetable, Cherry tomato recorded the highest yield/ plant (2.49kg). The highest yield per plant (1.9kg) was recorded in Megha Tomato-10 under net house. BT-1 and MT-1 were found resistant and To-017 and Rocky were found susceptible to early blight. Brinjal var. RCMBL– 2 recorded the highest yield of 35.84 t/ha. The highest yield (52.00 t/ha) was recorded in colocasia var.White Gauriya. Sweet potato var. Kokrajhar Local recorded the highest total tuber yield (29.41 t/ha). Karanjin @ 0.2 % controlled cabbage butterfly (*Pieris brassicae*). Seed treatment with thiamethoxam 25% WG gave complete protection against the sucking insect pests for 35 days after germination. *Beauveria bassiana*, brought 68.63 % reduction in population of *Mylabris pustulata* on okra.

In spices research, ginger var. Nadia recorded the highest yield (28.50 t/ha) followed by

MeghaTurmeric-1 (25.33t/ha) and Lakadong (20.00 t/ha). *Trichoderma* based formulations increased the yield without reducing foliar diseases. Maximum productivity of turmeric was with100% recommended NPK + 20% LR of agricultural lime + 1.5 t/ha weed biomass (*Ambrosia* sp.). Packaging was developed for long distance transport of ginger.

Thirty-seven gerbera genotypes and 25 hybrids were evaluated. Gerbera cv. Lion and Hybrid RCGH57 produced maximum number of flowers i.e.157/ m2 and 12/m2, respectively.

In cropping system research, total system productivity was highest with groundnut-capsicum (15.94 t/ha). The maximum toria equivalent yield was recorded with French bean (5.26 t/ha). Higher yields in ginger (11.1 t/ha) and turmeric (15.9 t/ha) were obtained with application of FYM +vermicompost with soybean *in-situ* green manuring. Different food and fodder crops were grown in various farming systems and productivity, economics were studied.

In Agricultural Engineering research, 12 different types of agricultural tools and equipments were manufactured and sold. Rain shelter and LDPE lined pond were designed for strawberry cultivation and evaluated in farmers' field.

In Agri- Extension research, gender issues in pig production and technology adoption and perception were studied. Adoption rate was found to be 50.5%. Inventory of pig production technology was prepared.

Soil profile moisture content was studied in conventional and conservation tillage, respectively. Liming study indicated when acid soils dropped below pH 5.3 and % base saturation was less than 66% of effective CEC; there would be probability to get the response of lime. Thirteen provenances of *Jatropha curcas* were evaluated for growth and yield traits.

In biodiversity, true identity of powdery mildew pathogen was established. Several pathogens were recorded as new reports.

In mushrooms, *Pleurotus florida,* recorded the highest yield of 77 kg/100kg straw in strain PF 01 followed by strain PF 04 (71.8 kg). Wet bubble disease in button mushroom was observed in severe form during survey in Laitdiengsai village, East Khasi hills Meghalaya.

Total requirement of meat + poultry for the seven states of northeastern India for the years 2010, 2015, 2020 and 2025 was projected to be 505.74, 560.89, 623.21 and 693.89 thousand tons respectively.

In animal sciences, study on preservation of boar semen indicated that 18°C tended to induce acrosome reaction and reduced acrosomal integrity. The fertility of liquid boar semen was reduced after 72h of storage at 18°C in BTC. Study on estrogen receptor gene in pig was carried out. The incidence of reproductive disorders in dairy cattle in Meghalaya was recorded. Semen evaluation of Assam hill Buck was done. In animal health, surveillance, monitoring and investigation of disease outbreaks in the region were done. Isolation, identification and characterization of *Listeria monocytogenes* recovered from animal and environment samples were done. RAPD analysis of *A. hydrophila* was studied. In animal parasitology research, *Strongyle* sp. (53.03%), Strongyloides sp. (9.09%), *Moniezia* sp. (0.75%) and *Eimeria* sp. were detected in faecal samples of goats. Three blood samples of cattle, out of 29 collected from slaughter house were found positive for *Theileria* sp. and *Babesia* sp. 59.29% samples were found positive for coccidial infection in rabit. *Dermanyssus gallinae*, red mite of poultry was also detected in 100 *Gallus domesticus* birds of about 18 weeks of age.

Feeding complete feed blocks having 1:1 roughage to concentrate ratio, with chopped and ground paddy straw to crossbred HF lactating dairy cattle resulted in an increase in the daily average milk production and intake of DM, with a smaller reduction in the digestibility of nutrients. Some potential probiotic organisms for livestock and poultry were identified. Phytase supplementation@ 2.0 lac units / 100kg feed in the diets of swine, based on rice polish (70% of total concentrate) was found sufficient for proper utilization of P. Quantification of available biomass for swine feeding was done.

In Arunachal Pradesh Centre, the maximum rice grain yield of 3.96 t/ha was recorded with var.VL61+ one spading at the time of transplanting under puddle condition. The maximum grain yield was recorded by rice var. Luit + *Tephrosia* (4.25 t/ha) green pods of pea var.TRCP8 (2.33 t/ha). Aromatic rice var. Kalajoha recorded the highest

grain yield (1.78 t/ha) in 5th May transplanting with 100% RDF. Mung bean var. SM9-165 recorded the highest seed yield (0.93 t/ha).The maximum groundnut pod yield (2.88 t/ha) was obtained in var. GG7with P50+K100+lime+FYM. Under AICRP on rice, of the 220 test entries screened against leaf blast, only six entries showed resistance. In another trial 11 varieties showed resistant reaction. Toria var.TS-38 recorded 0.28 t/ha yield. Cowpea (var. Kashi Kanchan) – okra was the most profitable crop sequence. In pineapple, broad leaved weeds were less in 2, 4-D (1.5 kg a.i. /ha) and Glyphosate (1.5 lit/ha) treatment and grasses were less in Alachlor treated plots. The highest yield was recorded from colocasia local (15.0 t/ha). Higher yield of *Khasi* mandarin was recorded when crop received drip irrigation at 1.0 Epan covered with black polythene.

In Mizoram Centre, upland rice varieties RCPL 1-101 (2.33t/ha) and RCPL 1-96 (2.25 t/ha) were found high yielding. Among low land varieties, UPL 1.5 (4.78 t/ha) was the best. In IVT trials, entry no. 2305 recorded 4.92 t/ha grain yield. In maize, Vivek QPM 9 (7t/ha) and Vivek HYB 31 (6.99 t/ha) were found at par in grain yield. In groundnut var. ICGS 76, spraying of Colemanite @ 2 kg/ha was found at par with 20 kg/ha soil application of boron. Maximum groundnut pod yield 2.31 t/ha was recorded in *Rhizobium* + P50 treatment in var. ICGS 76. In black gram, RCRT BG 09-20 recorded 0.93 t/ha in pre *Rabi.* In green gram RCRT Mo9-23 (0.57 t/ha) and Mo9-9 (0.57 t/ha) were found at par. In lentil spacing of 30x10cm gave 0.62 t/ha yield in var. VL 307. Application of vermicompost increased yield by 37% in lentil and 31% in rice bean.

In plant protection research, population dynamics of insect pests of rice, maize, fruits and vegetables were studied and peak infestation periods were recorded. Overall fruit fly catches were greater in guava (41%) followed by chilly (36%) and tomato (23%). IPM practices for major insect pests of fruits, vegetables and spices were developed.

In vegetables, 30 land races of French bean from Mizoram and 24 exotic collections from outside sources were used for variability study. Sixteen genotypes of *Capsicum annum*, 2 variants of *C chinense* and *C. frutescene* were collected. Cultivation of French bean var. Arka Komal and okara var, Prabhani Kranti was found most profitable. Thirteen genotypes of chow chow were collected. Cabbage var.KGMR-1and Golden Acre was found best. In carrot var. Nantes, application of 50-75% of RDF + vermicompost @ 2.5 t/ha + mulching was found to sustain the yield even under 50% of irrigation water.

Under AICRP on spices, turmeric genotypes Duggurala (56.4 t/ha), Pratibha (51.2 t/ha), Roma (49.5 t/ha) and RCT-1(49 t/ha) were identified for cultivation in Mizoram. Ginger cultivars viz. Nadia, Himgiri, Mahima and Varda were found most productive. Under Network Research Project on 'Management of Soft Rot of Ginger', a survey was conducted in Kolasib, Bukpui and Nisapui area and genotypes were collected.

Under NAIP, improved technology for citrus, passion fruit, and banana cultivation were introduced to farmers. The productivity of pea cv Arkel, ranged from 60-80 q ha in various farmers' field when planted during 1st week of November. The okra cv. Arka Anamika recorded 7-10 t/ ha yield in various farmers' fields.

In animal science research, litter size was studied in Large White Yorkshire (LWY) sows. Feeding trials were conducted in piglets for a period of 5 months. The feed cost was significantly reduced with supplementation of *Spilanthus* sp and *Ipomea batata*.

In Sikkim Centre, maize var. Vivek Sankul Makka-11 recorded yields from 1.6 to 4.45 t/ha under organic nutrition. In soybean-mustard rotation, soybean var. PK-1024 recorded 3.24 t/ha yield with neem cake 1 t/ha+ mixed compost 2.5 t/ ha + dolomite. Mustard var. M-27 sown in the same soybean plots under INM and irrigated once at the flowering stage, recorded the highest grain yield (8.12 q /ha) with urea + SSP + MOP @ 30:30:30 + dolomite @ 2 t/ ha + neem cake @ 0.5 t/ ha. The yields of rice varieties - Pant Dhan-10, VL Dhan-61 and Pusa Sugandh-II and one local cultivar 'Attey' under organic nutrition ranged from 2.32 to 3.84 t/ha compared to controls (1.20 to 1.64 t/ha). The yellow stem borer was dominant pest followed by striped borer. Spiders, Dragon flies and Coccinellid beetle were some potential natural enemies in rice ecosystem of Sikkim. Twelve rice varieties were found promising against rice pests

The highest grain yield (1.55 t /ha) of buckwheat was recorded with organic nutrition.

The degree of polyembryony in mandarin and Rough lemon was 65.30 and 62.80 %, respectively. Physico-chemical and sensorial attributes of Sikkim Mandarin were studied. The major mandarin growing belts of Sikkim were found infected with CTV by DAS-ELISA test. *Bacillus thuringiencis* (Delfin 3G) was found most effective to control lemon butterfly while Agrospray (Servo) was found effective against aphids and leaf miners in Sikkim Mandarin. Methyl eugenol + Ethanol + Malathion (4:5:1) was found best trap for fruit fly and trapped 40.54 adults/week. Strawberry var. Chandler and Ofra were found promising and recorded fruit yield of 800g/plant and 750g/plant, respectively. In chilli germplasm, maximum fruit yield/plant was recorded in Collection-6 (1.27 kg/plant). Cherry pepper cultivation recorded calculated return of Rs. 10.0 lakhs / year. Mulching in cherry pepper with *Schima wallichi* recorded minimum (21%) wilting compared to control (75%). Sprinkler irrigation in vegetables increased yields by 15%.

In animal nutrition research with fodder, the lowest methane production was observed in Tapioca root (37.23%) followed by tree fodder *Ficus bengalensis* (38.74%). Reproductive disorders of bovine were studied. Studies on genetic improvement of Sikkim local goats for litter size were undertaken. Twinning and triplet incidence were 42.11% and 10.53% respectively. Biometrical performance was also studied.

In animal health research 8.23% milk samples were found positive for mastitis by CMT. The major bacterial pathogens recovered were *Staphylococcus* and *E. coli.* The antibiogram study against 18 different antibiotic discs showed the highest sensitivity to enrofloxacin followed by chloramphenicol and tetracycline. Yak faecal samples collected from Gnathang village of East Sikkim showed enteric pathogen *E. coli* (53.8%). The samples were negative for *Salmonella.* An overall prevalence of 31.31% helminthic infestation was observed. Occurrence of GI helminthic infestation was higher in goats (52.02%) than in cattle (22.37 %) and yaks (14.86%). *Haemonchus* was the most prevalent parasite in all three animals throughout the year in Sikkim.

In Manipur Centre, a new rice var. from Manipur RCM-21 (IET 20193) was identified and recommended for valley and terraced areas of Meghalaya and Manipur. The mean yield of RCM-21 was recorded 5.68 t/ha. Six new rice cultures developed at the Centre were recommended for IVT-IM and IVT-IME of AICRIP. Five rice lines (medium duration) with 9.07-9.57 t/ha yield were identified. Data were collected on eighteen DUS traits under INEVDUST for characterization. The pigeon pea variety CORG 2001-05 showed the highest yield (2.01 t/ha). Tomato var. RCT-9 showed resistance against water logging and bacterial wilt. RCT 3 was found best yielder (45.5 t/ha). Brinjal var. RCMB 10, recorded the highest yield (31.00 t/ha). Colocasia var. RCMC 2 showed higher yield (30.91 t/ha). Turmeric var. RCMT-7 recorded the highest curcumin (8.6%) and yield (28.7 t/ha). Application of 25% N through vermicompost +75% N through urea was the best for maximizing the yield of King chilli (1.50 kg/plant). Application of vermicompost @ 8 t/ha + *Azospirillum* + PSB was found best for broccoli (18.68 t yield /ha). For oyster mushroom production, paddy straw followed by banana pseudostem were found best substrates.

In Nagaland Centre, analysis of 12 years weather data (1998-2009) on annual and monthly rainfall distribution and potential evapotranspiration (ET_o) indicated that there was a decreasing trend in the total rainfall pattern over the years. A case study on the water poverty mapping based on household surveys in Lampong Sheanghah village of Mon District showed that all the households fared very poorly in terms of the most components of the water poverty index. Among the aromatic rice lines tested, the highest yield was recorded in IET 16313 (4.77 t/ha). In groundnut, the maximum yield was recorded in FESEG- 10 (3.04 t/ha). In rapeseed and mustard varietal testing the maximum yield was recorded in PT-303 (2.32 t/ha). Under AICRP trial on linseed, Line 90221 exhibited the highest grain yield (0.67 t/ha). Under Nucleus/Basic Seed Production Programme ,10,000 nos. of Assam lemon cuttings, 5000 nos. of *Khasi* mandarin seedlings, 1000 nos. of rough lemon seedlings, 5000 nos. of black pepper cuttings, and 50 kg French bean seeds were produced. Molvum provenance of Jatropha exhibited the highest plant height (2.55 m). Intercropping was not found suitable with groundnut, sesamum, green gram and paddy in the

under storey plots of Jatropha. In all, 43.5 ha of degraded lands were rehabilitated through agroforestry interventions. Large Black and Ghungroo breeds of pig were studied for growth performance. Pathogenic bacteria of zoonotic importance were isolated from pigs and their environments. The study on Axone, a fermented product of soybean revealed the probiotic value for pigs which significantly improved weight gain in suckling and in growing pigs. Further, it protected piglets against diarrhoea, it had no significant effect on humoral immune response against *Salmonella choleraesuis*.

In Tripura Center, rice var.TRC 2005 -3 was promoted to AVT 1. In yield trials, IET entry no. 21531 recorded highest grain yield (8.39 t/ ha) under irrigated condition. Under IRRI – INDIA upland shuttle breeding network project entry no RR 509-6-B-2 recorded highest grain yield (4.0 t/ ha). IR 82589-B-B-2-2 recorded 2.81 t/ha under OYT (stress) trials. Less susceptible genotypes against sheath blight disease were identified. *Pseudomonas fluorescens* (Guard) controlled sheath blight and increased the yield. Field pea genotype TRCP - 8 was released by His Excellency the Governor of Tripura, Dr. D. Y. Patil. Groundnut var.GG-13 produced the highest pod yield (2.88 t/ha). The varieties like, FeESG-10 and FeESG-8 showed high leaf spot disease incidence (disease score: 6.33 – 6.70) although FeESG-10 was resistant to rust. The tomato vars. Trishul and All rounder were tolerant to leaf curl disease of tomato.

In Jatropha, four trials, viz., progeny trial, agri-silviculture trial, package of practices and multi national trials were undertaken under National Network Programme on Jatropha. Soil samples (0-15 cm) were collected from 31 farmers' club in South Tripura for soil health analyses.

In Agroforestry, various crops were grown in association with forest tree species and their productivity was studied.

In animal science research, phenotypic characterization for variation in kidding size in Black Bengal goats was done. A pilot study on productive and reproductive traits of 'Mali' pigs was undertaken. In poultry, 6,200 nos. of good chicks of different varieties / lines of poultry were supplied to the farmers under AICRP on Poultry Breeding Programme. Performance of Gramapriya male × Deshi black female cross and performance of 1st generation of Tripura Local Germplasm (Black) were studied. Genetic improvement studies of growth and production traits of Japanese quail were undertaken.

2. INTRODUCTION

ICAR Research Complex for NEH Region, a premier institute in the field of hill agriculture and allied sector research, development and extension in tribal and backward areas has completed 34 years of its service to the tribal farmers, development departments, NGOs and other stake holders in NE India. As per the QRT recommendations, the 18 divisions have been clubbed into 10, including bio-technology and fisheries. Out of 10 divisions, the scientists of six divisions are engaged not only in technology generation and dissemination but also in tacking regular post-graduate classes of CPGS, CAU, Barapani. To promote the open and distant mode of education, ICAR has signed an MOU with IGNOU in 2007 and established programme study centre for agriculture and allied sciences.

To meet the requirement of different regional problems of research, interdisciplinary mode of projects has been undertaken with 90 projects spread over headquarters and different regional centers. Further 23 external funded projects including Department of Science and Technology, Department of Biotechnology, National Research Institute, National Horticulture Board, National Medicinal Plant Board, National Board for Agricultural and Rural Development, International fund for Agricultural Development etc. Twelve All India Coordinated Research Projects, 5 Network projects and collaborative projects are being undertaken.

While strategies for technology generation for achieving food sufficiency is the focus point of the institute, newer areas of research viz. bio-prospecting, precision farming, crop bio-dynamics, allele mining, climatic change and carbon sequestration, conservation agriculture and market intelligence and dynamics has also been initiated. The institute has also focused on water productivity analysis, crop diversification with wheat/floriculture, bamboo and fruit tree based agro-forestry system, development of soil health card, crop weather monitoring modules, promotion of organic agriculture, action research on farming system, development of diagnostic kits for animal disease, quality control issues eg. SPS, gender friendly agri-business and IT based information and dissemination. Strength of biodiversity in the region with special reference to rice, pulse, horticultural, medicinal and aromatic plants, fisheries and livestock has been explored.

Thrust areas

- To evolved 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 agro climatic 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.

Human resources

i. Institute

Category	Sanctioned	Filled	Vacant
RMP	7	7	-
Scientific	184	94	90
Technical	255	236	19
Administrative	133	114	19
Supportive	114	105	9

ii. KVKs

Category	Sanctioned	Filled	Vacant
Scientific	13	5	8
Technical	143	129	14
Administrative	26	16	10
Supportive	26	23	3

Budget

Head	Allotted (Rs. in Lakh)	Expenditure (Rs. in Lakh)
Plan	800	799.83
Non -Plan	4378.9	4378.49

Library

Nature of publication	No. of copies available
Books and reports	24644
Back issues	11063
Foreign journals	18
Indian Journals	85
Hindi books	2090

IT facilities

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 governments, 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, Kisan mela, technology showcasing, field days, front line demonstrations.

Important events

Institute recognition with the prestigious National Ground Water Augmentation Award, 2008

ICAR Research Complex **Umiam** has been conferred with the prestigious **"National Ground Water Augmentation Award, 2008"** for outstanding works on augmentation of ground water in agricultural uses in the north eastern Hilly Ecosystem by Ministry of Water Resources, Govt. of India

Dr. S.V. Ngachan, Director received "National Ground Water Augmentation Award-2008"

Dr. R. Laha, Senior Scientist & I/C, Division of Veterinary Parasitology, has been awarded with "ICAR Jawaharlal Nehru Award for Outstanding

Post Graduate Agricultural Research in the field of Animal Production and Veterinary Science".

Dr. R. Laha, Senior Scientist, Veterinary Parasitology, receiving " ICAR Jawaharlal Nehru Award " from Dr. Farooq Abdullah, Honourable Union Minister of New and Renewable Energy, at NASC Complex, New Delhi, on 16.7.2009

Organization of Summer School at ICAR Research Complex for NEH Region, Umiam

A summer school (21 days) was organized from 25th August to 14th Sep 2009 on "Conservation of Natural Resources for Sustainable Hill Agriculture". The objective of the course was to familiarize the participants with the natural resources and their importance, various approaches and technologies, socio-economic aspects and policy interventions for conservation of natural resources in hill agriculture. A total of 25 participants from ICAR institutes, SAUs and CAUs from different parts of the country participated in the Summer School. The course consisted of lectures, tutorials, laboratory and field exercises.

Organisation of XIXth Regional Committee Meeting at ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok

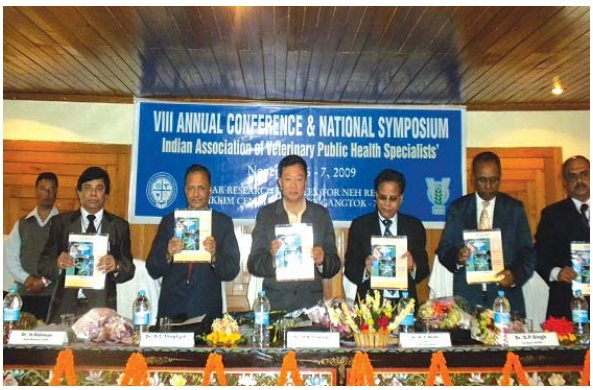
XIXth Regional Committee Meeting, Zone – III was organized by ICAR Research Complex for NEH Region at its Sikkim Centre, Tadong Gangtok during October 23-24, 2009. Sh. B P Singh, Hon'ble Governor of Sikkim, inaugurated the function. Dr. Mangala Rai, Secretary, DARE and DG, ICAR, New Delhi. Dr. S. P. Tiwari, DDG (Education), Dr. A K Singh, DDG (NRM), Dr. M. M. Pandey, DDG (Ag. Engg.) Dr. K. D. Kokate, DDG (Ag. Extension), VCs, Secretaries, ADGs, Directors of different ICAR institutes participated in the meeting. The function was graced by Sh. Dawcko Lepcha, Hon'ble Minister for Agriculture, Sh. D. N. Thakarpa, Hon'ble Minister for A.H. & Vety. , Govt. of Sikkim, Sh. T. R. Zeliang, Hon'ble Minister of Forests, Ecology, Environment & Wildlife, Govt. of Nagaland, Sh. Jitendra Chaudhury, Hon'ble Minister for RMDD and Forestry, Govt. of Tripura. The summit contemplated upon the various issues and programmes for the proper utilization of the resources and the development of agriculture, horticulture, animal husbandry, floriculture, fisheries, etc., in the northeast. Addressing the summit, the Governor said that agriculture remains the major source of livelihood for the people of this region thus priority needs to be accorded to the development of agriculture. Dr. Mangla Rai, highlighted the challenges before research institutes and government in tackling both quantitative and qualitative food security. The delegates of different NE states presented their progress and put forth their suggestions for the improvement of agriculture.

Dr. Mangla Rai, DG, ICAR & Secretary DARE delivering speech in XIXth RCM

National Symposium and VIII th Conference of IVPHS

A National Symposium on "Trans-boundary Zoonotic Diseases: Challenges and Strategies", and VIIIth Conference of Indian Association of Veterinary Public Health Specialists was organized by ICAR Research Complex, Sikkim Centre, Tadong, Gangtok during November 6-7, 2009. The symposium aimed to infuse knowledge and ideas about Zoonotic diseases for making a roadmap for

the management of diseases by government, institutes and by public in general. The Symposium cum Conference was inaugurated by Sh. D. N. Thakarpa, Hon'ble Minister for A.H. & Vety., Govt. of Sikkim.



National Symposium on "Trans-boundary Zoonotic Diseases" in Gangtok

DBT Interactive Workshop on Large Cardamom

A day long DBT Interactive Workshop on "Management of Pest and Diseases of Large Cardamom in North-East Region using Potential Bio-Pesticides and Biotechnological Approaches" was organized by ICAR Research Complex, Sikkim Centre, Tadong, Gangtok on 5th October, 2009. The workshop aimed to address the problems of large cardamom cultivation in the region. The workshop was inaugurated by Prof. S. N. Puri, Vice Chancellor, CAU Imphal, Manipur. Dr. Seema Wahab, Advisor, DBT, New Delhi, Dr. Opendra Koul, Director, IBRC, Jalandhar, Punjab and Shri. M L Arrawatia, Secretary, DST, Govt. of Sikkim, graced the workshop by their presence. The workshop was attended by the scientists of ICAR, Indian Cardamom Research Institute and DBT, New Delhi and State officials. Task force came out with a conclusion that, there is an urgent need of a Network project and ICAR, Sikkim Centre, should be the lead centre and other concerned institutes and departments should join to formulate feasible and outcome oriented programme so that problem associated with large cardamom could be well solved.

DBT workshop on large cardamom

Celebration of Technology Week at ICAR Manipur Centre, Imphal

Technology week for Krishi Vigyan Kendra Imphal West, Churachandpur, Chandel, Ukhrul and Tamenglong was jointly organized at ICAR Manipur Centre Imphal from 29.10.09 to 4.11.09. The inaugural function was graced by Shri. N. Loken Singh Hon'ble Minister of Agriculture, Govt. of Manipur as Chief Guest, Shri O. Nabakishore Singh IAS, Principal Secretary (Agril Production), Smt. R. K. Nayansana Devi, Director of Agriculture Govt. of Manipur, Shri K. Saratkumar Singh, Director Fishery, Govt. of Manipur, Shri K. Ngachan, Director of Horticulture and Soil Conservation, Govt. of Manipur and Prof. N. Iboton Singh, Dean, Central Agricultural University, Imphal Manipur as Guests of Honour. About 500 farmers and invitees from line departments and NGOs attended the programme. Farmers from 5 districts i.e. Imphal West, Churachandpur, Chandel, Tamenglong and Ukhrul were present. Critical inputs viz. rabi

Hon'ble Minister of Agriculture, Govt. of Manipur distributing Critical Inputs to the farmers

vegetable seeds, rabi pulse, oil seeds, poultry birds, fish fingerlings, mushroom spawn, preservatives and chemicals for fruit and vegetable preservation, fruit seedlings etc were distributed to the farmers. A Farmers' Fair was also organized on the occasion. Line departments, NGOs, KVKs, Progressive farmers participated in the exhibition and altogether 14 stalls were opened to the farmers displaying new technologies and achievements in agriculture and allied fields.

His Excellency, the Governor of Manipur Visiting ICAR Stall, at NE Regional Fair 2010 in Imphal

Foundation Stone Laying of Central Laboratory at ICAR Research Complex for NEH Region, Umiam

Dr Mangala Rai, Secretary DARE and Director General ICAR laid the foundation stone for the Central Laboratory of ICAR Research Complex Head Quarters, Barapani. He also inaugurated the KVK (Ri Bhoi) Administrative building along with its Farmers Hostel. Hon'ble DG also inaugurated the scientists' home.

Dr Mangala Rai, Secretary DARE and Director General ICAR laying foundation of central Lab

Northeast Media Meet for "Mobilizing Mass Media Support for Sharing Agro-Information"

ICAR Research Complex, Umiam organized the first ever North east media meet at the Institute on the 19th January 2010, under the project "Mobilizing Mass Media Support for Sharing Agro-Information". The basic objective of this meet was to focus on strengthening of agricultural communication through media participation. Leading media personalities form Shillong and Guwahati attended the meeting. Director, Dr S.V. Ngachan, showcased a summary of the technologies available at the Institute for the farmers to the journalists. He said that the region must adopt a scientific approach on a wider scale to meet the challenge and be self-sufficient in food grain production. The scientists of the institute requested the journalists to cover timely and needful agro-information available to farmers from the institute in every language so that farmers can use them at the time of need.

Mobilizing Mass Media support for sharing Agro-Information

Organization of Technology Showcasing

Two days' long technology showcasing was organized at ICAR Research Complex, Umiam, on 19th and 20th of March 2010 where, Institute (HQ) along with its other centers and the KVKs, displayed their individual technologies available with them. Among the guest participants National Research Centres (NRCs) on Pig, Mithun and Yak and the Assam Agricultural University (AAU) also showcased their technologies. The programme was inaugurated by the Zonal Project Director, Dr A. K. Gogoi. Seeds and soil testing kits were also distributed to the selected farmers. In total, about 150 farmers from the entire region attended the two days programme. A Kisan Mela and Gosthi were also organized on the occasion where the farmers had a close interaction with the scientists.

Interactive Workshop on Black Bengal Goat

A State level workshop on 'Conservation and Utilization of Black Bengal Goat Resource for Rural Livelihood' was organized on 10th June 2009 at ICAR Research Complex, Tripura Centre, Lembucherra, West Tripura. Thirty eight officers from Animal Resource Development, Rural Development Department and Tripura Tribal Areas Autonomous District Council from four districts of Tripura state participated in the workshop.

State Level Workshop on Rural Poultry Production

A state level workshop on "Rural Poultry Production" was organised at ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra, Tripura West on 3rd November, 2009.

Dr. S. V. Ngachan, Director of the institute along with other dignitaries visiting the stalls during organization of technology showcasing

Dr A. K. Gogoi, Project Director Z III distributing seeds and soil testing kits to the farmers on the occasion of Kisan Mela organized at ICAR Research Complex, Umiam

Spring / Summer Pulses Group Meet 2010 & Symposium on "Food Legumes for Nutritional Security in NEH Region"

ICAR Research Complex for NEH Region, Tripura Centre, hosted the Spring / Summer Pulses Group meet 2010 during 27-28th January 2010 at Agartala. Simultaneously, regional symposium on "Food Legumes for Nutritional Security in NEH Region" was also organized. His Excellency Governor of Tripura, Dr. D. Y. Patil, graced the occassion as the Honourable Guest. Dr. Swapan Kr. Datta, Deputy Director General (Crop Sciences), ICAR, New Delhi, presided over the function.

Farmers' Meet 2010

Farmers Meet 2010 was held on 30th January, 2010 at ICAR Research Complex for NEH Region, Tripura Centre. The Chief Guest was Shri Manik Sarkar, Hon'ble Chief Minister, Govt. of Tripura and the event was attended by many dignitaries such as Shri Haricharan Sarkar, Hon'ble Member, Tripura Legislative Assembly, Dr. A.K. Singh, Deputy Director General (NRM), ICAR, New Delhi, Mr. K. V. Satyanarayan, Principal Secretary, Govt. of Tripura and Dr. S.V. Ngachan, Director, ICAR, Meghalaya. All Directors of Department of Agriculture, Animal Husbandry, Horticulture and Soil Conservation, Govt. of Tripura were also present in the meeting.

Participatory Rice Variety Selection Day

Under the Bill and Melinda Gates Foundation (BMGF) project **"Stress Tolerant Rice for Poor Farmers in Africa and South Asia"** Participatory Rice Variety Selection was conducted at Magpuskarini, South Tripura on 3rd December, 2009. The PVS was followed by organization of "Participatory Rice Variety Selection Day and Kharif Rice Day". PVS conducted at this location was the Mother Trial comprised of 23 entries drawn from the line developed by ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra.

Hybrid Rice Day 2009

Even after a decade of release of first set of hybrids in India the area under hybrid rice has reached only about 1.0 million hectares. The rate of adoption is much slower than expected. Considering the lack of adequate initiative and effort for popularization of this innovative hybrid rice technology, ICAR Research Complex for NEH Region, Tripura Centre has taken up the initiative to demonstrate the potential of Hybrid rice in Tripura in collaboration with Bayer BioSciences. In boro 2008-09, demonstrations were taken up in Bagma, Bagabasa, Koroiamura, Magpuskarini and Mirza in South Tripura. Apart from this, a large number of FLDs were also conducted on HYV + ICM, HYV + SRI, Field experiments on ICM vs SRI and replicated yield trials on 5 hybrids. To mark the success of the demonstrations "Hybrid Rice Day" was celebrated on 20 May 2009. Principal Secretary of Agriculture, Govt. of Tripura, Shri Shushil Kumar visited the demonstration plots and graced the occasion as chief guest. Director of Agriculture and other senior officers from Dept. of Agriculture were also present during the visit in the function at Mirza, Tripura.

Hon'ble Minister for Agriculture of Tripura, Shri Aghore Debbarma visiting the Participatory Varietal Selection site at Magpuskarini and over looking the activity that was first of its kind in Tripura

Principal Secretary of Agriculture, Govt. of Tripura visiting Hybrid rice demonstration plots in South Tripura

Hybrid Rice Day at Mirza, South Tripura

3. RESEARCH ACHIEVEMENTS

MEGHALAYA

Weather Report

The weather of Ri-Bhoi District during 2009-10 was erratic in nature. The total annual rainfall (2263.3mm) was below normal rainfall (2399.7mm) whereas monsoon rainfall (1643.2mm) was more than the normal monsoon rainfall (1543.95mm). The highest rainfall in a single day was 146.9mm on 2nd May, 2009. Total rainy days were 139 which was more than the normal annual rainy days (129days). The total evaporation was 945.3mm with a mean evaporation of 1.63mm. The highest evaporation in a single day was 7.0mm on 27th February, 2009. The minimum evaporation in a single day was 0.4mm on 1st July, 2009. The water temperature of the open pan evaporimeter was observed varying from 7.8^0 C to 25.3^0 C with a mean value of 17.6^0 C. The relative humidity (RH) during morning hours was between 47.0 to 98.0% with a mean value of 80.85% whereas, during evening hours RH varied between 0.0 to 98.0% with a mean value of 65.26%. The total sunshine hour during the whole year was 2079.2 with mean daily sunshine of 5.86 hours. The highest sunshine hour during a single day was 10.5 hours on 7th May, 2009. The highest wind speed in a single day was 10.7 kmph with a mean value of 2.63 kmph. The mean soil temperature in 5cm, 10cm, 20cm and 30cm during morning hour was found varying from 20.58 to 22.74^0 C. whereas during evening hour, it was observed varying from 22.98 to 28.23^0 C. The highest soil temperature was found 33.9^0 C at 5cm depth during evening hour whereas minimum was 19.7^0 C. The mean maximum temperature was 26.4^0 C with a highest temperature of 33.2^0 C in a single day on 21st July, 2009. The mean minimum temperature was found 14.9^0 C. The mean cloud cover during monsoon season (June-September) was recorded varying between 4.63 to 6.24 Okta. The wind direction was observed blowing at 141.9 degree to 206.4 degree during monsoon season (June-September).

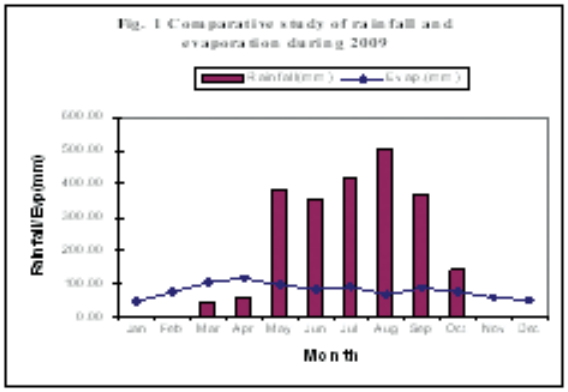
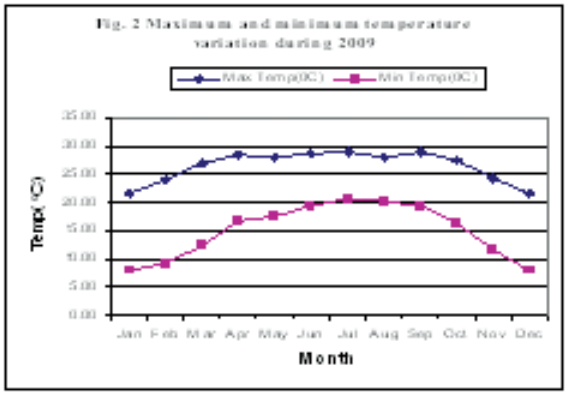
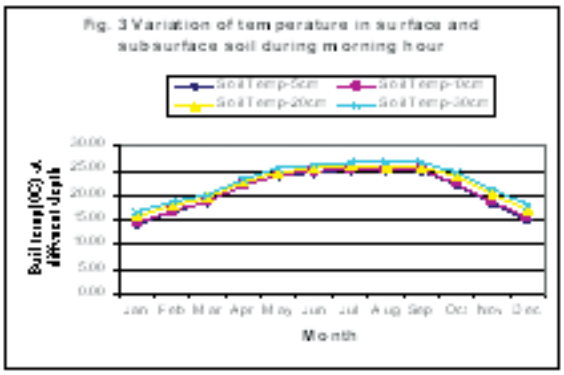
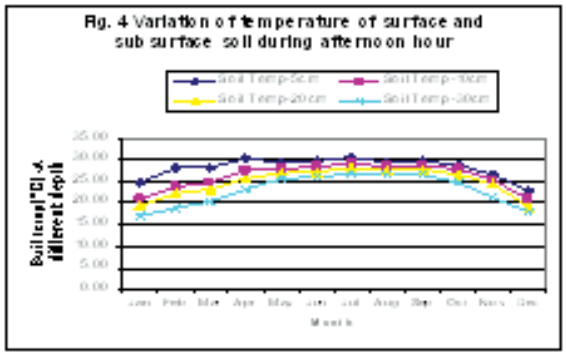


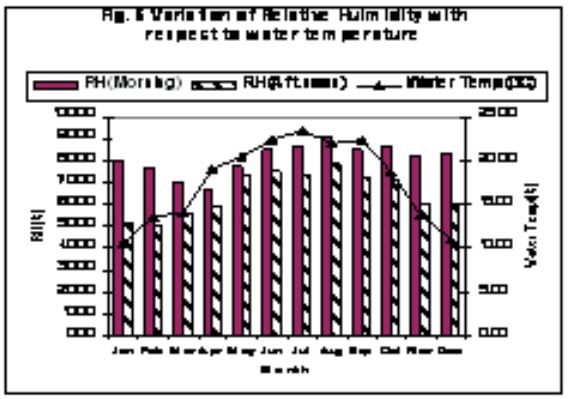
Table 1. The annual abstract of meteorological data of ICAR, Umiam, Meghalaya

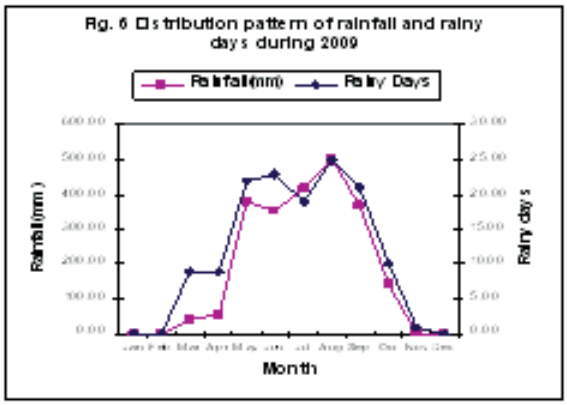
Parameters	Total	Average	Maximum	Minimum	Days
Rainfall (mm)	2263.3	-	146.9	-	139
Evaporation (mm)	945.3	1.63	7.0	0.4	-
Water Temperature (^{O}C)	-	17.64	25.3	7.8	-
Relative Humidity -Morning (%)	-	80.85	98.0	47.0	-
Relative Humidity -Evening (%)	-	65.26	98.0	0.0	-
Sun Shine Hour (Hours)	2079.2	5.86	10.5	0.0	-
Wind Speed (Kmph)	-	2.63	10.7	0.0	-
Wind Direction(Degree)					-
Cloud Cover(okta)					-
Temperature -Maximum (^{O}C)	-	26.40	33.2	0.0	-
Temperature -Minimum (^{O}C)	-	14.93	23.5	0.0	-





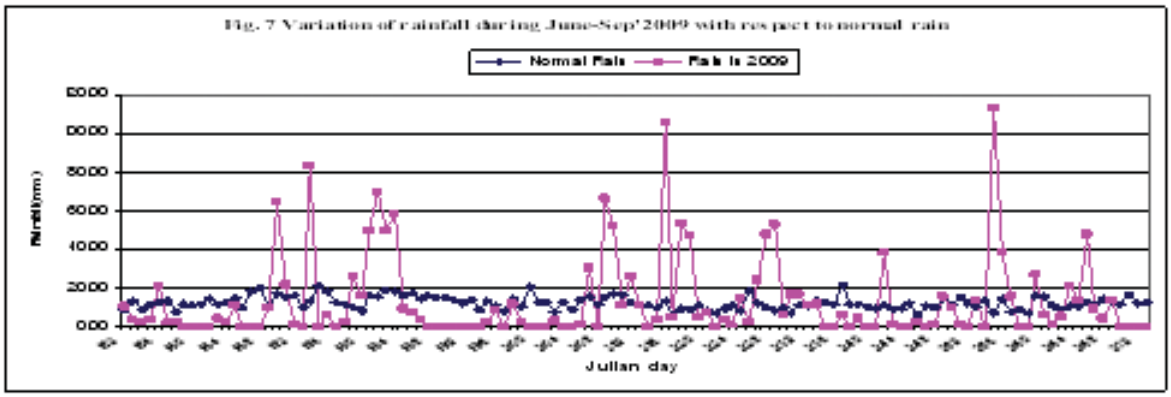






Weather services

Integrated Agromet Advisory Services (IAAS) were provided to the farming communities for agro-advisory according to prevailing weather since 1996. Agromet Advisory Service, ICAR, Umiam regularly provided (twice in a week) the agro-advisory bulletin to the farmers as well as through local newspapers, Doordarshan (*Agriculture: Nerrocasting, Time:*



6.00-6.30PM), All India Radio *(Farm & Home, Time: 06.50-07.20PM)*, Meghalaya Web Portal, ICAR NEH Web portal, India Weather Web Portal, Crop Weather Outlook, NCMRWF Web Portal, IMD Web Portal. A total 80 nos. of agro-advisory bulletins in 51weeks were disseminated for the farming community during the year 2009, for all seven districts of Meghalaya. These bulletins mainly contained weather forecast for 5days and advisories for agricultural operation according to prevailing weather. Agromet services also helped Zonal Project Directorate, Zone-III and Krishi Vigyan Kendra, Ri-Bhoi district in preparation of climatic anomaly (Agricultural Drought) report

R & D Activities

The accuracy of the weekly cumulative rainfall forecast was 70-75% whereas seasonal rainfall forecast accuracy was between 60-70%. The Crop Calendar and Climatic Atlas (Fig. 8: Isohyetal and Isothermal Map) of Meghalaya, Manipur and North Eastern India were the major achievement of agromet for weather based crop planning. Participation in Farmer' Fair and Farmer's Training was also a common mandate of the service. Economic analysis of agromet services was also done by collection of feed back from the farmers. A profit of 35-42% was achieved due to advance sowing of Maize which was advised through agromet services.

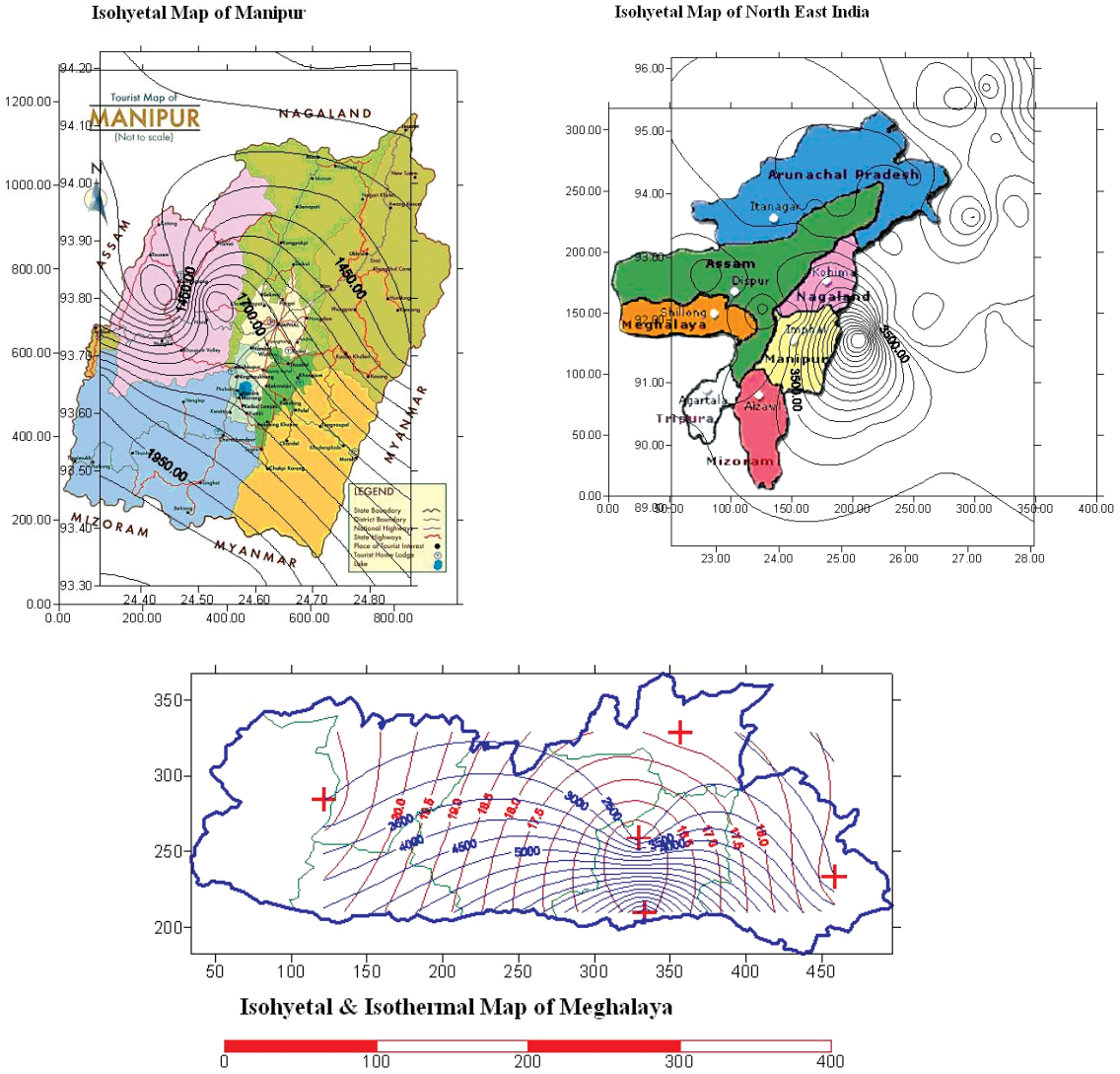


Fig 8. Climatic Atlas for Manipur, North East India amd Meghalaya

CROP SCIENCE

Rice

Yield trials in upland ecosystem

Six yield trials and one International Upland Rice Observation Nursery (IURON) were conducted (Table 1). In the RCRT upland and IVT – UL trials, RCPL 1-115 and RCPL 1-116 (Figs. 1a & b) were the top two genotypes that yielded 28.5 – 61.5% higher than the check. Both the genotypes were included in IVT – UL of AICRIP where they ranked 1st and 2nd, respectively. Station Trial 1 was conducted with 22 genotypes where only basal dose of 30:60:40 NPK was applied. Genotype RCPL 1-128 recorded 70.8% higher yield than the check Bhalum 1.

(a) RCPL1-115 (b) RCPL1-116

Figs 1. a & b. Two promising genotypes for upland ecology

In station trial 2, RCPL 1 – 86 and in Station Trial 3 (comprising selected genotypes from IURON 2008) BP278D-MR6 and BP278D-MR4 performed significantly better than the best checks Bhalum 1 and RCPL 1-115, respectively. In IURON trial, none of the genotypes performed better than local check Bhalum 1.

Lowland ecosystem

In station trials RCPL 1-147, RCPL 1-167, CT x Manipur–2 and RCPL 1-160 were found promising. However, none of these genotypes were significantly superior to the check. In the coordinated trials, IET 21393 (IVT EH), IET–20812 (AVT1 MH) were found promising but were not significantly superior to the checks.

However, in the AVT 2 MH the genotype IET 20193 was found significantly superior to all checks and recorded 5.67 t/ha yield.

Evaluation of segregating generations / advanced generations

Under upland condition, 78 lines selected from 147 F_3 lines were advanced to F_4. Under lowland condition, based on various agronomic characters, 183 lines were selected from 625 F_3 and F_4 lines and were advanced to next generation. Sixty-eight advanced generation lines were evaluated for yield in Augmented RCBD. Three genotypes (T x Ng – Pl3, T x CT-Pl1, IR x IET-Pl9) were found promising and yielded significantly better than all checks.

Table 1. Summary of yield data from various trials in upland ecology

Rank / Check	RCRT (Y,DF)*	Station 1 (Y,DF)*	Station 2 (Y,DF)*	Station 3 (Y,DF)*	IVT (UH) (Y,DF)*	AVT-1(UH) (Y,DF)*
1	RCPL1-115 (3.87,104.67)	RCPL 1-128 (3.25,106.33)	RCPL 1-86 (3.63,91)	BP-278D-MR 6 (4.22,106.5)	IET 21319 (3.10,96)	IET 20957 (2.33,87.5)
2	RCPL1-116 (2.39,95.33)	Bhalum-1 (1.91,101.00)	RCPL 1-129 (2.98,100.5)	BP-278D-MR 4 (4.03,106)	IET 21318 (2.73,103)	Local check (2.27,96)
3	RCPL1-117 (2.08,100.67)	RCPL 1-93 (1.77,100.00)	RCPL 1-82 (2.66,94)	IR60080-46A (3.35,98)	IET 21323 (2.21,86)	Vivekdhan 15 (2.09,92.5)
Check 1	Bhalum-1 (1.86,94.00)	Bhalum-1 (1.905,101.00)	Bhalum-1 (1.94,91)	Bhalum 1 (2.08,98)	Vivekdhan 1 (1.33,82)	Vivekdhan 15 (2.09,92.5)
Check 2	Bhalum-2 (1.37,96.00)	Sukaradhan-1 (1.70,72.33)	Sukaradhan-1 (1.67,88)	RCPL 1-115 (3.06,102)	Sukaradhan-1 (1.92,93)	Sukaradhan-1 (1.61,86)
Check 3	Sukaradhan (1.60, 88.67)				Local check (1.79,96)	Local Check (2.27,96)
CD (*P*=0.05)	(0.10, 9.69)	(0.99,18.16)	(1.38,1.98)	(1.07,1.21)	(0.31,1.23)	(0.74,2.5)

* Y = Yield in t/ha, DF = Days to 50% flowering

Table 2. Yield data under lowland ecology

Rank / Check	Station 1 (Y,DF)*	Station 2 (Y, DF)*	Station 3 (Y,DF)*	Station 4 (Y,DF)*
1	RCPL 1-147 (4.70,130.66)	RCPL 1-167 (4.37,126.5)	CT98461-7-1-1-2 PM x Manipur (3.68, 113)	RCPL 1-160 (5.06, 113)
2	RCPL 1-149 (4.67,111.67)	RCPL 1-187 (4.06,113.5)	SEL 2 (3.45, 113)	RCPL 1-300 (4.54,123)
3	RCPL 1-144 (4.61,105.33)	RCPL 1-188 (3.86,115.0)	Tox3055-10-1-1-2 x Ngoba (3.35, 116)	UPL1-5 (4.29, 112)
Check 1	RCM 21 (4.2.09,112.66)	RCM 11 (4.06,113.5)	Shahsarang (2. 83, 120)	UPL1-5 (4.29, 112)
Check 2	VL 31335 (3.12,102.66)	Shahsarang (3.78, 112.0)	RCM 11 (2.63, 121)	IR 64 (2.98, 104)
Check 3	RCM 11 (4.49,113.00)	-	Lampnah (2.45, 119)	-
Check 4	Shahsarang (4.53,110.00)	-	-	-
CD (*P*=0.05)	(0.69, 1.57)	(0.96, 2.55)	(1.54, 7.84)	(1.24, 1.6)

*Y = Yield in t/ha; DF = Days to 50% flowering

Germplasm evaluation, maintenance and characterization

Under upland condition, 103 germplasm were maintained. Under lowland condition 120 germplasm were evaluated and 12 were selected for further evaluation. At high altitude 103 germplasm were maintained.

Two sets of germplasm were characterized for cold tolerance and soil acidity tolerance. At Upper Shillong farm 153 germplasm were planted on 18th May and 3rd June with 2 replications and evaluated for 12 characters. Germplasm included collections from NE, HP, J&K and international collections. Principal component analysis indicated that the genotypes varied along the axes for yield related traits like harvest index, tiller number, panicle characters, grain number, grain fertility and grain weight. Plotting on a biplot separated the genotypes from Kashmir as a distinct group. Majority of the international collections was also identified as separate group along the axes of panicle characters. Genotypes Abor – A, IRCTN 91 – 62 and 8F8 – 10 – 1P – 5 – 6 were distinct from the other genotypes for their fertility, grain weight and panicle exertion. Some genotypes like IR72, IR64, PSBRC 2 etc. failed to flower at Upper Shillong. Genotypes identified for prospecting/allele mining are given in Table 3.

Table 3. List of genotypes selected for bioprospecting / allele mining

Selected genotypes for acid tolerance	Selected genotypes for cold tolerance
Aaha, Chankimaso, Ching, Moiramsbhi, COL- 4, IR1552, IORO epyo, IR1552, SKAU-390, VL 31329, VL 31331, UPR 2919-14-1-1, UPR 2992-17-3-1, Lespah, Motodhan, N-861, Pancoas, Posimot, RCPL- 13, Sanri fiirii, Tsamu fiirii, Yimyu, Vietnam – 1, Khougjai phou	8F8-10-IP-5-6, Khonorullo, Kohsar, Prem Niver, Abor – A, Baber, IRCTN 91-96, Larbeoul, PsBRC2, PsBRc18, SR13363 – 28-2-1, Bala Koun, IR-50, PsBRc64, IR64, Loul ANZUL, Suloeon 235, RCPL – 11C, Milyiang-15, Budghi, Tumla Hall, K–39, Miyang – 93, Uri Zag, Kaba sawrit B2, Wazul Krer, Chuch Never, IRCTN 91-100, Yunlen – 12, Knew, Kal Brer

For screening against soil acidity, 81 genotypes comprising collections from NE, selections from AICRIP and international collection were grown at 4 pH levels *viz*., 4.19, 4.69, 5.69 and 6.63 (control). All Genotypes failed to grow at pH 4.19. Data were collected for 16 characters from the other three treatments. Variations between pH 5.69 and pH 6.63 treatments were insignificant. Analysis of comparative data from pH 4.69 and pH 6.63 indicated that the genotypes varied widely for

flowering time, tiller number, spikelet fertility and harvest index (3). As high variation in flowering time was expected, other characters were considered for discriminating genotypes. Biplots indicated that genotypes Aaha, N-861, Chankimaso, IORO epyo, Megilai, Kulu fiirii, COL 4 etc. are suitable for bioprospecting. Identified genotypes for bioprospecting using a modified heuristic algorithm are given in Table 3.

Research Complex Regional Trial (RCRT)

Three RCRTs *viz.* two upland trials and one lowland fine grain trails completed testing for 3 years. Trials were conducted at 5 regional centres of the institute and 2 state level research centres. Complete data for all 3 years were received from Manipur, Meghalaya and Nagaland locations only. Data were analysed for stability using Genotype x Genotype-environment interaction model and genotypes were plotted on a biplot on the basis of their performance to identify best genotype for a location. Vertex genotype in each sector was considered as the best genotype for the locations falling in that sector.

In the Upland trial 1, RCPL1-103 was the best genotype for Meghalaya and Manipur while RCPL1-114 was the best genotype for Nagaland. In the Upland trial 2, RCPL1-128 was the best genotype for all the three states. This genotype was the most stable upland genotype tested during 2009. In the RCRT of fine grain genotypes, RCPL1-300 was the best genotype for Meghalaya while RCPL1-307 was the best genotype for both Manipur and Nagaland.

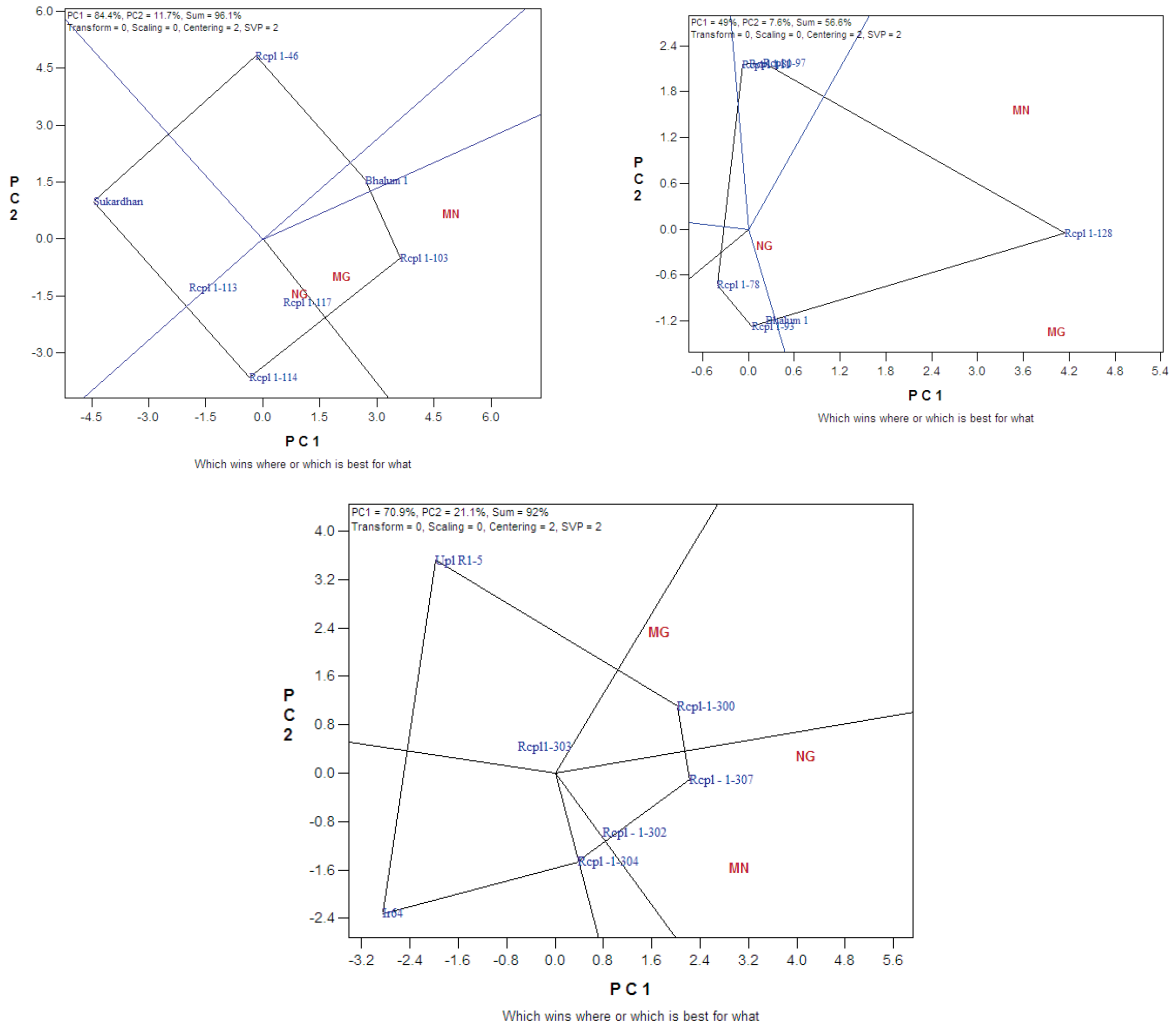


Fig. 2a-c. GGE biplot of three RCRT trials showing best genotypes for each location

Nutritional quality analysis

Twenty-nine rice cultivars from Meghalaya were analyzed for nutritional parameters. Total crude protein (CP) contents of the cultivars ranged from 5.24% to 13.85%. Amylose content varied from 4.04 to 29.71%. Ten cultivars were of low amylose type whereas, 13 cultivars were intermediate type and 6 cultivars of high type. Iron content ranged from non-detectable to 22 ppm. Twenty-five cultivars showed 0 to 10ppm iron and three cultivars had more than 20ppm iron which can be considered as high iron types. Zinc content of the cultivars varied from non-detectable to 39.2 ppm of which majority were possessing 0 to 20ppm. Four cultivars showed 30 to 39.2 ppm Zinc (Fig. 3).

Other nutrients such as total carbohydrate, crude fibre, total fat and ash contents are given in table 4.

Table 4. Contents of other nutrients

Nutrient	Range	No. of cultivars
Total carbohydrate	61.67 to 70%	03
	71 to 80%	15
	80 and above	11
Total fat	0.1 to 0.6	20
	0.61 to 0.9	09
Crude fibre	0.04 to 0.2	16
	0.21 to 0.4	13
Ash	0.1 to 0.5	15
	0.6 to 1.0	05
	1.1 to 1.6	09

The study could identify three cultivars of high protein, 10 cultivars of low amylose, three cultivars of high iron and four cultivars of high zinc types.

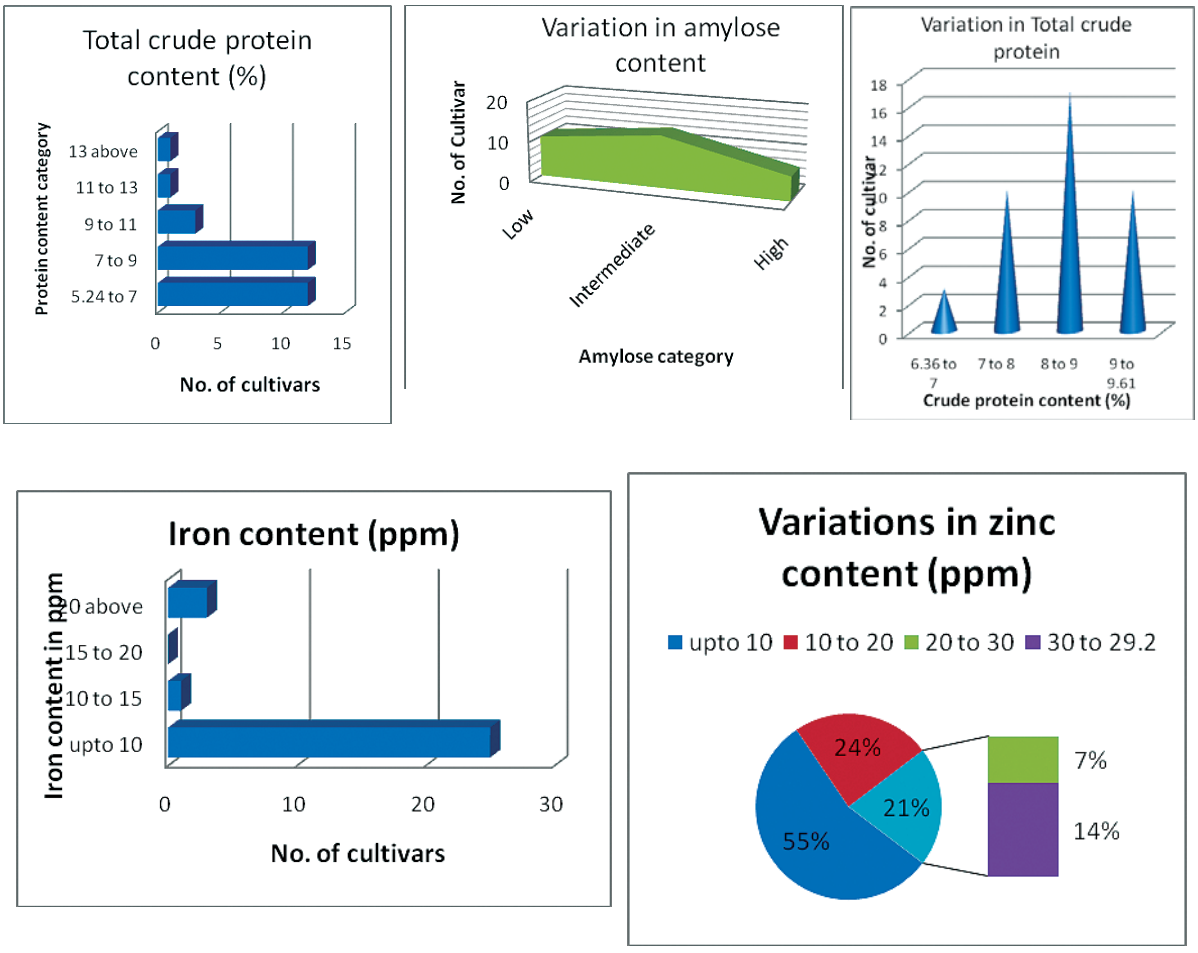


Fig 3. Distribution of various nutritional qualities in the rice cultivars

Phosphate use efficiency of different rice cultivars under rainfed condition

The experiment comprised four low land rice cultivars (*viz*. Shasarang, Ngoba, RCPL-1-75 and RCPL-1-160) grown under four doses of phosphorous (0, 30, 60 and 90 kg ha^{-1} P_2O_5) in 16 treatment combinations, replicated thrice in split plot design. Additionally one absolute control without N, P and K treatment was kept. The full doses of P and K were applied at the time of transplanting while N was applied in 3 splits (50% at basal, 25% at maximum tillering and the remaining 25% at flowering stages of crop growth). Results revealed that under natural fertility condition (absolute control), cultivar Ngoba produced highest grain yield (4.89 t ha^{-1}) while RCPL-1-160 produced lowest yield (4.11t/ha). However, under fertilized condition, cultivars Shasarang and RCPL-1-160 demonstrated consistent increase in grain yield with the increase in rates of phosphorous application from 0 up to 90 kg ha^{-1} (Fig.4). This was exhibited by an increase in grain yield from 4.83 to 5.88 t ha^{-1} and 4.56 to 5.98 t ha^{-1} in Shasarang and RCPL-1-160, respectively. On the contrary, cultivar Ngoba responded only up to 30kg while cultivar RCPL-1-75 responded up to 60 kg ha^{-1} applied phosphorous in producing maximum grain yield. Plant growth and other yield attributing characters also reflected significant variation in bi-directional way: among the cultivars as well as at varying rates of phosphorous application. Similarly, total phosphorous uptake was almost two fold higher in RCPL-1-160 compared to Shasarang and Ngoba. Thus, among the four cultivars, RCPL-1-160 was the most responsive to phosphorous fertilisers at higher doses while Ngoba was the most efficient under natural fertility condition in producing higher grain yield.

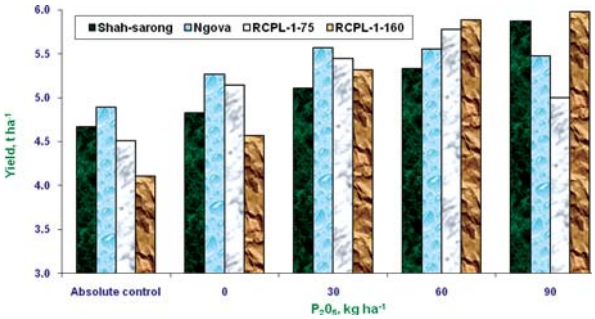


Fig 4. Differential response of low land rice cultivars to phosphorous fertilization

Disease

Uniform blast nursery screening trial was conducted. Out of 881 entries tested against rice blast disease (*Pyricularia oryzae*), one hundred seventy-nine entries were found to be resistant (Table 5). In DSN nursery many entries viz. CR 2642-52, 2646-4, 2620-1, VL 30424, 30661 etc. were found to be resistant.

Table 5. Screening for rice blast

Name of the nursery	Total entries	Resistant entries
NHSN	83	16
NSN-1	220	49
NSN-2	473	78
DSN	75	18
NSNH	30	18

Field monitoring of virulence of *Pyricularia oryzae*

In nursery, 25 cultivars consisting of international differentials, donors and commercial cultivars were studied. IR 64, Tetep, Raminad str 3, BL122, NP 125, C101 LAC, Tadukan, Dular, Co101 PKT, Kanto 51, and Usen were found to be resistant against blast disease. NP 125, CO 105 TTP-4-L-23, Rasi, RIL 29, Zenith and HR 12 were susceptible. Virulence pattern was found to be different from the previous year reaction.

Maize

Genetic improvement of two gene pools

Two gene pools – white kernel and yellow kernel, created from the germplasm of Nagaland, were evaluated. Original germplasm had very tall plants but after two generations of selection, plant height was reduced in yellow gene pool but not in white gene pool. Yellow gene pool did not lodge but white gene pool was susceptible to lodging. Grain yield of both of the gene pools was less but a broad range and better mean for this character in yellow gene pool offered opportunity for improvement in further generations. The mean and range for different yield components are given in Table 1.

Table 1. Range and mean of different yield components of two gene pools

Character	Yellow gene pool		White gene pool	
	Range	Mean ± SE	Range	Mean ± SE
Plant height (cm)	152.6-242.5	215.3 ±10.5	289-347	316 ±10.3
Ear length (cm)	94.3-170.6	110.4 ±6.8	190-220	204 ±5.1
Cob length (cm)	9-17.5	10.6 ±1.17	9.0 -18.5	14.3 ±1.8
Number of row/cob	10-18	13.6 ±1.26	10.3 -13.9	12.2 ±0.57
Number of kernel/row	14-37	20.2 ±3.12	8-12	10.0 ±0.63
Kernel yield/ plant(g)	50-155	65 ±13.7	14-33	24 ±3.5

Intra population improvement

For developing high yielding populations, plants were selected based on the vegetative vigour from the existing high yielding populations *viz.* RCM1-1, RCM1-2, RCM1-3, RCM 76 and RCM 75. These plants were selfed and selection was made for high yielding plants at the time of maturity

In RCM 76, 21 plants with two cobs and high yields were selected for developing a new population. In this population 29 plants with single cob and high yields were also selected for intra-population improvement. 24 plants in RCM1-1, 16 plants in RCM 1-3, 16 plants in RCM 75 and 18 plants in RCM 1-2 were selected. These plants would be used for modified ear to row method of intra-population improvement. The mean and range of selected plants for different yield components are given in Table 2.

Screening maize for water logging tolerance

Thirty six germplasm and 10 composites including two varieties Vijay and Hemant were screened for water logging tolerance in glass house using cup method of screening. Seeds of each of the maize lines were sown in plastic cups (i) placed in 5 cm standing water and (ii) outside water (control). Scoring was done for germination (%), and water logging tolerance on a visual scale of 1(susceptible) to 9 (tolerant):

Most of the genotypes were highly susceptible to water logging and 31(67.4%) genotypes did not germinate (score 1). Seed germination was the main susceptible stage and most of the seeds germinating in water logging conditions could reach maturity and set seed. From initial cup screening only one genotype appeared to be tolerant to water logging tolerance. Surviving plants would be inter-crossed randomly to generate a population tolerant for water logging.

Farmer's field trial

RCM1-1 was tested against Vijay in farmer's field in Umsning in collaboration with State Agriculture Department. RCM 1-1 out yielded Vijay by 39.6% (Table 3).

Table 2. Range and mean of different yield components in selected plants

Popualation		Plant height (cm)	Ear length (cm)	Cob length (cm)	Number of row / cob	Number of kernel / row	Kernel yield / plant(g)
RCM 1-1	Range	200-275	100-180	9-17	10-16	12-46	40-125
	Mean±SE	248.8±3.9	151.9±3.9	13.5±0.4	13.2±0.3	23.5±1.5	68.1±3.5
RCM 1-2	Range	200-260	105-170	14.5-18.5	12-16	32-48	55-90
	Mean±SE	226.4±4.0	129.7±3.2	16.3±0.31	14.2±0.42	38.9±1.2	78.3±2.6
RCM 1-3	Range	215-295	145-185	14-20	8-16	29-46	105-165
	Mean±SE	266.3±5.6	162.5±2.5	17.6±0.5	12.5±0.4	33.9±1.0	131.7±3.8
RCM75	Range	210-290	135-200	12-18.6	12-16	28-42	130-245
	Mean±SE	248.8±6.2	161±4.2	15.1±0.51	13.9±0.38	33.6±1.0	193.8±8.9
RCM 76	Range	128-294	73-157	9.5-21	10-18	10-43	60*-268
(Two cob)	Mean±SE	219.4±9.6	115.3±4.9	16.0±0.44	13.3±0.30	30.8±1.23	265.7±6.3
RCM 76	Range	143-302	50-147	16.0-21.5	10.0-18.0	33.0-49.0	150-220
(One cob)	Mean±SE	190.3	89.1	17.1	13.1	35.4	170.2

*Lower yield from 2nd cob

Table 3. Performance of RCM1-1 against var.Vijay in farmer's field

Variety	Days to 50% Tassel	Days to Silking	Days to 70% Maturity	Plant Height (cm)	Ear height (cm)	Yield (t/ha)
RCM1-1	58.5	62.4	103.1	194.5	100.1	2.71
Vijay Composite	64.0	67.6	109.5	192.1	93.9	1.94

AICMIP trials

Eight trials received from All India Co-ordinated Maize Improvement Project were conducted. Mean and range of yield and name of identified good hybrids/composites are given in Table 4.

Table 4. Mean and range of yield of identified genotypes from AICMIP trial

Trial	Range	Mean±SE	Superior lines
61	3.9-37.9	19.2±1.4	1305 and 1342
63	18.3-45.9	30.4±0.3	1233,1246,1247
64	24.1-52.3	35.2±0.43	1214, 1215
66	13.9-47.2	27.9±0.38	1117,1118,1122
67Z1	11.8-25.4	15.6±0.65	1101
70Z1	13.5-18.8	16.8±1.0	1121, 1122
72Z1	8.8-19.2	13.5±0.71	1001
103	3.3-33.2	15.1±0.27	123

Protein, tryptophan and lysine analysis in local germplasm

Forty maize populations were evaluated for tryptophan and lysine content. Among 40 maize populations 30 were from Nagaland, one was from Manipur, eight were identified materials of the institute and one was QPM check (CML 172).

Total crude protein contents ranged from 6.36 to 9.61% majority of which lies in the category of 8 to 9 %. The highest tryptophan content was recorded in check 'CML-172' with 0.76% and the lowest was recorded in 'NM-49' with 0.38%. Among the local material RCM 1-3 (0.7451%), QPM Yellow (0.6612%), and scented maize (0.6365%) with more than 0.6% tryptophan content were identified. The tryptophan content of RCM 1-3 was at par with the check CML-172. Total fat content of the genotypes ranged from 4.45 to 15.5 % (Fig. 1).

Development of QPM through MAS

Two crosses were made to convert non-QPM inbreds to QPM. Inbred V336 (recipient) was crossed with CML 180 (donor) and V398 (recipient) was crossed with CML173 (donor). Both CML lines contained *opaque2* (*o2*) gene. F_1s were grown in the winter nursery at Hyderabad and all plants were tested for successful hybridization. Molecular analysis was done using 4 markers. Testing using the SSR marker *umc1066* showed that the cross between V398 x CML173 was successful as seen from the two bands amplified by the marker (Fig.2).

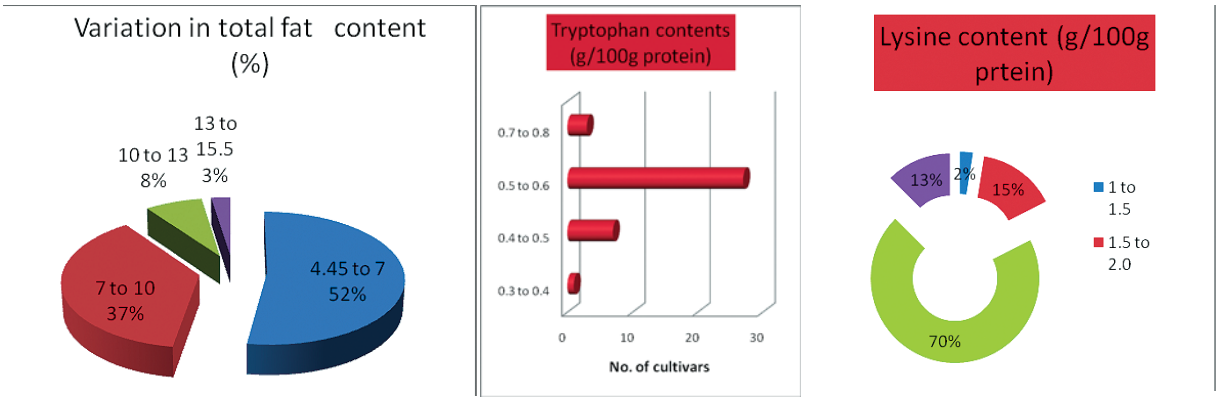


Fig 1. Distribution of nutritional quality in the maize germplasm

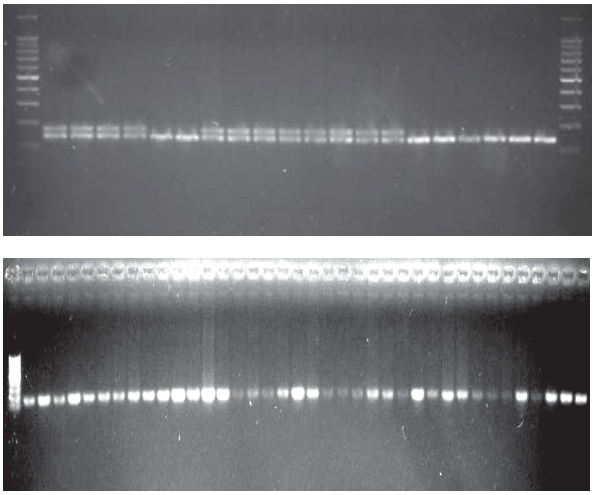


Fig. 2. DNA analysis to check heterozygosity using marker *umc 1066*

The other cross was unsuccessful as observed from the single bands amplified by the marker in all plants.

Residual effects of lime sources on maize yield

In the third year, residual effect of dolomite and paper lime mud on maize yield was profound and in that year lime mud performed better than dolomite. The yield of maize grain increased almost linearly as rate of lime increased applied (single dose). However, once broadcasted lime rate equivalent to 40% of LR gave optimum and economic productivity as compared to higher rates. At this rate of lime, soil pH was around 5.6 and exchangeable aluminium below 0.5 [c mol (p^+) kg^{-1}]. The availability of soil N, P, K, Ca+Mg and S almost tended to increase with increase in lime rates.

Residual effect of paper mill sludge on maize productivity

Third year of the residual effect of paper mill sludge (PMS) and lime once applied to the first direct crop of maize in an acid soil was significant. The residual effects of PMS and lime was highly significant over the control without PMS and lime. Among the doses of PMS, 10 t/ha gave almost at par maize grain yield (2.68 t/ha) as compared to 20 t/ha (2.74 t/ha). The yield of maize also increased linearly up to lime of 40% of LR application. The application of lime rate equivalent to 40% LR gave higher yield than that of PMS application. The yield of maize was significantly higher than that of PMS or lime application alone and when PMS applied along with 10% LR rate of lime. So it revealed that the higher productivity of maize can be achieved by the application of PMS and lime (10% LR) together in acid soils. The application increased soil pH more as compared to PMS application and further augmented when both were applied together.

Integrated effects of amendments and fertilizer on crop productivity and soil health

Field experiment was conducted during the *kharif* season to study the integrated effects of amendments (organic and inorganic) and fertilizers on crop productivity of maize var. RCM-1 and soil health in acid soils of Meghalaya. Locally available organic viz. FYM, poultry manure, weed biomass and inorganic viz. agricultural lime (AL) amendments along with recommended doses of fertilizers (NPK) at varying combinations were explored.

In maize, agricultural lime was applied at varying rates (from 12.5 % LR up to 75% LR) in combination with FYM and poultry manures. There were ten treatments with three replications in randomized block design. Results from first year (2009) reflected that with the increase in lime rate (from 12.5% LR up to 50% LR), maize yield also increased consistently (Fig 3). However, beyond 50% LR, no response was observed. Organic amendments: FYM @ 5 t/ha when applied with 100% recommended NPK, maize yield increased by 65% over control. However, maximum yield of maize (2.99 t/ha) was recorded when 12.5% LR of

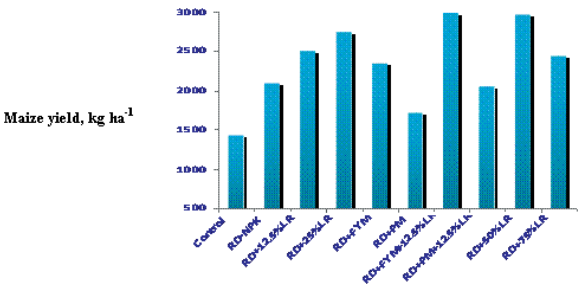


Fig 3. Effects of amendments (organic and inorganic) and fertilizer on maize productivity

lime was integrated with FYM and NPK. This was at par with 50% LR of lime + 100% recommended NPK. Poultry manure increased the yield (>40%) only when applied in combination with lime (12.5% LR) and 100% recommended NPK. This study demonstrated that instead of higher doses of lime (=50%LR) with NPK, proper combination of FYM with NPK and lesser amount of lime (12.5%LR) can become very effective in producing optimum yield while reducing the input cost.

Furthermore, poultry manure alone or in combination with NPK without liming is not much effective in increasing the productivity of neither turmeric nor maize crop. Therefore, poultry manure should be applied along with proper doses of lime and NPK.

Organic amendments (FYM, poultry manure and weed biomass) when applied without lime significantly improved soil hydro-physical properties (e.g. soil moisture content, bulk density, porosity and saturated hydraulic conductivity) only at the surface layer (0-15cm). Influence of lime with organic amendments was, however, quite encouraging on these hydro-physical properties only at sub surface layer (15-30 cm). Similarly, application of lime and organic amendments on soil acidity indices (pH, exchange acidity, exchangeable aluminium, exchangeable bases etc.) were visible significantly only up to a depth of 30 cm. Beyond 30 cm depths, however, influence of lime and organic amendments were negligible.

Diseases

Trap nursery

Eleven genotypes were evaluated for naturally occurring diseases under trap nursery trial from AICMIP, DMR, New Delhi. In the trial, Turcicum leaf blight (*Exserohilum turcicum*) was most frequent (in CM 128, CM 136, CM 137, CM 138, CM 150, CM 151, CM 212)followed by maydis leaf blight (*Helminthosporium maydis*) (in CM 128, CM 138 and CM 151). Both diseases appeared in all genotypes with varying degree of severity.

Screening for Turcicum leaf blight resistance

Four (#75, 76, 77, & 78) screening trials were conducted in row system in two replications. Altogether, 75 genotypes were screened for resistance/susceptibility against Turcicum leaf blight. Of 75 the genotypes, 29 (BH-4062, BISCO-111, BISCO-555, BISCO-855, CP-838, Kaveri-25K60, HM-8, HM-9, HM-10, COM PR-2006-1, COM PR-2007-1, FH-3463, FH-3464, FH-3473, FH-3356, FH-3358, FQH-38, Vivek QPM-9, Vivek Hybrid-9, BH-417135, Laxmi-9495, GK-3059, PAC-745, KMH-3669, KMH Super-244, BL-2801, HTCH-5401, MCH-38, BH-406126) found resistant, 27 (BH-407138, X7B401, X7B403, M05008, PFMH-9737, SMH-4502, MDMH-101, MCH-36, BIO-9681, HQPM-1, HQPM-7, BH-408005, KLM-766, EC-3160, KH-717, KH-9452, Hybrid VMH-4060, MCH-37, JH-31153, KDMH-1001, Navjot, UMC-10, UMC-11, KML-9, KML-15,Vivek Hybrid 21,Vivek Hybrid 17) moderately resistant, 14 (PHS-520247, JKMH-8003, BISCO-4564, X6B269, Seed Tec-2324, JH-31240, JH-31242, EH-1858, KMH-3712, BL-2802, CP-828, UMC-12, FQH-55, Parkash) moderately susceptible and 5 (EH-1877, Parkash, Pratap Makka-4, Pratap Makka-5, JH-31110) were susceptible.

Yield loss assessment from turcicum leaf blight

A field trial was conducted in paired plot design using maize var. RCM 1-2 with nine replications of protected and unprotected plots. Recommended fungicide Mancozeb @ 4 g/ l was sprayed in protected plots; where as unprotected plots were allowed to develop disease in natural conditions. The treatment showed 74% reduction in disease. However, the yield difference was non-significant in protected and unprotected plots indicating disease tolerant nature of the variety.

Testing of new fungicide for management of turcicum leaf blight, common rust and phytotoxicity.

Efficacy of Ergon 44.3 % (w/w) [Kresoxim-methyl 500g/L SC] against maize common rust and turcicum leaf blight (TLB) was tested in the field trial using a popular hybrid variety PEHM-2. Seeds were sown on 3rd week of July. The observations were recorded as per the CIB guidelines. No leaf injury, yellowing, wilting, necrosis, hyponasty and epinasty were observed, before and after spray,

which indicated that the product was not phytotoxic at concentrations used in the trial. The fungicide failed to control turcicum leaf blight and there was no effect on yield. However, rust disease was significantly reduced in comparison to untreated check (Table 5)

Insect Pests

Varietals screening against stem and cob borers on maize

Twelve varieties were evaluated for resistance against maize stem borer (*Chilo partillus*) and maize cob borer (*Stenochroia elongella*) during *kharif*, 2009. Infestation of cob borer and stem borer ranged from 4.13-9.71% and 5.83-18.9 %, respectively. The variety FH-3356 (New hybrid) was most susceptible to cob borer and stem borer with 9.71 and 18.88% damage, respectively. The variety Vivek Maize Hybrid-15 recorded the lowest stem borer infestation (5.83%), where as Local yellow showed minimum cob borer infestation (4.13%).

PULSES

Evaluation of photo-insensitive F_8 single plant progenies of rice bean

Based on the yield performance of the F_7 of a cross PISRB 3 X RBS 24, seventy five single plant selections were made. Individual F_8 plant progenies of these selected plants were evaluated during *kharif* in augmented design and RBD with RBL 1 and PRR 2 as checks (Table 1). All of the single plant progenies flowered and matured significantly earlier than both of the check varieties. Although none of the F_8 single plant progeny was superior to the check varieties for grain yield per plant, 45 F_8s were at par with the checks for this trait. For harvest index 4 F_8s were superior to and 22 F_8s were at par with the checks. These materiasl hold promise for the identification of extra early rice bean genotypes with good yield.

Eighty one rice bean germplasm were evaluated for yield in augmented design with checks RBL-1 and PRR-2. Many germplasm lines like LRB 160, EC-OI8181, BK 07 -07, RCRB-I-6, and RCRB-16 were found promising.

Table 5. Efficacy of Ergon on Turcicum leaf blight and common rust of maize

Treatments		PDI		Plot yield (kg/ha)	Test wt. (g)
		TLB	Rust		
T1 :	One application of Ergon 44.3% (w/w) SC @ 0.7 ml/L at cob initiation stage for bio-efficacy.	66.67	30.09	1861.20	23.67
T2 :	Two applications of Ergon 44.3% (w/w) SC @ 0.7 ml/L starting first at 30-35 days after sowing and second at cob initiation stage for bio-efficacy.	70.83	29.17	2250.00	22.67
T3 :	One application of Ergon 44.3% (w/w) SC @ 1.0 ml/L at cob initiation stage for bio-efficacy and phytotoxicity.	60.83	31.48	1861.10	23.67
T4 :	Two applications of Ergon 44.3% (w/w) SC @ 1.0 ml/L starting first at 30-35 days after sowing and second at cob initiation stage for bio-efficacy.	60.83	48.15	2388.90	22.00
T5 :	One application of Ergon 44.3% (w/w) SC @ 2.0 ml/L at cob initiation stage for phytotoxicity.	65.00	32.41	1805.6	24.00
T6 :	One application of Ergon 44.3% (w/w) SC @ 4.0 ml/L at cob initiation stage for phytotoxicity	68.33	22.22	1916.70	23.00
T7 :	Two applications of Hexaconazole 5% EC (Contaf) @ 1.0 ml/L starting first at 30-35 days after sowing and second at cob initiation stage for bio-efficacy and phytotoxicity.	52.50	36.57	2083.30	23.67
T8 :	Two applications of Mancozeb 75 % WP@ 2.5g/L starting first at 30-35 days after sowing and second at cob initiation stage for bio-efficacy and phytotoxicity.	62.50	42.59	1930.60	24.00
T9 :	Untreated check	61.67	61.57	1902.6	22.33
	CD (P=0.05)	NS	17.88	NS	NS

Table 1. Mean and range of different yield components of F_8s and checks

Material		Days to 50% flowering		Days to 70% maturity		Grain yield/ plant (g)		Harvest index	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
F8		54.0	45.0- 63.0	95	89.0-102.0	17.0	6.1- 27.9	62.0	24.6- 81.7
Checks		66.0	65.3- 66.7	111.7	110.8-112.5	35.5	23.4- 30.0	74.5	75.0- 77.2
Number of F_8s (%)	Superior to checks	110(100%)		110 (100%)		0(0%)		4 (5.3%)	
	At par with checks	0(0%)		0(0%)		50 (69.4%)		16 (21.0%)	

Diseases

Screening of vegetable pea genotypes against rust and powdery mildew

Forty genotypes of vegetable pea collected from Indian Institute of Vegetable Research, Varanasi, were sown for evaluation against pea rust and powdery mildew. The entries were sown on 25.11.2009 in three lines of 1m row for each entry at a spacing of 45cm row to row and 10cm for plant to plants. Data on powdery mildew and rust were recorded at 112 days after sowing following 1-5 scale. Percent Disease Index (PDI) was calculated. Among the tested entries, VRP 82, VRP 322, NO 23, VRP 373, VRP 316, VRP 186, VRP 281, NO. 3, EC 881123 and VRP 118 were found resistant to powdery mildew (PDI ranged from 0-4.0) and VRP 373, VRP 316, VRP 281 and EC 881123 to rust (PDI ranged from 0-6.0). Whereas, VRP 373, VRP 316, VRP 281 and EC 881123 were resistant to pea rust as well as powdery mildew.

Insect Pests

Pigeon pea

Management of pod boring weevil (*Apion clavipes*) in pigeon pea

An insecticidal trial was conducted to evaluate the efficacy of eight insecticides against pod boring weevil (*Apion clavipes*) in pigeon pea. Two sprayings were applied at 15 days intervals starting from flowering initiation. Among tested insecticides, thiamethoxam 25%WG @ 0.2 ml/l recorded the lowest pod infestation (10.5%) and showed 66.5 % reduction over control. Other promising insecticides were fipronil 5% EC @ 1 ml/l with 11.4% and 63.6%; endosulfan 35EC @ 2 ml/l with 12.4% and 60.5% and karanjin 2% with 15.0% and 52.0% pod damage and reduction over control respectively while in control plot damage was 31.3%.

OILSEEDS

Toria

Two newly developed *toria* composites RCT 1 and RCT 2 were compared with M-27 and SCRT 1-2 for various agronomic characters (Table 1). RCT – 2 was significantly better than the best check M-27 for root and pod characters although seed yield/plant was not significantly higher. The data indicated that RCT – 2 is expected to perform better than M-27 in low-moisture plots and further selection for yield would improve the composite.

Soybean

One co-ordinated yield trial and one station trial were conducted. In the station trial 5 advanced generation lines were evaluated for yield with JS – 335 and RAUS – 5. Although H – 01 (0.47 t/ha) was better than best check JS – 335 (0.43 t/ha), the difference was not significant. The trial was severely affected by moisture stress. In the initial varietal trial genotypes Code – 03 (2.26 t/ha), Code – 18 (2.23 t/ha) and Code – 21(1.99 t/ha) were significantly better than the check Bragg (1.41 t/ha).

Table 1. Comparison of performance of different *toria* genotypes

Genotype	Plant height (cm)	Number of siliqua/ Plant	No. per branches / plant	Length of pod (cm)	length of the primary root (cm)	No. of branches of primary roots	No. of seeds per siliqua	Seed weight / plant
M-27	62.07	131.9	3.87	4.77	11.23	4.33	15.5	5.50
RCT-2	63.67	130.0	4.23	5.02	11.87	4.87	18.5	6.34
SCRT1-2	66.67	118.3	4.10	4.75	12.27	5.30	17.3	5.30
RCT-1	55.67	109.1	3.63	4.73	10.60	5.17	17.6	4.93
CD(*P*=0.05)	3.69	27.6	0.39	0.29	0.79	0.59	1.45	1.26

Effect of lime, organic manure and fertilizer on groundnut and soybean productivity

In the second year of experiments, the productivity of groundnut and soybean increased significantly with lime, organic manure and fertilizer (recommended) application (Table 2) and recommended dose of fertilizer and its combination with organic manure and lime further increased the productivity. The application of lime and organic manure alone without fertilizers gave less yields as compared to fertilizer application only. The application lime (40% LR) with fertilizers gave significantly more yield as compared to lime + organic manure application only and later performed even better than the fertilizer application alone. Maximum productivity of both crops was found when all were applied together. Thus, it can be concluded from this experiment on acid soils, the application of lime and organic manure are equally or more effective increasing the productivity of soybean and groundnut as compared to recommended dose of fertilizer application alone.

Disease

Evaluation of breeding materials for resistance donors against rust disease

Under AICRP on soybean, 35 genotypes were screened in field against rust disease caused by *Phakopsora pachyrhizi*. Percent disease index (PDI) ranged from 24.22 to 87.33 among test genotypes. Four genotypes were found moderately resistant, 18 moderately susceptible, 12 susceptible and one highly susceptible. The check variety JS 335 showed high disease score (PDI 87.33) indicating sufficient natural disease pressure for screening.

Thirteen genotypes were grown under fungicide protected and unprotected conditions and yield losses were estimated. Yield losses ranged 17 to 73%. Based on yield potential and loss, genotypes MAUS 417 and DBS 2 were identified as high yielding and low yielding resistant genotypes respectively. The

Table 2. Effect of lime, FYM and fertilizer on groundnut and soybean productivity and soil pH and exchangeable Al

Treatments	Grain yield, t/ha		Soil pH		Exch. Al, [c mol (p^+) kg^{-1}]	
	Groundnut	Soybean	Groundnut	Soybean	Groundnut	Soybean
T1	1.48	0.61	4.8	4.8	1.61	1.78
T2	2.67	1.49	4.8	4.8	1.42	1.65
T3	2.05	1.12	5.0	4.9	1.02	1.23
T4	1.73	1.24	5.9	5.9	0.46	0.48
T5	2.21	1.64	6.0	6.0	0.45	0.28
T6	2.99	1.84	5.9	6.0	0.31	0.33
T7	3.22	2.04	6.1	6.1	0.25	0.22
CD (*P*=0.05)	0.93	0.86				

T1 = Control, T2 =RDF, T3 = Organic manure @ 5 t/ha, T4 = Lime (40 % LR) alone,T5 = Lime + organic manure, T6 = Lime + RDF, T7 = Lime + Organic manure + RDF, RDF = Recommended dose of fertilizers (20-60-20 kg N, P_2O_5 and K_2O/ha)

susceptible high yielding i.e. tolerant genotypes were DS 2614 and MACS 1138. The susceptible low yielding genotypes were MACS 1039, DS2613, MACS 1084, NRC 1080, MACS 1140, JS 2, AMS 1, RKS 52 and JS 335.

Insect Pests

Seasonal incidence of mustard aphid

The first appearance of mustard aphid *Lipaphis erysimi* was observed in 2nd week of November 2009 (20 DAS) with an average population of 0.47 aphids/3 leaves/ plant. The aphid population gradually increased during vegetative stage of the crop and reached the population of 5.48 aphids/3 leaves/ plant in the last week of November. During the reproductive stage of mustard crop there was steady increase in mustard aphid population on 3rd and 4th week of December (20 - 55 aphids/ 2 cm apical shoot/ plant) and reached its peak level of 70 aphids/ 2 cm apical shoot/ plant on last week of December (69 DAS). The aphid population was completely disappeared from the field during 2nd week of February.

Varietal screening of toria for insect resistance

Seven genotypes of *toria* were screened for insect resistance. Population of aphids and cabbage butterfly (*Pieris brassicae*) were found initially less in almost all genotypes. Aphids, *Pieris brassicae* and coccinellid population were highest in later stages of RCT-2, RCT-1 and SCRT-1-3 genotypes while painted bug was only observed at flowering and fruiting stage. Saw fly population was very less in almost all the genotypes. Biny and M-27 genotypes recorded very less incidence of aphids, *Pieris brassicae*, painted bug and saw flies showing partial susceptibility to these insect pests.

VEGETABLES

Tomato

Evaluation of tomato varieties

Out of the thirty five lines/varieties of tomato cultivated in open condition, number of fruits/plant was found to be highest for Cherry tomato (180.00), whereas, the line Megha Tomato– 4 recorded the highest average fruit weight (104.00 g). The same line also recorded the highest yield/plant (2.49 kg) followed by Megha tomato– 10 (2.25kg).

Off-season production of tomato in polyhouse

Three tomato varieties, namely, Megha Tomato – 1, Megha Tomato – 2 and Megha Tomato – 10 were planted in a net house cum rain shelter during the last week of June. The highest yield per plant (1.9kg) was recorded in Megha tomato– 10 (Table 1). Average fruit weight was highest in Megha Tomato – 2 (70.23g).

Evaluation of brinjal varieties for productivity

Eighteen varieties/lines of brinjal were grown during rainy season in open condition and RCMBL–2 recorded the highest yield of 35.8 t/ha, followed by RCMBL – 3 (35.7 t/ha). The variety Bholanath recorded the highest average fruit weight (340.0g).

Organic production of off-season King Chilli in polyhouse

An experiment on King Chilli under protected cultivation was taken up with three treatments i.e. FYM (25 t/ha), pig manure (25 t/ha) and FYM (12.5 t/ha) + pig manure (12.5 t/ha). The yield/plant was highest (1.3 kg) when FYM and pig manure were applied in equal proportion. The same treatment also recorded the highest number of fruits/plant (110.10). Average fruit weight was highest (12.01g) with the pig manure 25 t/ha application (Table 2).

Table 1. Performance of tomato varieties under net house during off-season

Variety	No. of fruits /plant	Average fruit weight (g)	Yield/ plant (kg)	Fruit length (mm)	Fruit diameter (mm)
Megha Tomato – 1	27.67	50.11	1.20	52.75	63.00
Megha Tomato – 2	26.00	70.23	1.60	57.67	63.50
Megha Tomato – 10	28.33	62.30	1.90	61.40	66.67

Table 2. Yield and yield attributing characters of off- season King Chilli

Treatment	Yield/plant (kg)	Number of fruits/plant	Average fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)
FYM (25t/ha)	0.90	91.00	10.23	81.10	30.50
Pig manure (25t/ha)	0.95	88.30	12.01	81.76	32.10
FYM (25t/ha) + pig manure (25t/ha)	1.30	110.10	11.95	81.15	33.33

Diseases

Screening of tomato genotypes against late blight

Twelve genotypes of tomato viz. MT-1, BT-106, LE-626, Selection-3, Co-3, BT-1, Arihant, Avinash, Gotya, To-017, ALT-0239 and Rocky were screened for resistance/ susceptibility against late blight of tomato. Among them MT-1 and Co-3 were found tolerant, whereas ALT-0239 and Rocky were found susceptible.

Screening of tomato genotypes against early blight

Eight genotypes of tomato viz. MT-1, BT-106, BT-1, Avinash, Gotya, To-017, LE-626 and Rocky were screened for resistance/susceptibility against early blight of tomato. Data revealed BT-1 and MT-1 as tolerant and To-017 and Rocky were found susceptible.

Bacterial wilt of solanaceous crops

Survey for estimation of losses and collection of isolates

One hundred and two villages covering all 7 districts of Meghalaya were surveyed and interacted with 195 farmers. The access to the villages and farmers was made possible through Government of Meghalaya, Meghalaya Rural Development Society and village headmen. The villages were selected based on random sampling technique. The information on crop losses on farmers' view and data regarding disease intensity in the field itself following quadrate sampling for confirmation of crop losses was gathered. Disease as well as soil samples were collected for isolation and identification of pathogens. The pathogen (*Ralstonia solanacearum*) causing wilt disease of Solanaceous crops was isolated. Sixty-six isolates from tomato, brinjal, capsicum and chilli were preserved for study.

Virulence test of collected isolates

The collected isolates were tested for their virulence in TZC (Triphenyl Tetrazolium Chloride) amended medium. The degree of virulence was recorded in 1-4 {1= Creamish pink, 0-25%), 2 = Orange pink (25-50%), 3 =Light pink (50-75) %, 4=Dark pink (75-100) %} rating scale based on the intensity of colour produced by the isolates in reaction to the TZC. Among 66 isolates, 8 fell in colour class 1, 9 in 2, 18 in 3 and 31 in colour class 4 (Fig 1).

The pathogenicity of collected isolates was tested against tomato (Pusa Ruby), and capsicum (Thai wonder). The isolates were rated based on their ability to cause infection under artificial inoculation in potted plants.

1 2 3 4 Basal medium

Fig 1. Colour classes (1-4) of *Ralstonia* on TZC medium and basal medium

Isolation of bio-agent (s) for *Ralstonia*

Rhizosphere soil samples of healthy tomato, soybean, bitter gourd, groundnut, brinjal, pepper and capsicum were collected from fields subject to various cultural practices, across Meghalaya, Assam and Arunachal Pradesh. The isolation was done in King's B Medium (KMB) by pour plate method taking different aliquots of different dilution. So far, we have 10 isolates of *Pseudomonas fluorescens*. The *Bacillus subtilis* was isolated on Nutrient agar medium from rhizospheric soil samples of tomato, brinjal and soybean collected from Meghalaya. So far, we have 4 isolates preserved for further studies.

Screening of tomato genotypes against bacterial wilt

Under the network project PHYTOFURA altogether 13 genotypes *viz.* MT-1, BT-106, LE-626, Selection-3, Co-3, BT-1, Arihant, Avinash, Gotya, To-017, ALT-0239, Rocky and Pusa Ruby were screened (Fig 2). Among the genotypes, MT-1, BT-106, LE-626 and BT-1, were found tolerant, whereas Rocky and Pusa Ruby were highly susceptible to bacterial wilt. The highest yield was recorded from MT-1 genotype in the screening trial.

Fig 2. Rocky and LE-626 genotypes showing susceptible and resistant reaction in field

Broccoli

Effect of integrated nutrient management on yield and quality of broccoli

Field experiment was conducted to study the effect of ten different INM practices on the productivity and quality of broccoli variety Pushpa. Transplanting was done during the month of November. The highest average head weight (360g) and productivity were obtained with application of vermicompost 1t/ha + FYM 10t/ha + full dose of NPK (Table 3). The highest plant height (55.68 cm) was recorded with vermicompost 1t/ha + FYM 10 t/ha + lime 2 t/ha. Ascorbic acid was recorded highest (81.84 mg/100g) with the integrated application vermicompost 1/ha + FYM 10t/ha, while β – carotene was found to be highest (20.22 mg/100g) with vermicompost 3t/ha + FYM 10t/ha + lime 2 t/ha).

Insect Pests

Cabbage

Studies of aphid population on different cole crops

Cole crops viz., cabbage, cauliflower, knol khol and broccoli were transplanted on two different

Table 3. Physico–chemical properties of broccoli variety Pushpa under different treatments

Treatments	Plant height (cm)	Head weight (g)	Head yield (t/ha)	Ascorbic acid (mg/100g)	β - carotene (mg/100g)
Vermicompost 1t/ha + FYM 10t/ha + N: P: K 25%	51.00	300.00	3.30	69.30	14.03
Vermicompost 1t/ha + FYM 10t/ha + N: P: K 50%	51.67	214.00	5.51	66.00	16.78
Vermicompost 1t/ha + FYM 10t/ha + Full N: P: K	55.00	360.00	6.60	73.70	19.37
Vermicompost 1/ha + FYM 10t/ha	50.50	220.00	2.50	81.84	16.50
Vermicompost 3t/ha + FYM 10t/ha	50.00	190.00	2.50	72.16	12.59
Vermicompost 1t/ha + Lime 2t/ha	53.00	133.00	2.00	75.50	16.73
Vermicompost 3t/ha + Lime 2t/ha	53.33	114.29	2.20	63.36	14.59
Vermicompost 1t/ha + FYM 10t/ha + Lime 2 t/ha	55.67	237.00	2.80	68.64	17.06
Vermicompost 3t/ha + FYM 10t/ha + Lime 2 t/ha	53.00	145.00	2.71	72.60	20.22
Recommended dose of N: P: K	50.67	200.00	3.50	73.92	12.97

dates i.e on 1st week and 4th week of October, 2009 to study the incidence of aphids. The early planted broccoli was less infested with aphids (1.13 aphids/ leaf) which was followed by cauliflower (1.35 aphids/leaf), cabbage (1.62 aphids/leaf) and knol khol (2.78 aphids/leaf). Among the late planted crops, cauliflower showed least infestation (1.39 aphids/ leaf) followed by broccoli (1.67aphids/leaf), cabbage (3.14 aphids/leaf) and knol khol (3.68 aphids/leaf). The study revealed that the aphid population is more in late planted crops than the early planted cole crops.

Development of mass production technology for *Hyposoter ebeninus*

Hyposoter ebeninus Gravenhorst is the most dominant parasitoid of cabbage butterflies. Mass culture of this parasitoid was developed on larvae of *Pieris brassicae* reared on cabbage leaves in the laboratory. Five pairs of parasitoids were found sufficient to parasitize 95 % larvae at 23 ± 1^{0}C. Total life cycle of parasitoid was 25-30 days at 23 ± 1^{0}C. Both fecundity and longevity of adult female was increased on 5 % honey solution. Laboratory reared parasitoids were also showed equal parasitisation as their field strain.

Efficacy of bio-rational pesticides against major insect pests of cabbage and their natural enemies

Bio-efficacy experiment was carried out to develop eco-friendly control measures against major insect pests of cabbage and safety to their natural enemies. Among all, karanjin 0.2 % was found to be most effective insecticide for controlling cabbage butterfly (*Pieris brassicae*), which was followed by spinosad (0.01%), *B. t.* var *kurstaki* (2 g/l of water), endosulfan (0.2%), NSKE (0.02%), neem oil (0.02%) showing 85, 81, 78, 28 and 20 per cent reduction of pest population over control, respectively. Anonin (0.2%) was found least effective against *P. brassicae*. First instar larvae were found most susceptible to all the insecticides than succeeding instars.

B. t. var *kurstaki* (2 g/l of water) was found most effective against diamond back moth (DBM), *Plutella xylostella* followed by anonin (0.2%) and endosulfan (0.2%). Other insecticides were found less and equally effective against DBM. Coccinellid population was significantly reduced in spinosad (0.01 %) treated plots than other insecticides. Activity of larval endoparasitoids was observed less in spinosad (0.01%) treated plot followed by NSKE (0.2%), neem oil (0.2%) and endosulfan (0.2%) treated plot over control.

Okra

Seed treatment against sucking insect pests

Seed treatment with thiamethoxam 25% WG was found effective and gave complete protection against the sucking insect pests for 35 days after germination.

Management of aphids (*Aphis gossypii* Glover)

Out of nine insecticides evaluated, imidacloprid was found most effective with least number of aphids (9.40 to 1.80 aphids/leaf) on okra and reduced 94.04 % aphid population. However, amongst the botanicals, karanjin was found to be most effective and recorded least number of aphids (9.53 to 2.93 aphids/leaf,) with a total per cent reduction of 90.29 % and amongst microbial *Verticillium lecanii* was effective (9.93 to 4.10 aphids/leaf and a total per cent reduction of 86.42 %) in controlling the aphid population. Imidacloprid and karanjin were at par with the conventional insecticide, endosulfan.

Management of jassid (*Amrasca bigutella bigutella*)

Amongst synthetic insecticides, imidacloprid was found most effective against jassid on okra and reduced its population from 2.27 to 0.90 jassids/leaf. However, it was at par with the conventional insecticide, endosulfan. Neem oil amongst the botanicals was found to be most effective with a total per cent reduction of 93.49 % jassids/leaf and amongst microbial, *Beauveria bassiana*, with jassid population of 4.00 to 2.00 jassids/leaf and a total per cent reduction of 89.98 %, was found to be most effective.

Management of blister beetle (*Mylabris pustulata*)

After 3, 5 and 7 days of spray and up to harvest, amongst synthetic insecticides, imidacloprid was found most effective with least number of beetles

(2.80 to 0.80 beetles/flower) and a total per cent reduction of 84.31 %. However, amongst the botanicals, NSKE 5% was found to be most effective with least number of beetles (3.13 to 1.30 beetles / flower) and a total per cent reduction of 74.51 %. Amongst microbial formulations, *Beauveria bassiana*, reduced beetle population from 3.17 to 1.60 beetles/ flower (total per cent reduction of 68.63 %) was found to be most effective

Evaluation of indigenous leafy vegetables

Several locally available leafy vegetables such as *Houttuynia cordata Thunb, Fagopyrum cymosum, Justica* sp., *Rauvolfia* sp., *Rheum* sp., *Piper* sp., *Centella asiatica, Plantago major, Alisma* sp., *Monochoria* sp.,*Adhatoda viscia, Eeringium foetidum, Leucas aspera, Homalomena sp.,Begonia* sp., *Abelmoschus sp.,Mentha arvensis, Spilanthes acemellla, Brassica* sp., *Bacopa monnieri, Amaranthus* sp *Amaranthus viridis, Comelina bengalensis, Colocasia esculenta,Oxalis corniculata, Rumex* sp, *Chenopodium album etc*., were collected from different parts of Meghalaya and were introduced in the Experimental Farm, Division of Horticulture, ICAR (RC) NEH, Umiam.

TUBER CROPS

Colocasia

Evaluation of varieties for growth and productivity

Forty one varieties/genotypes of *Colocasia* were planted in the month of March'09 for varietal evaluation. Among the genotypes, the highest plant height (76.3 cm) was recorded in IG Col – 5, the maximum leaf size (993.7 cm^2) was found in the variety IG Col- 5, while the variety AR Col – 8 recorded the highest number of side shoots (8.50).

The maximum corm length and diameter were recorded in AR Col – 7 (27.4cm) and in AR Col – 6 (23.3 cm) respectively. The highest cormel length (25.1 cm) was noted in ML – 1 and highest cormel diameter (20.7 cm) in AR Col – 6. In case of number of side tubers, the variety Nainital recorded the highest number (30.3). The highest yield (52.0 t/ ha) was recorded in White Gauriya which was closely followed by Nayabunglow (51.0 t/ha). Varieties Kandha Local, ML – 1, ML – 2, Muktakeshi were found to be tolerant to leaf blight disease.

Taro

Integrated nutrient management in taro

Organic sources of nutrient on the colocasia variety BCC 1 with seven treatments were tried. INM involving vermicompost 1t/ha+ full FYM + 25% recommended N: P: K showed the highest total yield (5.40 t/ha) followed by FYM 10t/ha + neem cake 1t/ha (4.75 t/ha), while the lowest yield (1.80 t/ha) was recorded under control (Table 4).The highest plant height was recorded with recommended dose of FYM + N: P: K @ 80: 60: 80 kg/ha (54.00cm) followed by vermicompost 1t/ ha + Full FYM + 75% recommended N: P: K (53.89cm). Combined application of vermicompost 1t/ha + full FYM + 75% recommended N: P: K also exhibited maximum leaf size (343.89cm^2). The highest number of side shoots and number of side tubers were observed in vermicompost 1t/ha + full FYM + 75% recommended N: P: K (4.00) and vermicompost 1t/ha+ full FYM + 25% recommended N: P: K (6.00), respectively. The highest corm length (5.0 cm) and diameter (3.7 cm) were recorded with integrated application of vermicompost 1t/ha+ full FYM + 25% recommended N: P: K and the highest cormel length and diameter were recorded with vermicompost 1t/ ha + full FYM + 50% recommended N: P: K (4.2 cm) and in full vermicompost 1t/ha+ FYM + 25% recommended N: P: K (3.09cm) respectively.

Sweet potato

Evaluation trial in sweet potato

Six sweet potato varieties were evaluated for yield and other parameters. The variety Kokrajhar Local recorded the highest total tuber yield (29.4 t/ ha) as well as the highest marketable tuber yield (25.0 t/ha). Dry matter content was found to be highest (35.20%) for the variety Meghalaya Local, whereas the variety Sree Bhadra recorded the highest harvest index of 59.32%. Weevil damage was least (7.12%) for the variety X – 24 (Table 5).

Table 4. Integrated nutrient management in taro var. BCC – 1

Treatment	Plant height (cm)	Leaf size (cm^2)	No. of side shoots	No. of side tubers	Total yield (t/ha)
Vermicompost 1t/ha+ Full FYM + 25% recommended N: P: K	41.5	284.7	1.89	6.00	5.40
Vermicompost 1t/ha + full FYM + 50% recommended N: P: K	49.3	245.6	2.78	4.22	3.10
Vermicompost 1t/ha + full FYM + 75% recommended N: P: K	53.9	343.9	4.00	5.22	3.15
FYM 10t/ha + neem cake 1t/ha	42.4	229.1	2.89	5.67	4.75
FYM10t/ha + mustard cake 1t/ha	42.7	249.6	2.78	4.78	2.20
Recommended dose of FYM + N: P: K @ 80: 60: 80 kg/ha	54.0	292.4	3.00	3.22	4.70
Control	40.2	205.8	2.56	3.88	1.80

Table 5. Evaluation of six sweet potato varieties

Varieties	Marketable yield (t/ha)	Total tuber yield (t/ha)	Dry matter (%)	Harvest Index (%)	Weevil damage (%)
Sree Bhadra	23.6	26.9	27.3	59.3	8.6
Meghalaya Local	17.1	21.0	35.2	48.4	8.7
S – 107	24.4	28.2	31.3	38.5	7.4
X – 24	18.1	22.6	28.0	48.7	7.1
Kokrajhar Local	25.0	29.4	34.3	40.4	8.4
Kokrajhar Red	21.8	25.5	34.7	46.7	8.8

Performance of sweet potato cultivars

Twenty three different sweet potato varieties were evaluated in the varietal trial for yield and other characters. The variety 440038 recorded the highest tuber yield of (36.50 t/ha). The maximum tuber length (249.0 mm) was recorded for Meghalaya Local**,** whereas tuber diameter was highest (99.8 mm) for the variety Pol – 21 – 1.

Maturity indices in six sweet potato varieties

Six sweet potato varieties, namely, Kokrajhar Local, Sree Bhadra, Meghalaya Local, S–107, 440038 and ST - 14 were planted during July 2009 and physico - chemical changes were recorded during different stages of growth. The varieties were harvested after 90, 105, 120, 135, 150 and 165 days after planting for various physical and chemical analysis. It was found that the weight of tuber increased with maturity and the highest average tuber weight (201.00g) was recorded in the variety Meghalaya Local at 165 DAP. The highest starch value (14.55%) was observed in the variety Meghalaya Local and the highest value for ascorbic acid (22.45 mg/100g) were recorded in ST- 14 at 165 DAP. β – carotene values were highest for the variety ST – 14.

FRUITS

Khasi mandarin

Evaluation of nucellar seedling, tissue cultured and grafted plants for growth, yield and quality parameters

Tissue cultured and grafted plants of *Khasi* mandarin (Rootstocks like *Citrus volkamariana, C. latipes, C. taiwanica* and *C. reshni*) of six years old and *C. jambhiri* of five years old were evaluated for their growth, yield and quality attributes. Plant height (2.75 m) and rootstock diameter (5.3 cm) was found maximum in grafted plant on *C. reshni* rootstock. However, the highest mean plant spread (91.5 cm) and fruit yield/plant (50 nos) was recorded in grafted plant on *C. taiwanica* rootstock. Commencement of flowering was also noticed this year on tissue cultured plants.

Studies on intercropping

Six crops namely French bean (RCFB-1), cow pea (RCCP-1), groundnut (ICGS-76), soybean (JS-335), rice bean (RCRB-1-6) and urd bean (T-9) were grown as intercrops during *kharif* season in four years old *Khasi* mandarin orchard. The yield data of different crops revealed that maximum yield was recorded in groundnut (3.33 t/ha) followed by French bean (1.33 t/ha), cow pea (0.83 t/ha), urd bean (0.33 t/ha), soybean (0.29 t/ha) and rice bean (0.20 t/ha).

Effect of mulching on plant growth and weed population

An experiment on mulching viz. black polythene, pine tree leaves, farm grass, leaves of ricebean, *Flemingia macrophylla*, *Crotolaria tetragona* and *Tephrosia candida* along with control (without mulch) was executed on four years old *Khasi* mandarin. The leaves and grass were applied @ 2 kg/m^2 twice in a year i. e. July and November. Maximum plant height (2.53 m) and canopy spread (88.75 cm) was recorded in *C tetragona* mulch, while stem diameter (6.07 cm) and No. of branch/plant (30) in *T. candida* leaves and ricebean mulch, respectively. Minimum weed density was found under black polythene mulch (0.15 kg/m^2) followed by pine leaves (1.07 kg/m^2) and maximum in control (1.97 kg/m^2).

Diseases

Citrus scab (*Elsinoe fawcettii*)

Collection of samples and pathogen isolation

Disease samples were collected from various parts of Meghalaya (East & West Garo Hills), Arunachal Pradesh and Assam. The pathogen was isolated from new flush leaves as well as older lesions. The pathogen was isolated from mature lesions using scrap method. Nine different isolates were selected.

Management of citrus scab

Efficacy of fungicide Bavistin (Carbendazim 50WP) for management of citrus scab was undertaken. 2 g of Bavistin in 1 liter of water, sprayed at the interval of 15 days starting from the initiation of new flush, was found suitable. 1 g/l of Bavistin could reduce 36% disease, whereas 2 g/l reduced 93%. The trial was repeated twice in order to confirm the results.

Fig 1. Scab infected citrus fruit

A commercial formulation Nisarga (*Trichoderma viride*1%WP) @ 6 g/l was applied for management of citrus scab. The results revealed 61.11% management, in terms of healthy and infected leaves, of diseases over control.

Isolation of bio-agents from soil

Twenty soil samples from Meghalaya, Assam and Arunachal Pradesh were collected and bio-control agents were isolated on PDA amended with antibiotics. Seven *Trichoderma* sp. were recovered on PDA. *In-vitro* bio-efficacy test against *Elsinoe fawcetii* was evaluated.

Citrus *Phytophthora*

Survey for estimation of losses and collection of samples

An exhaustive survey was conducted to designated citrus orchards of Government and progressive farmers of Meghalaya (34); Tinsukia district of Assam (10) and Lohit district of Arunachal Pradesh (66). Altogether 110 orchards were surveyed for collection of samples. The access to the villages was made possible through the government officials as well as village headmen.

The samples comprised of rhizopheric soil including infected roots/wood, were collected for isolation. Three to five samples from individual orchards lying at a radius of 1km were taken to form one composite sample. The baiting method of isolation was also done by using healthy leaves and fruits of *khasi* mandarin as baits.

Isolation of pathogen

Soil samples collected from a periphery of 1 m around the infected tree trunk at a depth of 15-30 cm were pour plated and infected roots along with healthy parts were seeded on amended corn meal Agar for isolation of *Phytophthora***.** The isolated cultures were further purified in V_8 Juice Agar and incubated under dark condition. The cultures on V_8 Juice Agar media showed clear and distinguishing rosette pattern of colony morphology. Altogether, 35 composite samples from Meghalaya, Assam and Arunachal Pradesh were used for isolation, of that only 22 (3 from Assam and 19 from Arunachal Pradesh) were found positive for *Phytophthora* spp.

Sporulation of *Phytophthora* spp.

Young mycelial disc cut from the periphery of 4 days old cultures grown in V_8 Juice Agar were transferred to sterile Petriplates containing Non Sterile Soil Extract Solution (NS-SES) and kept under continuous fluorescent light at room temperature in a sporulation chamber. Microscopic observations were recorded after 24 hours and repeated for every 24 hours for detection of sporangial production.

Microscopic observation of *Phytophthora* spp.

After seven days of incubation, the sporangial production was observed (Fig2). The sporangia were papillate measuring (32.4-40.5 µm) x (12.15-19.0 µm). The hyphae were hyaline, coenocytic and 4-5 µm thick with coralloid type of hyphal swelling and bulging. Distorted shape of sporangia and both terminal as well as intercalary chlamydospore were also observed.

Isolation of bio-control agents for *Phytophthora* spp.

Fungal bio-agents were isolated from healthy citrus rhizosphere soil samples collected from

Fig 2. Sporangia of *Phytopthora*

Meghalaya, Assam and Arunachal Pradesh. So far, we have 7 isolates of *Trichoderma* spp. and *Gliocladium* spp. producing different colony colour and morphology.

Soil analysis of samples collected for isolation of *Phytophthora* from citrus field

Of 35 samples used for isolation, only 20 samples comprising 19 *Phytophthora* positive and 1 negative sample were subjected to soil analysis for various parameters *viz.* pH, Organic carbon (%), N (kg/ha), P_2O_5 (kg/ha) and K_2O (kg /ha). In the analysis**,** pH ranged from 4.62 to 5.15, organic carbon (%) from 0.42 to 2.69, N (kg/ha) from 1.89 to 412.6, P_2O_5 (kg/ha) from 12.76 to 42.62 and K_2O (kg/ha) from 122.64 to 212.68. However, no correlation could be drawn from soil parameters for presence or absence of *Phytophthora* sp.

Guava

Growth, yield and quality attributes of guava cultivars

Five years old 10 cultivars of guava viz. RCG-1, RCG-3, Allahabad Safeda, L-49, Lalit, Sangam, RCG-11, RCGH-1, RCGH-4 and RCGH-7 were evaluated for growth, yield and fruit quality traits. RCGH-1, RCG-1, Allahabad Safeda and RCGH-4 recorded the vigorous growth among all cultivars. The maximum fruit/plant was recorded under RCG-1 (278 Nos.) followed by Lalit (254 Nos.), Allahabad Safeda (253 Nos.) and RCGH-1 (248 Nos.).

Whereas, the highest yield/plant was found in Allahabad Safeda (36.25 kg) followed by Lalit (34.38 kg) and RCGH-1 (34.66 kg). The maximum TSS was recorded in RCG-11 (12.2%) followed by RCGH-7 (11.8%) and Sangam (11.2%).

UNDERUTILIZED FRUITS

Performance of grafting methods and growing environment on graft success and growth performance of *Sohiong* (*Prunus nepalensis*)

Two methods of grafting viz. wedge and tongue were performed on one year old seedling of *Sohiong* rootstock during 3rd week of October. The grafts were kept in three growing environment viz. open, net house and polyhouse. The maximum graft success (80%) was recorded under open and polyhouse condition through wedge grafting and in net house condition through tongue grafting, however, the lowest success (60%) was recorded under net house and open condition with wedge and tongue method of grafting, respectively. Plant growth parameters like plant height (45.23 and 47.67 cm), rootstock dia. (8.14 & 8.0 mm), scion dia. (6.13 & 6.25 mm), no. of leaves (33 & 42) and branch/plant (2.75 & 3.33) was found maximum in growing environment of net house than open and polyhouse condition with both wedge and tongue methods of grafting at 4 months after graft success.

Fig 1. Grafted Sohiong plants

Physical and biochemical studies of *Sohiong* fruit

Two genotypes (bigger and smaller size) of *Sohiong* fruit were analyzed for physical and biochemical parameters. Data revealed the wide variation between both the genotypes (Table 1).

Table 1. Physical and biochemical studies of *Sohiong* fruit

Parameters	*Sohiong* fruit	
	Bigger size	Smaller size
Fruit weight (g)	7.91	3.98
Fruit volume (ml)	8.33	4.25
Specific gravity	0.95	0.94
Fruit length (mm)	21.76	18.16
Fruit diameter (mm)	21.80	17.12
Stone weight (g)	2.44	1.00
Stone length (mm)	15.94	13.48
Stone diameter (mm)	15.08	11.48
Pulp recovery (%)	69.11	74.71
Pulp: stone ratio	2.24	2.95
TSS (%)	19.6	20.15
Acidity (%)	3.32	2.56
Ascorbic acid (mg/100g)	58.38	50.04
Reducing sugar (%)	4.44	4.26
Total sugar (%)	8.75	7.50
'β' Carotene (mg/100g)	2.16	2.76
Anthocyanin (mg/100g)	313.34	358.86
Pectin (%)	2.0	1.80
Moisture (%) Fruit	61.84	59.71
Seed	33.33	25.22
Fibre (%)	1.71	2.50

Areca nut Diseases

All the seven districts of Meghalaya were surveyed to find out the problems of areca nut. Altogether, ninety-nine villages were randomly selected and surveyed. The access to the villages was made possible with the help of the officials, Department of Horticulture, Government of Meghalaya; Meghalaya Rural Development Society (MRDS) and village headmen. Based on the questionnaires, the farmers and the government officials were asked for the gross cropped area and production statistics; crop losses, incidences of diseases and pest, any control measures adopted either of their own or from government assistance. The samples were collected and on site observation for assessment of crop losses were assessed. The crop losses varied from 9-11% in West Garo Hills, 15-20% South Garo Hills, 45-50% East Garo Hills, 5-10% West Khasi Hills and 2.5-25% East Khasi Hills. The diseases samples/ insect specimens were identified in the laboratory.

Identification of areca nut problems

Disease identification: The diseased samples were collected and pathogens were isolated. The following pathogens were identified:

a. Bud rot: *Phytophthora palmivora*
b. Leaf spots: *Phyllosticta arecae*
c. Leaf blight: *Pestalotia* spp. and *Phomopsis* spp.

Insect incidence: Insect infested samples, which were showing bud rotting / drying of crown, were observed. From the samples, a new insect was recovered and identified as Red Palm Weevil (*Rhynchophorus ferrugineus*). The insect infested mostly the young and juvenile trees. Both adult and larvae were found tunneling inside the young tender buds thereby damaging the growing point and ultimately the trees died. And also the plant parts damaged by the insects served as a vulnerable spot for secondary bacterial as well as fungal infection.

Fig 1. Collection of Bud rot sample

Fig 2. Red palm weevil from Areca nut

The disease incidence and insect prevalence were found to be higher in the southern and northern parts of the state. These regions being nearer to the plains of Bangladesh and Assam, respectively, are comparatively lower in altitudes to the central highlands. Thus the climate is hotter which favours higher incidence of disease and insect.

Insect Pests

Citrus

Eco-friendly management of citrus leaf miner (*Phyllocnistis citrella* Stainton)

Four biopesticides and five conventional insecticides were evaluated against citrus leaf miner of which the imidaclopid (0.075%) treated plants recorded the lowest numbers of larvae /twig. Among the botanicals, karanjin (2%) recorded the lowest larvae but it was at par with other botanicals. At 3 DAT, larval population for the treatment of imidaclopid (0.075%) was at par with all the other insecticidal treatments. The observations made at 5 DAT revealed that the number of larvae/twig for the treatment imidaclopid (0.075%) (1.47) differed significantly from neem formulation (2.23) (1.97), prithvi garlic gold (2.20) and control (3.33) however, it was at par with azadirachtin 300 ppm, karanjin, spinosad, monocrotophos, endosulfan and lamdacyhalothrin at 5 DAT. The data showed that the treatment imidaclopid differed significantly from control on 7 DAT and 14 DAT, however was at par with all the treatment except for neem and prithvi garlic gold, respectively. Out of nine insecticides evaluated, imidaclopid (0.075%) and karanjin (2%) were found most effective in management of citrus leaf miner.

SPICES

Ginger

Evaluation of ginger varieties for yield and quality

Ten ginger (*Zingiber officinale*) varieties/ genotypes were evaluated to study the effect of environment on their growth and quality parameters. Among the genotypes evaluated highest plant height was found in Nadia (42 cm) with lowest crude fibre content (2.93%). *Khasi* Local showed comparable crude fibre content (2.97%). Highest dry recovery was recorded in V_3S_1-8 (25.20%). The highest yield (28.50 t/ha) was recorded in the variety Nadia, which was followed by Jamaica (22.3 t/ha).

Genetic diversity analysis in the traditional and improved ginger genotypes of northeast India using RAPD markers

Zingiber officinale Rosc. (Ginger) is one of the most valued horticultural crops of northeast India used extensively as spice and for its medicinal properties. The research was conducted to study the genetic diversity of ginger germplasm of northeast region of India using RAPD markers and

comparison of the same with some established varieties cultivated in the region as well as other parts of India.

- The 18 RAPD primers amplified 109 distinct fragments and the number of fragments per primer ranged from 1-13 in the size range of 0.3-2.5 Kb (Table 1).
- Dendrogram (Fig.2) based on UPGMA analysis separated the 49 genotypes into 5 major clusters with a Jaccard's similarity co-efficient of 0.57 to 0.96.
- High polymorphism of 92.85% detected in this study confirmed the high allelic diversity associated with ginger germplasm using 18 RAPD primers.
- 4 primers produced bands specific to a group of genotypes *viz.* Meghalaya local, MLG-30, MLG-34 and MLG-39.
- These specific fragments could serve as a potential source for genotype identification especially for the varieties which are in great demand for their high medicinal values/oleoresin content.
- The information generated by the DNA profiling of these fragments will also provide a basis for developing SCAR/STS markers.
- The research on DNA profiling is being carried out with more cultivars collected from other states of North east to generate more information on allelic diversity associated with quality ginger germplasms.

Table 1. List of genotype with specific unique bands

Primers	Genotype(s)	Molecular weight (Kb)
OPA 03	MLG-34	2.05
OPA 13	All genotypes other than Khasi local, MLG-39, MLG-34, MLG-30	0.82
OPA 19	PUNE	1.61
OPA 19	MLG-39, MLG-34, MLG-30	1.27
OPB 06	Khasi local, MLG-39, MLG-34, MLG-30	1.16
OPB 07	All genotypes other than Khasi local, MLG-39, MLG-34, MLG-30	2.38
OPB 07	Khasi local, MLG-39, MLG-34, MLG-30	1.58
OPB 07	Khasi local, MLG-39, MLG-34, MLG-30	0.97
OPB 07	Khasi local, MLG-39, MLG-34, MLG-30	0.75

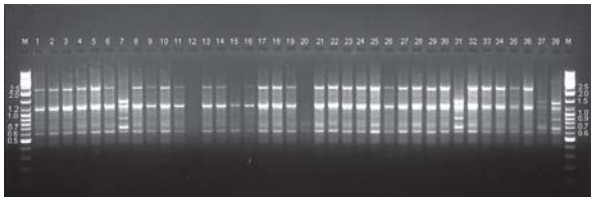


Fig 1. Agarose gel photograph of ginger genotypes with OPB 09 primer

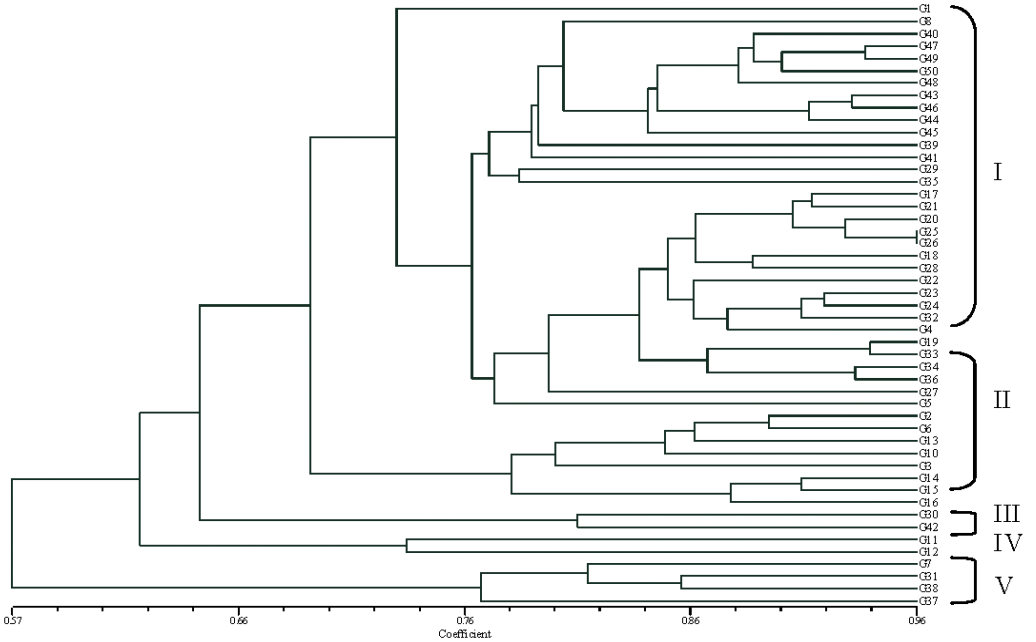


Fig 2. Dendrogram depicting genetic relationships among the ginger genotypes

Diseases

Eco-friendly management of ginger diseases

Eco-friendly methods of disease management were evaluated against diseases of ginger. *Trichoderma* based formulation viz. Trichostar, Nisarga and copper oxychloride as a check were used for rhizomes treatment and Panchgavya was used as soil drench. Total three sprays were given at an interval of one month. Apparently there was no difference in *Phyllosticta* and *Cercoseptoria* leaf spots but yield differences were significant indicating yield enhancing (20-23%) effects of *Trichoderma* based formulations (Table 1).

Table 1. Yield enhancing effects of *Trichoderma* based formulations

Treatments	Dose	Yield (t/ha)
Trichostar (*Trichoderma viride* 1% WP)	5 g/l	24.6
Nisarga (*Trichoderma viride* 1% WP)	5 g/l	23.7
Blue copper (Copper oxychloride 50% WP)	3 g/l	15.2
Panchgavya	30 ml/l	16.7
Control	-	18.9
CD (*P*=0.05)		5.6

Turmeric

Evaluation of turmeric varieties for yield and quality

To study the interaction of genotype and environment (G x E) on growth and quality characters, ten different varieties/genotypes of turmeric (*Curcuma longa*) were evaluated. Dry matter recovery was highest in Pratibha (23.3%) closely followed by Rasmi and Kedaram (22.7 % each) while lowest recovery (14.5%) was in Rajendra Sonia. Highest curcumin content was recorded in Megha Turmeric-1 (7.73%). BSR-2 (Fig 1) produced the heaviest rhizomes per plant (642.2 g/plant).

In another trial, 44 different varieties/lines of turmeric were planted during April'09 and were evaluated. The maximum yield (25.3 t/ha) was obtained in Megha Turmeric-1 followed by Lakadong (20.0 t/ha). The variety Narendra Haldi recorded the highest yield /plant (960 g/plant).

Fig 1. High yielding turmeric genotype BSR-2

Field trial of *Curcuma longa* var. Lakadong in different agro climate zones of northeast India for ascertaining factors influencing curcumin content

In order to test the curcumin rich varieties of turmeric like Lakadong under different agroclimate of the North East India so as to identify the factors responsible for sustaining the quality of the varieties. Based on two years trials in Assam, Meghalaya, Manipur and Sikkim, the salient findings of the project are as follows:

a. Rhizome of Lakadong cultivar has unique orange red colour with curcumin content approx. 8-8.7% in its natural habitat and Megha Turmeric-1 is 5-6.5%.
b. Lakadong is prone to leaf blotch attack whereas, Megha Turmeric-1 has the tolerance to the same.
c. Lakadong matures in 240-245 days whereas; Megha Turmeric-1 matures in 255-260 days.
d. Lakadong rhizome is smaller in size and fresh weight is 47 % less than Megha Turmeric-1.
e. Co cultivation of Lakadong with Maize (traditional practice) helps in reducing leaf blotch attack and enhances curcumin content than mono cultivation.
f. Phosphate content in soil influences positively to curcumin content

Diseases

Eco friendly management of turmeric diseases

Eco-friendly methods of disease management were also evaluated against diseases of Turmeric.

Treatments like RCH 1, Nisarga, Panchgavya and Sixer were evaluated against *Taphrina* leaf spot of turmeric. Only fungicide Sixer was effective in managing the diseases. However, yield differences were non significant.

Integrated effects of amendments and fertilizer on crop productivity and soil health

Field experiment was conducted during the *kharif* season to study the integrated effects of amendments (organic and inorganic) and fertilizers on crop productivity of turmeric var. RCT-1 and soil health in acid soils of Meghalaya. Locally available organic (e.g. FYM, poultry manure, weed biomass) and inorganic (e.g. agricultural lime-AL) amendments along with recommended doses of fertilizers (NPK) at varying combinations were explored.

Rhizome yield (fresh weight) of turmeric reflected a wide variation among the treatments and ranged from 5.0 t ha^{-1} to 16.98 t ha^{-1} (Fig 2). Application of FYM @ 5 t ha^{-1} alone increased the rhizome yield by 60% while in combination with 100% recommended NPK or with 20% LR of agricultural lime, the corresponding increase was more than 70% over absolute control. Application of poultry manure @ 2.5 t ha^{-1} with 20% LR of agricultural lime increased the yield by 85% while application of poultry manure alone reduced this increase to 40% over absolute control (5 t ha^{-1}). However, weed biomass (*Ambrosia spp.*) as mulch influenced rhizome yield most prominently and along with 100% recommended NPK, the rhizome yield increased by 183% over absolute control. Addition of lime (20% LR) with mulches + 100% recommended NPK further increased the rhizome yield by an additional 50% and thus recorded the highest rhizome yield of 16.98 t ha^{-1}(Fig 2). Thus, the best combination to attain maximum productivity of turmeric (rhizome yield) was 100% recommended NPK + 20% LR of agricultural lime + 1.5 t ha^{-1} weed biomass.

FLORICULTURE

Gerbera

Evaluation of gerbera under poly house and open condition

A total of 37 cultivars of gerbera were evaluated under poly house condition (Fig 1). The planting was done during 3rd week of September and plants started the flowering in the month of December. Cultivars Lion produced maximum number of flowers per unit area (157 nos/m^2) and per plant (3.74 nos), while flower diameter (11.89 cm) and disc diameter (3.41cm) were found maximum in cv. Rosalin and RCGH-12, respectively.

Whereas, maximum stalk length (48.31cm) and stalk diameter (6.54 mm) were recorded in cv. Venice and Leoni, respectively and plant spread (53.67cm) in cv. Shania. Field life (25 days) of the flower was observed to be maximum in cv. Leoni from the time of bud bursting.

Among the 25 hybrids/genotypes evaluated under open conditions (Fig 1), hybrid RCGH-57

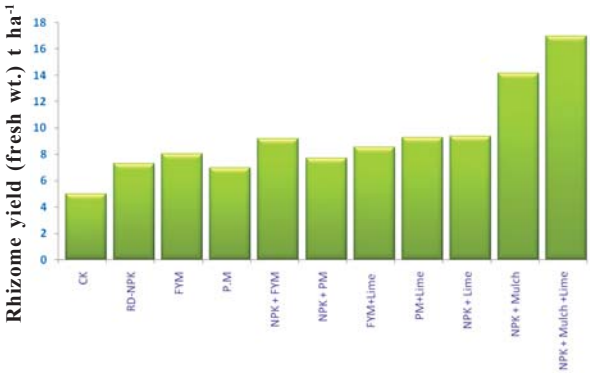


Fig 2. Effect of amendments (organic and inorganic) and fertilizer on turmeric productivity

Fig 1.Evaluation of gerbera in poly house and open condition

produced maximum number of flowers per unit area (12 Nos/m^2.). Maximum flower disc diameter (3.57cm) and stalk length (38.03 cm) were observed with RCGH-113. Stalk diameter (5 mm) and flower diameter (10.23 cm) were found maximum in RCGH-65 and RCGH-86, respectively.

Genetic diversity studies on 20 different species of *Dendrobium*

RAPD were used to investigate the genetic diversity among 20 different species of *Dendrobium* (G1-G20) as provided by NRC Orchid, Pakyong, Sikkim. Genomic DNA extraction was done using Qiagen DNA Ease Miniprep Kit. Reagents (PCR master mix and 1X TAE Buffer) used for the study were from Promega except for the Operon 10-mer OPA series primers. (Operon Technologies, Inc, USA.)

From the study a total of 677 RAPD bands were obtained from 16 different primers. The band data were analyzed for similarity using simple matching coefficient. The matching coefficient was clustered using UPGMA and the result is presented in Fig 2.

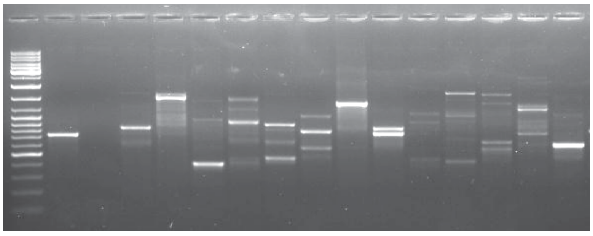


Fig 2. DNA profile of 20 different species of *Dendrobium* using OPA 9

In general, variability among the genotypes was low. However, three major groups could be identified.G1 and G10 were almost identical. Group I included G1, G10, G2, G11, G15, G6, G16, G9; Group II included G3, G18, G14, G4, G13 and Group III included G19, G20, G8. Genotypes G7, G17, G5 and G12 showed individual identities and were intermediate to Group II and Group III. Mantel's test indicated good correspondences (0.93) between the similarity matrix and the dendrogram.

Distinct bands present in some of the genotypes were identified and listed below for further development of SCAR primers for future research.

Table 1. List of specific markers identified

Primer	Genotype	Mol wt. (bp)
A2	5	2345.19
	12	1691.57
	5	406.58
	7	350.47
A4	1	2426.51
	4	531.92
	14	394.48
A5	5	3240.74
	4	749.68
	18	311.47
A8	16	187.1
A10	15	586.88
	5	364.9
A11	16	1328.91
	13	394.32
A12	14	1906.26
	12	568.65
	5	448.39
A13	5	349.25
A18	3	2359.63
	18	1325.92
	20	532.31
A19	14	500.16
	6	434.63
	5	285.21
	4	257.99

POST HARVEST TECHNOLOGY

Ginger

Shelf life extension of ginger through pre and post harvest treatments

Seven botanicals out of 30 botanicals showed some results in reducing the rate of physiological loss in weight (PLW) during storage. Therefore, seven identified botanicals were used for pre and post harvest treatment of ginger variety Nadia. Pre harvest treatment was given one month before harvest. After harvesting the rhizomes were kept in a field pit up to April 1st week, 2009. After 3 months of field storage, the ginger rhizomes were removed from the pit and after proper washing the rhizomes were stored at ambient condition up to July 3rd week, 2009 with or without botanical treatments to study the effect of botanicals on sprouting behaviors. The experimental study revealed that none of the botanicals was found to be effective sprout inhibitors in ginger.

Development of different packaging design for long distance transport of ginger

Five different Corrugated Fibre Board (CFB) boxes (Table 1) viz. 5 kg, 10 kg, 15 kg and 20 kg with and without tray were designed and manufactured for transportation losses of fresh ginger. CFB boxes with 5 ply having 150 GSM thickness of each ply was manufactured as per standard Truckload. Boxes of 10 and 15 kg capacity had 2 and 3 trays of 5 kg capacity each, respectively. The trays were of 3 ply and 150 GSM thick. Boxes of 20 kg with Honey comb packing (3 ply) were also designed and manufactured. Two holes (25mm diameter) were made horizontally in each tray for proper ventilation. After initial evaluation of its capacity, 50 boxes, each of different sizes were manufactured for storage and transportation study.

Sohiong

Post harvest management and value addition

The physico-chemical properties of *Sohiong* (*Prunus nepalensis*) fruit after 75 days of fruiting were analysed at 15 days interval in order to standardize appropriate maturity indices for harvesting of *Sohiong* in right time (Table 2). Within a span of 150 days there is an increase of 30.66 % in the length of fruit and 48.14% in diameter. The volume and weight increased almost five times from the initial stage. The maximum pulp stone ratio (2.12) was found at 225 days of maturity. However, a uniform trend in change was not seen in case of dry matter percentage of the fruit. A gradual decline in acidity and increase in TSS was observed during the study period. Ascorbic acid content also increased with increasing maturity level with the final reading of 32.10 mg/100gm at 225 days of maturity. The pectin percentage decreased with increasing maturity level. Hence, for extraction of pectin, fruits of early days should be selected. However for making of juice, the fruits of 225 days can be selected as they have TSS of 18.4 %.

Ready to Serve (RTS) *Sohiong* beverage

The *Sohiong* fruits of 225 days of maturity were selected for preparation of RTS beverage**.** The total

Table 1. Specification of boxes used in transport study

Type of CFB boxes	Capacity (kg)	Internal dimension (L x B x H) in mm	Tray dimension (L x B x H) in mm	No. of trays in each box	No. of holes in each box
1	5	360x 250x 150	-	Nil	2
2	10	515x 360x 150	350x 240x 140	2	4
3	15	770x 360x 150	350x 240x 140	3	6
4	20	515x 360x 310	350x 240x 140	4	8
5	20	515x 360x 310	-	Honey comb without tray	8

Table 2. Physico-chemical properties of *Sohiong* at different maturity levels of 15 days interval

Stage of maturity (Days after fruiting)	Size (mm)		Fruit wt. (gm)	Pulp: Stone ratio	Dry matter %	Acidity (%)	TSS (°B)	Ash %	Ascorbic acid (mg/ 100gm)	Pectin %
	Length	Diameter								
75	14.64	12.67	1.67	0.35	26.92	-	-	11.62	-	5.51
90	14.95	12.79	2.07	0.40	26.86	-	-	11.14	-	5.36
105	15.41	12.87	2.48	0.42	26.81	-	-	10.29	-	5.12
120	15.50	12.98	2.52	0.45	26.73	1.66	-	9.53	20.73	4.91
135	15.56	13.39	2.57	0.47	26.62	1.31	9.8	4.37	20.76	4.72
150	16.48	13.87	2.61	0.52	26.14	1.28	12.1	4.21	20.84	4.55
165	16.89	14.76	2.75	0.89	19.96	1.27	12.6	4.11	20.91	4.23
180	16.94	16.12	3.84	1.60	19.45	1.14	13.1	3.13	21.21	4.01
195	16.97	16.31	4.03	1.90	18.97	0.98	15.6	2.87	28.11	3.53
210	17.92	17.69	5.16	2.08	21.38	0.86	16.8	1.98	30.42	3.21
225	19.13	18.77	5.24	2.12	21.40	0.72	18.4	1.92	32.10	3.16

soluble sugar and acidity of 10% juice was adjusted to 15°B and 0.5% acidity respectively. The ingredients (Table 3) were mixed in calculated quantity of water. The RTS was filled in sterilized bottle immediately. It was then pasteurized at 80°C for 20 minutes.

Table 3. Different ingredient and amounts for preparation of RTS *Sohiong* beverage

Ingredients	Amount
Sohiong	1 L
Sugar	1.4 kg
Citric acid	17 g
Water	7.6 L

Standardization of protocols for preparation of passion fruit and *Sohiong* fruit jam and RTS

Experiments were conducted to standardize the recipes for preparation of jam and ready-to-serve (RTS) beverages from passion fruit (cv. Yellow) and medium size local *Sohiong* fruit. Fruit jam as prepared with various percentages of fruit juices/ pulp viz. 50-100% mixed with desired quantity of sugar and water to obtain the products. Final product qualities were evaluated in terms of final TSS (%) and overall acceptability (OAA). While, different percentages of fruit juices/pulp (10, 15, 20, 25, 30%) were mixed with desired syrup strength to obtain RTS with final TSS of 13-17% in the products. Final product qualities were evaluated in terms of final acidity (%), TSS (%) and OAA. Results of these products are shown in the Table 4 -5 and Fig 1. Effect of different percentage of passion fruit juice and *Sohiong* fruit pulp on quality of RTS were also evaluated (Table 6 & Fig 2)

Table 4. Effect of different percentage of passion fruit juice and *Sohiong* fruit pulp on quality of Jam

Initial raw materials			Product qualities					
			Passion fruit jam			*Sohiong* fruit jam		
Juice/ pulp (%)	Juice (ml)	Water (ml)	Acidity (%)	TSS (%)	OAA	Acidity (%)	TSS (%)	OAA
50	500	500	0.59	64.8	6.7	0.64	65.1	5.4
60	600	400	0.72	65.5	6.7	0.78	65.7	6.3
70	700	300	1.09	68.2	7.4	0.91	68.5	7.4
80	800	200	1.27	69.0	8.1	1.05	68.8	7.7
90	900	100	2.05	69.5	5.5	1.75	69.1	8.2
100	1000	000	3.19	69.8	5.0	2.31	69.2	7.4

Table 5. Effect of different percentage of passion fruit juice and *Sohiong* fruit pulp on quality of RTS

Initial raw materials			Product qualities							
			Passion fruit RTS				*Sohiong* fruit RTS			
Juice/ pulp (%)	Juice (ml)	Syrup of TSS 18% (ml)	Acidity (%)	TSS (%)	pH	OAA	Acidity (%)	TSS (%)	pH	OAA
10	100	900	0.39	16.8	3.40	7.2	0.32	16.5	3.65	5.2
15	150	850	0.57	16.0	3.45	8.1	0.49	15.4	3.60	6.0
20	200	800	0.79	15.4	3.42	7.1	0.63	14.3	3.55	7.1
25	250	750	0.96	14.6	3.28	6.3	0.71	13.8	3.49	8.3
30	300	700	1.18	13.2	3.24	5.5	0.85	13.0	3.44	7.5

Fig 1. Optimized *Sohiong* fruit jam

Fig 2. Optimized passion fruit RTS

Cho-cho

Standardization of protocol(s) for preparation of tooty fruity from cho -cho

A process for producing a natural cho-cho (*Sechium edule*) tooty fruity was prepared from matured cho-cho vegetable. In this method, peeled vegetables were sliced into pieces of (10-15) x (10-12) x 5 mm followed by blanching in boiling water for 5-10 minutes. Blanched vegetables were dipped in sugar syrup of 30-40% for 1-2 hours and 72-75% for another 2-3 hours with slow heating. Syrup was mixed with 15-20% *Sohiong* juice and 10-15% fresh ginger juice as a natural colouring, acidulant and flavouring agent. Drained slices were dried in tray drier for 15-30 minutes at 60°C. The cho-cho tuity fruity thus prepared had 70-73% total soluble solid (TSS) and the product is ready for packing in packaging materials. This product could be used as a confectionery, bakery and pan massala purposes.

Assam lemon

Post harvest management and value addition of Assam lemon

Assam lemon fruits were harvested at 10 days interval from 60-150 days after fruit set to identify the right time of harvesting for higher juice content and better fruit quality. Experimental findings revealed that the fruits harvested within 110-120 days after fruit set had the higher juice content (35-40 %), fruit size and pectin content (2.75-3.00 %) (Table 7 & 8).

Table 7. Physical changes of Assam lemon across maturity

Days after fruit set	Fruit weight (g)	Fruit volume (ml)	Specific gravity	Length from pith to albedo (mm)	Pedicel colour	Rind thickness (mm)	Smooth-ness of rind	Juice content (ml)
60	68.3	70.5	0.969	9.87	Light Green	5.77	Visible ridges	19.0
75	66.6	69.0	0.965	14.38	Light Green	5.92	Visible ridges	19.5
90	62.9	64.63	0.973	14.77	Light Green	4.93	Slight smooth	22.3
110	112.9	110	1.027	17.69	Light Green	4.34	Slight smooth	35.17
120	100.1	106.66	0.938	18.35	Yellowish Green	3.48	Very smooth	44.5
130	125.0	118.5	1.055	20.25	Yellowish Green	4.81	Very smooth	47.83
140	146.5	121	1.211	20.02	Yellowish Green	6.17	Very smooth	38.50
150	109.3	112.58	0.971	20.19	Yellowish Green	3.89	Very smooth	30.5

Table 8. Chemical changes of Assam lemon across maturity

Days after fruit set	Titratable acidity (%)	Ascorbic acid (mg/100g)	Chlorophyll content (mg/g)	Pectin (% as calcium pectate)	TSS (^{0}Brix)
60	3.712	51.393	1.20	3.06	6.825
75	3.968	51.393	2.131	2.44	6.55
90	3.648	44.448	2.115	0.892	6.50
110	3.8613	32.41	1.7066	2.781	5.933
120	4.459	30.558	1.205915	1.468	5.90
130	4.864	11.112	0.9251	2.60	6.30
140	4.13	27.79	0.281698	1.56	6.1
150	4.352	36.11105	0.07824	1.692	5.55

Pumello

Evaluation of quality of pumello fruits grown in different locations of Meghalaya

Fully matured ripe pumello fruits (*Citrus grandis*) were collected from different locations viz., Byrnihat A, Byrnihat B, Byrnihat C, Changbangla A, Changbangla B, Umsning and Shillong (Laban), Meghalaya. Physico-chemical analysis was performed and data presented in table 9 &10.

Table 9. Physical properties of pumello fruits grown in different locations of Meghalaya

Location	Weight /fruit (g)	Diameter (mm)	Volume (ml)	Rind thickness (mm)	LPT* (mm)	No. of segments	No. of seeds	Juice content (ml)	Oil gland / cm^2
Byrnihat A	1096.5	139.96	1853.33	15.70	38.15	14	109	337	33.66
Byrnihat B	865.33	123.01	1138.33	10.17	37.12	9	27	259	47.00
Byrnihat C	509.00	99.14	563.33	8.67	39.45	10	35	205	61.66
Changbangla A	1682.5	159.78	2845.00	25.86	45.04	14	13	382	23.00
Changbangla B	1147.75	142.88	1730.00	15.17	40.43	14	31	430	52.00
Umsning	928.00	129.16	1240.00	11.28	43.72	14	52	282	31.50
Shillong	871.00	135.16	1260.00	19.57	31.45	20	27	175	24.00

*LPT (Length from pith to albedo)

Table 10. Chemical properties of Pumello fruits grown in different locations of Meghalaya

Location	TSS (°B)	Ascorbic acid (mg/100g)	Acidity (%)
Byrnihat A	7.6	64.40	0.9
Byrnihat B	8.5	48.30	1.0
Byrnihat C	8.0	48.30	1.0
Changbangla A	8.6	57.96	0.8
Changbangla B	7.3	48.30	1.2
Umsning	7.7	35.42	1.6
Shillong	8.3	35.42	1.2

Mandarin

Utilization of *Khasi* mandarin peel for value added products

Different value added products viz. peel oil, peel colour and peel candy were developed. Peel oil was extracted with distillation method while colour was extracted with different solvents. Peel candy was prepared by making thin pieces of size 3-4 mm width and 30-35 mm length followed by boiling in water 5-25 minutes. Blanched pieces were dipped in sugar syrup (70% brix) along with 1% citric acid and heated slowly for 15 minutes to 75 minutes. Best quality peel candy in terms of organoleptic score (7.6) was obtained in the product with processing condition: boiling time (15 minutes) and heating time (60 minutes) in sugar syrup (70% brix) along with 1% citric acid.

Evaluation of physico-chemical properties of *Khasi* mandarin fruits grown in five locations of northeast India

Khasi mandarin fruits were collected during December, 2009 and January, 2010 from five

different locations of northeast viz. Arunachal Pradesh, Assam (Karbi Anglong), West Garo Hills. Fruits were evaluated for their physical and chemical characteristics such as TSS, acidity, ascorbic acid content, beta carotene and antioxidant activity (Table 11 & 12) to know the variation in quality with respect to location.

Minimal processing of vegetables

Broccoli (var. Pushpa) curds were harvested in the morning hours and brought to the laboratory. The curds were washed properly with potable water and thereafter 2-4 pieces were made. 4-5 pieces of 200-300 g were then packed in. different packaging material (maintained 0.004% perforation and non perforated) used viz. low density polyethylene (LDP, 200 gauge), combination of LDP + high density polyethylene (LDHM, 200 gauge) and polypropylene (PP, 200 gauge). The sealed packages were kept for storage study under ambient temperature (15.4 ± 2°C) and refrigerated storage (4 ± 0.5°C) during the month of January. Shelf life of these vegetables were determined by evaluating different quality parameters such as physiological loss in weight (PLW, %), ascorbic acid content (mg/100g), beta carotene content (mg/100g), antioxidant activity (µmol Trolox/g), chlorophyll content (mg/g), colour value, gas composition (%) and, visual and textural score at 3 days and 7 days interval for total period of 12 days and 28 days for ambient and refrigerated condition respectively. The maximum shelf life with minimum quality deterioration in terms of PLW (3.06% and 14.26%), ascorbic acid content (100 mg/100g and 125.74 mg/100g), beta carotene content (21.03mg/100g and 25.92 mg/100g), antioxidant activity (1.52 and 3.31µ mol Trolox/g), chlorophyll content (0.176 mg/g and 0.352 mg/g), colour value, gas composition (%) and, visual and textural score were recorded in broccoli packed in non perforated LDHM (200 gauge) for 12 days and 28 days respectively for ambient and refrigerated condition.

Shelf life extension of *Sohshang* using MA packaging

Shelf life of *Sohshang (Eleagnus latifolia)* fruits (Table 13) stored in different packaging materials was determined based on visual and textural properties of the fruits. A gradual decrease in both visual and textural property of the fruits was observed with the increase in storage period. On 9th day of storage, the fruits packed in non-perforated PP recorded the highest visual (5.5) and textural (3.0) score while the fruits packed in leaf recorded the lowest visual (3.0) and textural (1.0) score (Table 14). The highest shelf life of 9 days was found in the fruits packed in non-perforated PP followed by non-perforated LDHM with 8 days

Table 11. Physical properties of mandarin fruit collected from five locations of northeast India

Locations	Length (mm)	Diameter (mm)	Weight (g)	Colour			Juice percent
				L	a	b	
Arunachal Pradesh	54.55	61.59	112.45	47.90	17.99	25.39	35.27
Karbi Anglong	54.31	60.31	119.78	55.35	18.46	29.00	45.16
West Garo Hills A	46.01	53.34	77.47	53.98	30.18	28.67	48.86
West Garo Hills B	49.58	57.78	94.29	53.67	29.29	28.44	54.17
West Garo Hills C	49.18	56.49	90.65	54.18	30.00	28.71	51.71

Table 12. Chemical properties of mandarin fruit collected from five locations of northeast India

Locations	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100g)	Beta-carotene (mg/100g)	Antioxidant activity (µmol Trolox/g fresh wt.)
Arunachal Pradesh	9.94	0.58	41.20	2.91	1.56
Karbi Anglong	11.02	0.71	30.90	3.18	1.80
West Garo Hills A	11.20	0.38	24.50	1.94	1.47
West Garo Hills B	11.06	0.38	23.52	3.16	1.50
West Garo Hills C	11.23	0.34	26.46	3.77	1.52

Table 13. Effect of packaging materials on shelf life of *Sohshang* during storage

Treatments	Days after storage						Shelf life (Days)
	Visual quality			Textural quality			
	3	6	9	3	6	9	
Control	5.0	2.0	-	2.5	1.5	-	2-3
Perforated PP	8.0	6.5	5.0	4.8	3.2	2.5	6-7
Non perforated PP	8.0	7.5	5.5	4.8	3.5	3.0	9
Perforated LDPE	6.5	5.0	4.0	4.5	3.0	2.0	5-6
Non perforated LDPE	6.8	6.0	5.0	4.5	3.2	2.5	6-7
Perforated LDHM	8.0	7.0	5.0	4.5	3.3	2.5	6-7
Non perforated LDHM	7.5	6.2	5.0	4.8	3.5	2.8	7-8
Leaf	8.0	4.5	3.0	3.5	2.0	1.0	4
CD (*P*=0.05)		0.24	0.30	0.24	0.24	0.39	0.17

Table 14. Effect of packaging materials on PLW, texture and decay loss of *Sohshang* during storage

Treatments	Days after storage								
	PLW (%)			Texture (kg)			Decay (%)		
	3	6	9	3	6	9	3	6	9
Control	16.58	35.72	-	0.770	0.719	-	-	-	6.63
Perforated PP	1.02	2.15	3.49	1.472	1.407	1.181	12.41	13.01	33.18
Non perforated PP	0.58	1.16	2.42	1.550	1.298	1.261	-	-	10.20
Perforated LDPE	1.09	2.58	5.44	1.606	1.371	1.234	12.82	26.58	39.74
Non perforated LDPE	0.99	1.98	3.68	1.487	1.340	1.165	18.13	26.59	33.28
Perforated LDHM	1.11	3.87	5.08	1.479	1.259	1.207	-	-	39.88
Non perforated LDHM	0.97	1.95	2.89	1.611	1.251	1.243	6.47	19.94	26.66
Leaf	1.57	8.41	18.94	1.311	1.144	0.890	-	26.12	48.32
CD (*P*=0.05)	0.08	0.08	0.05	0.024	NS	0.017	0.10	0.08	0.08

of storage. However, the shortest shelf life was recorded in fruits without packaging, which had a shelf life of 3 days only.

CROPPING SYSTEM RESEARCH

Evaluation of groundnut based cropping system on permanent raised bed

The experiment was continued for the second year consisting of eight groundnut based cropping systems on permanent raised beds (Table 1). The results revealed that groundnut yielded more (2.8 t/ha) when grown after French bean and fallow systems while lowest yield was after radish (1.9 t/ha). Among the sequential crops highest groundnut equivalent yield (GEY) was recorded with capsicum followed by carrot resulting into improvement in total system productivity of which was highest with groundnut-capsicum (15.9 t/ha) followed by groundnut-carrot (14.0 t/ha) system. Groundnut-tomato cropping sequence was next to the higher yielding sequence which remained 44.51% inferior to groundnut-capsicum system but it was 288% higher than groundnut-fallow system. Other cropping systems like groundnut-potato, groundnut-cauliflower and groundnut-radish remained in between 6.43 to 9.04 t GEY/ha. In another study groundnut was sequenced with food toria, rajmash, ricebean, lentil, linseed and wheat. One groundnut-fallowed treatment was kept for comparison. It was

Table 1. Production potential of groundnut based cropping system on raised beds in lowland area

Cropping system	*Kharif* crop yield (t/ha)	Summer crop yield (t/ha)	Groundnut equivalent yield (t/ha)	Total system productivity (t/ha)
Groundnut-potato	2.20	16.38	5.78	7.98
Groundnut-tomato	2.24	21.37	8.80	11.03
Groundnut-capsicum	2.48	13.46	13.46	15.94
Groundnut-French bean	2.80	13.27	6.24	9.05
Groundnut-cauliflower	2.37	19.66	8.10	10.47
Groundnut-carrot	2.06	20.33	11.96	14.02
Groundnut-radish	1.90	25.71	4.54	6.44
Groundnut-fallow	2.84			2.84
CD (*P*= 0.05)	0.12	-	0.43	0.91

found that groundnut yield significantly reduced when grown after non legume crops component. Maximum reduction was observed with wheat which was 77.60% and 47.39% as compared to groundnut yield recorded with fallow system and groundnut-lentil system. Among the *rabi* crops, higher biomass yield was recorded with rajmash (3.6 t/ha) and lentil (3.5 t/ha) which resulted into maximum total system productivity of 5.94 t GEY/ha with groundnut-lentil which was closely followed by groundnut-rajmash system (5.90 t GEY/ha). Inclusion of wheat in the cropping system not only reduced the yield of groundnut but gave lowest total system productivity (3.20 t GEY/ha), which was however, 6.83% higher over mono cropping system i.e. groundnut-fallow system. Groundnut-toria was also the lowest yielder sequence under the trail registering GEY of 3.48 t/ha. Other higher yielding cropping systems remained in between 0.50-0.60 t GEY/ha under study (Table 2).

Effect of raised bed width and crops on grain yield of rice grown in sunken bed

The effect of width of raised bed and types of crops on rice grown in sunken bed was studied by keeping upland crops viz. maize, rice, soybean and groundnut in sub plot while raised bed width of 1, 2, 3 and 4 meter was kept in main plots. The experiment was laid in split plot design (SPD) with three replications. The results revealed that high stature crops viz. maize and rice significantly reduced the yield of rice var. Shahsarang in sunken bed. Low stature crops of groundnut did not influence sunken rice recording maximum yield of 3.56 t/ha in sunken rice followed by upland rice (3.45 t/ha). While the rice grown in open area registered 4.57 t/ha rice yield which was 28-115 % higher over the yield recorded in sunken bed in the presence of raised bed crops (Table 3). The width of raised beds also affected the sunken bed rice. Maximum rice yield was obtained with 1.0 - 2.0 m width and lowest

Table 2. Production potential of groundnut based cropping system

Cropping system	*Kharif* crop yield (t/ha)	Summer crop yield (t/ha)	Groundnut equivalent yield (t/ha)	Total system productivity (t/ha)
Groundnut-toria	2.31	1.00	1.18	3.48
Groundnut-rajmash	2.34	2.75	3.56	5.90
Groundnut-ricebean	2.61	1.73	2.55	5.16
Groundnut-lentil	2.49	2.45	3.45	5.94
Groundnut-linseed	2.21	1.40	2.88	5.09
Groundnut-wheat	1.69	2.58	1.52	3.20
Groundnut-fallow	2.91			3.00
CD (*P*=0.05)	0.1		0.35	0.43

Table 3. Effect of raised bed width and crops on grain yield (t/ha) of rice grown in sunken bed

Crop	Raised bed width				
	1 m	2 m	3 m	4 m	Mean
Maize	2.43	2.27	2.01	1.93	2.16
Rice	3.33	3.65	3.46	3.38	3.45
Soybean	3.79	3.33	2.88	3.12	3.28
Groundnut	3.43	3.64	3.43	3.75	3.56
Mean	3.04	3.22	2.94	3.04	
CD (*P*=0.05)	Crop 1.12 ,				

Raised bed width 1.76 C x R 7.54

was with 3 m. The height of raised beds was also evaluated keeping 10, 20, 30, 40 and 50 cm raised beds height in main plots with maize, rice, groundnut and French bean in subplots. Results revealed that all the crops under study did not perform up to 20 cm raised bed height excepting rice. Rice yield was maximum up to 20cm raised bed height thereafter it declined. Contrary to it, other crops improved yield after 20 cm raised bed height recording maximum yield at 50 cm raised bed height (Table 4).

Table 4. Effect of height of raised bed from moisture levels on yield (t/ha) of crops

Crop	Raised bed height					
	10 cm	20 cm	30 cm	40 cm	50 cm	Mean
Maize	1.02	1.74	2.83	1.43	3.01	2.00
Rice	3.51	3.57	3.22	3.28	3.12	3.34
Groundnut	0.48	0.75	1.56	2.15	2.47	1.48
Frenchbean	1.23	1.63	5.69	11.23	13.74	6.67
Mean	1.56	1.92	3.32	4.52	5.59	
CD (*P*=0.05)	Crop 2.35 ,					

Raised bed height 3.76 C x R 8.56

Evaluation of toria based cropping system

The experiment was continued for 5th year to find out sustainable cropping sequence for mid hills of NE India. Treatments comprised of four toria based cropping sequences were arranged under low and upland ecologies. In low land areas, raised bed were prepared but in upland area the crop was sown on flat well terraced field. The experiment was laid in SPD with three replications. Among the two ecologies, lowland recorded highest yield of component crops and total system productivity in terms of toria equivalent yield (TEY), which was 6.89% higher over upland cropping sequences (Table 5). Among the *kharif* crops, maximum TEY was recorded with French bean (5.26 t/ha) followed by groundnut (1.96 t/ha) (Table 5). Lowest TEY was recorded with maize (0.73 t/ha). The total system productivity of 6.34 t/ha (TEY) was recorded with French bean-toria followed by groundnut-toria and lowest system productivity of 1.94 t TEY being on par with rice-toria (1.99 t/ha) was recorded with maize-toria cropping system.

Table 5. Performance of toria based cropping system in two environments

Treatment	*Kharif* crop yield (t/ha)	*Kharif* crop product-ivity (t/ha) as toria equivalent yield	Toria yield (t/ha)	Total system product-ivity (t/ha)
Environment				
Upland	5.13	2.41	0.79	3.19
Lowland	7.45	2.41	0.10	3.41
CD (P=0.05)		NS	0.15	0.12
Cropping system				
Rice – toria	3.15	1.20	0.79	1.99
Maize – toria	2.44	1.22	0.73	1.95
Groundnut – toria	2.31	1.96	0.97	2.93
French bean – toria	13.52	5.26	1.08	6.34
CD (*P*= 0.05)		0.02	0.09	0.11

Evaluation of cole crops based inter cropping systems for raised bed

Cole crops based intercropping systems were evaluated to increase productivity of raised beds. The inter space between two lines of cauliflower was utilized by keeping one line of pea, methi, coriander, radish and carrot. All the crops were also grown as pure for comparison. The treatments were tested in RBD with three replications. It was observed that all the intercrops significantly reduced the yield of main cauliflower yield. Maximum yield reduction was recorded with cauliflower + radish and minimum was with cauliflower + pea. The yield of intercrop was converted into cauliflower equivalent yield (CEY) and added with cauliflower yield. Maximum total system productivity of 29.76 t CEY/ha recorded with cauliflower + pea followed by cauliflower + carrot (25.28 t/ha), which was 32.13 and 12.25 % higher over sole crops of cauliflower (Table 6). Growing of coriander and radish reduced cauliflower yield which could not be compensated by their yield as the total system productivity of sole crop of cauliflower yield was 31.62 to 58.10 % higher over cauliflower + coriander and cauliflower + radish, respectively. Intercropping studies with broccoli revealed that all the intercrops significantly reduced yield of broccoli. Maximum yield reduction was observed with radish (139.96%) and lowest was with pea (5.68%). The yield of

Table 6. Effect of cauliflower based intercropping system on system productivity on raised bed

Cropping system	Cauli-flower yield (t/ha)	Inter-crop yield (t/ha)	Cauliflower equivalent yield (t/ha)	Total system product-ivity (t/ha)
Cauliflower + pea	21.03	3.7	8.74	29.76
Cauliflower + methi	18.51	1.63	5.42	23.93
Cauliflower + coriander	13.59	0.85	3.53	17.11
Cauliflower + radish	11.53	6.54	2.72	14.25
Cauliflower + carrot	17.09	7.03	8.20	25.28
Cauliflower (sole)	22.53			22.53
CD (P =0.05)	0.56			0.73

intercrop was converted into broccoli equivalent yield (BEY) which showed maximum BEY of carrot (8.03 t/ha) followed by pea (5.86 t BEY/ha) resulting into maximum total system productivity of 18.41 t BEY/ha with broccoli + pea followed by 18.29 t/ha with broccoli + carrot (Table 7). Broccoli + lentil was the next higher yielder in terms of total system productivity (17.07 t BEY/ha).

Table 7. Effect of broccoli based intercropping system on system productivity on raised bed

Cropping system	Broccoli yield (t/ha)	Inter-crop yield (t/ha)	Broccoli equivalent yield (t/ha)	Total system producti-vity (t/ha)
Broccoli + pea	12.55	3.26	5.86	18.41
Broccoli + methi	12.44	1.85	4.06	16.50
Broccoli + radish	5.53	8.25	2.89	8.41
Broccoli + mustard	7.55	1.85	3.32	10.87
Broccoli + lentil	11.43	1.86	4.64	16.07
Broccoli + carrot	10.27	8.03	8.03	18.29
Broccoli (sole)				

Rice + fish system of cultivation

Rice +fish production system was evaluated by keeping seven treatments (Table 8). Data revealed the integration of rice with *Azolla* and fish significantly improved (17.80%) rice yield while rice +fish system gave 23.58% higher yield than rice

Table 8. Production potential of rice + fish system under mid hill altitude conditions

Treatments	Rice yield (t/ha)	Fish yield (kg/ha)		
		Common carp	Tilapia	Total yield
Rice – alone	4.15	-	-	-
Rice- *Azolla*	4.89	-	-	-
Rice-Fish	5.13	175.25	68.24	243.49
Rice- *Azolla* -Fish	4.96	310.40	74.48	384.88
Rice-Fish+Food	5.43	350.20	115.42	465.62
Rice- *Azolla*+Fish+ Food	5.22	518.24	108.45	626.69
Fish alone	-	715.24	164.35	879.59

alone. The yield of rice was equal with rice +fish and Rice +fish + food system but maximum rice yield was recorded with Rice + fish + *Azolla* + food (5.43 t/ha). Field strata were utilized with both Common crap and Tilapia fish. Highest fish yield was recorded with fish alone (879.59 kg/ha) while in association with rice, the fish yield was reduced. Maximum fish yield of 62.67 t/ha was recorded with rice + fish + *Azolla* + food and minimum with rice + fish treatment (243.49 kg/ha), which was 40.35 % and 270.15 % lower than fish alone treatment, respectively under mid hill altitude conditions of NE India.

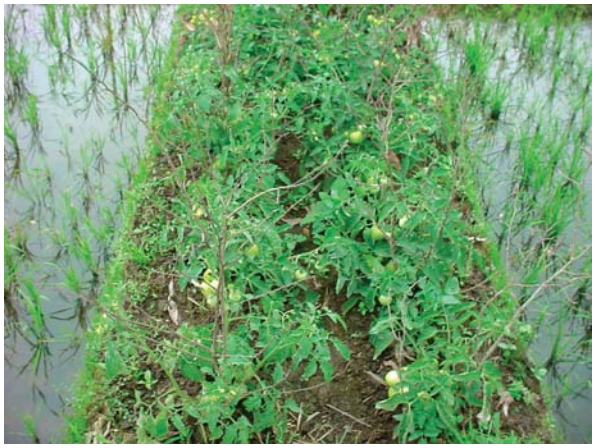


Fig 1. Pre-*kharif* rice and tomato on raised and sunken bed system

Effect of tillage and residue management on productivity of upland rice- toria cropping system

Field experiment was conducted with tillage practices viz., conventional (3 ploughing and leveling)

and minimum tillage (1 ploughing and leveling) as main plot treatment and residue management practices viz. 100 % recommended dose of fertilizer (RDF 60 : 60 : 40 kg/ha), 50 % RDF, 50 % RDF + Rice straw 5t/ha, 50 % RDF + green manuring (1:1) with *Crotolaria* sp, 50 % RDF + fresh biomass of *Eupatorium* 10t/ha, 100 % organic (rice straw 5t/ha + *Eupatorium* 10t/ha + rock phosphate 150 kg/ha) as subplot treatments for *kharif* rice (Bhalum 1). After harvest of *kharif* rice, toria (TS 38) was sown immediately by opening a furrow in between rice rows under zero tillage. A common fertilizer dose of 30: 30: 20 kg/ha was applied for all the toria plots except for organic plots, where FYM 10 t/ha was applied to meet crop nutritional requirement.

The result revealed that rice yield was similar under conventional tillage (2.72 t/ha) and minimum tillage (2.67 t/ha). However, there was significant effect of residue (nutrient) management practices on rice yield (Table 9). Application of 100 % RDF produced significantly higher grain yield (3.48 t/ha) of rice compared to all other treatments. Among the residue management practices, application of 50 % RDF + rice straw 5t/ha (applied 2 months before sowing and incorporated) recorded maximum grain yield (2.71 t/ha) followed 50 % RDF + fresh biomass *Eupatorium* 10 t/ha (2.61 t/ha). The productivity of succeeding toria was better under plots where minimum tillage was done for *kharif* rice followed by zero tillage (563 kg/ha) compared to conventional tillage for *kharif* crop and zero tillage in *toria* (506 kg/ha). Among the subplot treatments, *toria* yield was maximum where 100 % RDF was applied to preceding rice (652 kg /ha) followed by application of 50 % RDF + rice straw 5t/ha (624 kg/ha) to *kharif* rice (Fig. 2).

Table 9. Productivity of rice-toria system as influenced by tillage and residue management practices

Treatments	Rice (t/ha)	Toria (kg/ha)
Tillage		
Conventional tillage	2.72	506
Minimum tillage	2.67	563
Residue management practices		
50 % RDF	2.47	514
100% recommended dose of Fertilizer (RDF 60 :60 : 40 kg/ha)	3.48	652
50 % RDF + rice straw 5t/ha	2.71	624
50 % RDF + green manuring (1:1)	2.66	613
50 % RDF + fresh biomass of *Eupatorium* 10t/ha	2.61	423
100 % organic (rice straw 5t/ha + *Eupatorium* 10t/ha + rock phosphate 150kg/ha)	1.98	398

Fig 2. Zero tillage *Toria* (TS 38) in terrace after rice

Evaluation of resource conservation technology in lowland rice

The effect of tillage and plant biomass management practices was studied on productivity of lowland rice (var. Sahsarang-I). The main plot treatments included tillage practices viz. conventional (4 ploughings) and minimum tillage (2 ploughings), while the sub-plot treatments were plant biomass management viz. 50 % NPK, 50% NPK + fresh weed biomass 10t/ha (*Ambrossia* + *Eupatorium*), 100 % NPK (80: 60: 40 kg/ha), 50% NPK + green leaf manure (fresh *Tephrosia* biomass 10t/ha) and 50% NPK + in *situ* residue management (rice straw 6 t/ha approx.) and FYM 10t/ha + weed biomass 10t/ha + rock phosphate 30 kg P/ha (100 % organic). Among the two tillage practices, minimum tillage (Fig 3) gave the higher yield of rice in terms of grain, straw and total plant biomass yield. On an average, minimum tillage recorded 22 % higher grain yield over conventional tillage. Among the nutrient management practices, 100% NPK (5.45 t/ha) was the most efficient in increasing grain yield of rice followed by 50% NPK + fresh weed biomass 10t/ha (*Ambrossia* + *Eupatorium*) (5.37 t/ha) .

Fig 3. Healthy crop of rice under minimum tillage

N-response trial with selected AVT 2 early hill (irrigated) cultures

Field experiment was conducted with five AVT 2 early hill (irrigated) rice cultures viz. IET 20184, IET 20186, IET 20188, Vivek Dhan 82, RP 2421 and compared with local check Sahsarang 1 under three levels of N i.e., 50 % N (40 kg N/ha), 100 % N and 150 % N. The results revealed that (Table 10) in general rice productivity increased up to 100 % N and thereafter decreased. Among the varieties, IET 20186 recorded highest grain yield (3.62 t/ha) which was similar to local check Sahsarang 1 (3.53 t/ha).

Table 10. Productivity of selected AVT 2 early hill (irrigated) cultures grown under transplanted conditions at graded levels of recommended N

Treatments	Grain yield (t/ha)	Panicles /m² (No)	Panicle weight (g)
N- levels			
50 % N	2.95	286	2.37
100% N	3.56	320	2.51
150 % N	3.37	326	2.49
CD (0.05)	0.12	4.0	NS
CV (%)	4.70	17.2	4.02
Varieties			
IET 20184	3.23	256	2.78
IET 20186	3.62	308	2.44
IET 20188	3.29	336	1.94
VD 82	2.32	241	2.17
RP2421	2.66	350	2.35
Sahsarang 1	3.53	285	3.06
CD (*P*=0.05)	0.24	27	NS
CV (%)	9.53	11.4	4.05

N-response trial with selected AVT 2 upland hill cultures

Field experiment was conducted with four AVT 2 upland hill rice cultures viz. Vivek Dhan 154, IET 20204, IET 20207, IET 20203, and compared with local check Bhalum1 under three levels of N i.e., 50 % N (30 kg N/ha), 100 % N and 150 % N. The results revealed that (Table 11) in general rice productivity and N response increased up to 100 % N and thereafter decreased. Among the varieties, IET 20204 recorded highest grain yield (3.72 t/ha) which was significantly higher compared to all other rice cultures and local check Bahalum1 (3.43 t/ha).

Table 11. Productivity of selected AVT 2 upland hill cultures at graded levels of recommended N

Treatments	Grain yield (t/ha)	Panicles /m² (No)	Panicle weight (g)	N response (kg grain/ kg N applied) *
N- levels				
50 % N	2.70	249	2.28	-
100% N	2.95	264	2.40	8.56
150 % N	2.71	260	2.32	0.20
CD (0.05)	NS	NS	NS	-
CV (%)	17.1	13.08	8.52	-
Varieties				
V Dhan 154	2.61	321	1.59	11.99
IET 20204	3.72	299	2.51	2.45
IET 20207	2.03	247	2.00	-0.74
IET 20203	1.58	211	1.76	6.34
Bhalum1	3.43	208	3.81	1.85
CD (*P*=0.05)	0.45	22	0.16	-
CV (%)	16.8	8.85	7.37	-

*Base level 30 kg N/ha

Productivity of rice + groundnut (confectionary) intercropping system under mid-hills of Meghalaya

A field experiment was conducted to find out suitable confectionary groundnut varieties for intercropping with upland rice (Bhalum1) in collaboration with Directorate of Groundnut Research, Junagadh. Three groundnut varieties tested as intercrop (replacement series) with rice (4:2 ratios) were GG 7, TG 37A and ICGS 76 (check). Rice equivalent yield (REY) was computed based on the farm price of rice (Rs.6/kg) and

groundnut (Rs. 20/kg). The productivity of rice as sole crop was recorded as 2.61t/ha. Rice productivity decreased significantly when intercropped with groundnut and highest rice productivity was recorded in rice + ICGS 76 (2.29 t/ha) intercropping system closely followed by rice + TG 37A (2.24 t/ha). Among the groundnut varieties, highest pod yield was recorded with TG 37A (3.34 t/ha) followed by ICGS 76 (3.29 t/ha). The pod yield of groundnut as intercrop with rice was 1.05 t/ha, 0.1.03 t/ha and 0.91 t/ha for TG 37A, ICGS 76 and GG-7, respectively. The REY was higher when groundnut was grown as sole crop compared to its intercropping with rice (Table 12).

Table 12. Productivity (t/ha) of rice, groundnut and rice equivalent yield as influenced by rice + groundnut intercropping

Variety/Intercropping	Rice	Groundnut	REY
Sole crops			
Rice (Bhalum 1)	2.61	-	2.61
ICGS 76	-	3.29 (2.59)*	10.96
GG-7	-	2.89 (2.89)	9.63
TG 37A	-	3.34 (3.34)	11.13
Intercropping (4 :2)			
Rice + ICGS 76	2.29	1.03 (0.83)	5.72
Rice + GG-7	1.75	0.91 (0.91)	4.78
Rice + TG 37A	2.24	1.05 (1.05)	5.74

* Respective kernel yield

Effect of stand establishment methods and planting geometry on productivity of lowland rice under in-*situ* fertility management

A field experiment was conducted under in-*situ* soil fertility management in lowland field of rice. Minimum tillage was adopted for transplanting. All the crop and weed residues were incorporated into the field time to time and only economic portion of grain was removed from the field. No external input was applied to the experimental field. Three establishment methods i.e. system of rice intensification (SRI- 12 days seedling, single seedling /hill), integrated crop management (ICM-20 days seedlings, 2 seedlings /hill) and conventional rice culture (CRC- 30 days seedlings, 3 seedlings/hill) were adopted with three planting geometry i.e. 25 x 25, 20 x 20 and 20 x 15 cm. The result indicated that SRI with 20 x 20 cm spacing recorded the highest grain yield (6.12 t/ha) closely followed by SRI with 25 x 25 cm spacing (5.46 t/ha) and ICM with 20 x 20 cm spacing (5.34 t/ha). However, incase of closer spacing i.e., 20 x 15 cm, SRI recorded highest grain yield (5.26 t/ha) followed by ICM (4.94 t/ha) and CRC (4.80 t/ha). These results confirmed that under mid hill conditions of North East India, wider spacing of 25 X 25cm or more is not economical to get higher productivity in rice. A medium spacing 20 x 20 cm seem to be more suitable for SRI and ICM method of stand establishment for achieving higher productivity of rice var. Sahsarang-1 (Table 13).

Effect of date of transplanting and nutrient management on performance aromatic rice

A field experiment on aromatic rice (cv. RCPL 1-160) was conducted in *kharif* season with five nutrient management practices and three dates of transplanting. The maximum grain yield was recorded with application of 50 % recommended NPK (40: 30: 20 kg/ha) + FYM 7.5t/ha (4.85 t/ha) followed by 100 % recommended NPK (4.67 t/ha). Among the three dates of transplanting, 16th July transplanting recorded the highest grain yield followed by 26th July (Table 14).

Table 13. Effect of stand establishment method and geometry on productivity of rice var. Sahsarang-1

Stand establishment	Panicles/m^2			Grain yield (t/ha)		
	25x25cm	20x20 cm	20x15 cm	25x25cm	20x20 cm	20x15 cm
SRI	255	294	277	5.46	6.12	5.26
ICM	246	264	282	4.43	5.34	4.94
CRC	238	240	270	4.40	4.50	4.80

Table 14. Effect of date of transplanting time and nutrient management on grain yield (t/ha) of aromatic rice cv RCPL 1-160

Nutrient source	Date of transplanting		
	6th July	16th July	26th July
Control	2.04	2.32	2.20
FYM (15 t/ha)	3.65	4.39	4.14
Recommended NPK (80:60:40 kg/ha)	3.97	4.67	4.40
50 % rec. NPK	3.16	3.48	3.30
50 % rec. NPK + FYM (7.5 t/ha)	4.22	4.85	4.58

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Response of fodder grasses to sources of nutrient supply

Field experiment was initiated during June 2009 to study the effect of organic and inorganic sources of nutrient supply on productivity of fodder grasses. The nutrient sources were 100 % organic (FYM 10 t/ha supplement with rock phosphate 30 kg P_2O_5 /ha); 100% inorganic (80:60:40 N, P_2O_5, K_2O) and compared with control (no manure and no fertilizer). During the reporting year, 2 cuttings were taken and green fodder yields were recorded. During first year, all the fodder yielded maximum under organic sources of nutrient supply followed inorganic (Table 15). Among the fodder crops, Congo signal recorded highest fodder yield (44.2 t/ha) followed by Guinea grass (33.52 t/ha).

Table 15. Effect of nutrient management practices on green biomass yield (t/ha) of fodder crops

Fodder sp	Nutrient source			
	Control	Organic	Inorganic	Mean
Broom	2.40	2.90	2.74	2.68
Congo	33.7	57.71	41.14	44.19
Napier	25.3	43.43	30.17	32.95
Guinea	21.6	48.34	30.63	33.52
Mean	20.74	38.10	26.17	-

Studies on photothermic indexing of rice

This is an ongoing study in collaboration with DRR, Hyderabad under AICRIP trial of Plant Physiology to understand relative performance of genotypes for their photo and nycto period insensitivity. In the previous three years, the selected genotypes were evaluated under normal and late sown conditions. On evaluation of three year data sets, it was observed that both photo and nycto periods were insufficient for flowering, particularly under late sown conditions. The elasticity of the genotypes in response to the environment was expressed properly. In view of the above, the present trial was modified where in the seed sets were sown 15 days early to that of normal and normal (usual) sown sets. In this trial, 20 genotypes (12 IET cultures and 8 checks) were tested. The experiment was conducted in a split plot design following all the cultural practices recommended for normal rice cultivation. The essential plant parameters required for computing the photo period and nycto periods (genotype wise- days taken for panicle initiation (PI), 50% flowering and maturity) and for responsiveness (total dry matter (TDM) and grain yields) were recorded. Based on weather, phenology of the crop parameters, cumulative degree days (CDD) and cumulative nycto periods (CNP) were computed using modified crop model.

The results revealed that all the rice cultures responded favourably to early sowing. Rice being a quantitatively short day plant is relatively more sensitive to nycto periods (CNP) compared to that of CDD (means of difference of stage is very less between the early and normal sown set) compared to that of CNP (means of difference of stage is higher between the early and normal sown set). The wider difference of CNP for PI under early and normal sown condition confirms the importance of CNP in relation to flowering in rice. When the results were critically viewed the superiority of the genotypes in terms of CDD, CNP, TDM and yield together revealed consistency of IET 20924 followed by IET 21119 though less yielding but consistent in their advancing the earliness in flowering. Among checks, Tulsi, Govind, Annanda and IR 64 were more consistent in their physiological response. Some of these genotypes could be useful starting material for developing genotypes for future climate change conditions.

Influence of boron on spikelet fertility

This new study was initiated under AICRIP trial of plant physiology to investigate the influence of

boron on spikelet fertility and yield. Five genotypes which had poor spikelet fertility were selected from breeding trials of AICRIP along with Rasi as check. Boron was applied as foliar spray at anthesis stage @ 0.2, 0.4 and 0.8 ppm and data were recorded for spikelet fertility, panicle topology, high density grains and other yield attributes. The results showed that application of boron (0.4 ppm) resulted 9.5 % improvement in grain yield over control. However, there was no significant improvement in spikelet fertility, high density grains and yield attributes which needs further confirmation of the results. All the cultures performed better than check veriety Rasi showed positive response to 0.4 ppm boron application.

ORGANIC FARMING

Ginger and Turmeric

Ginger and turmeric were grown in rainfed dry terraces following two methods of cultivation i.e. flat bed and bun (raised bed of 30cm height, 1 m. width) along with four organic nutrient management practices. Soybean as green manure crop was grown in the inter row spaces of ginger and turmeric and was incorporated during earthing up operation. Experimental results revealed that integrated application of FYM & VC with soybean *in-situ* green manuring produced significantly higher yield in ginger (11.1 t/ha) and turmeric (15.9 t/ha) compared to control in bun system of cultivation. Yield of these two crops was found more in bun beds compared to flat bed system of cultivation, probably because rhizome development of these two crops needs more soil depth which fulfills in the bun beds.

Groundnut

Twelve organic nutrient management combinations were tested to find out suitable organic nutrient source for groundnut in mid hills of Meghalaya during *kharif* season. Application of FYM (15 t/ha) along with rock phosphate (150 kg/ha) and lime produced maximum pod yield (3.36 t/ha) followed by FYM 10 t/ha + RP 150 kg/ha. Application of fresh biomass of *Indigofera*, *Ambrosia* and *Eupatorium* spp. with and without FYM or vermicompost increased pod yield significantly over control (Table 1).

Table 1. Groundnut productivity (t/ha) as affected by source of nutrient supply

Treatment	Pod yield (t/ha)
Control	2.0
FYM @ 10 t/ha	2.9
FYM @10 t/ha + RP 150 kg/ha	2.9
FYM @ 15 t/ha + RP + lime	3.4
Vermicompost @ 5 t/ha	2.2
Vermicompost @ 5 t/ha + RP 150 kg/ha	2.8
Vermicompost @ 10 t/ha + RP 150 kg/ha + lime	2.3
Ambrosia/Eupatorium green biomass @ 15 t/ha	2.3
Ambrosia green biomass @ 15 t/ha (FW)	2.8
FYM @5 t/ha + *Ambrosia/Eupatorium* green biomass @10 t/ha	2.8
FYM @5 t/ha + *Ambrosia* green biomass @ 10 t/ha	2.5
Bun with FYM @ 10 t/ha	2.9
CD (*P*=0.05)	0.12

Rice

Six organic nutrient management combinations were tested in direct seeded rice. Integrated application of FYM + VC+ rock phosphate produced significantly higher grain yield (3.1 t/ha) and was found at par with FYM (15 t/ha) + RP compared to all other treatments (Table 2) Incorporation of fresh biomass (weed / hedgerow) of *Indigofera, Ambrosia* + *Eupatorium* 15 days before sowing resulted significantly higher grain yield in rice over control.

Table 2. Yield of rice (t/ha) as affected by various organic nutrient management practices

Treatment	Grain yield (t/ha)	Straw yield (t/ha)
FYM @ 15 t/ha + RP	3.0	2.1
Vermicompost @ 7.5 t/ha + RP	2.6	2.2
½ FYM + ½ VC + RP	3.1	3.2
Indigofera green leaf biomass @ 15 t/ha	1.6	2.6
Ambrosia + *Eupatorium* green leaf biomass @ 15 t/ha	2.6	2.7
Farmer's practice (control)	1.0	2.2
CD (*P*=0.05)	0.31	0.22

Soil fertility management in field crop based system using organic amendments

A field experiment was laid out under Network Project on Organic Farming in a split plot design with two maize based cropping sequences as main plot viz. CS_1: Maize (seed)-Toria and CS_2: Maize (green cob) – French bean and six nutrient sources viz. N_1:FYM + vermicompost, N_2: FYM + VC + Panchagavya, N_3: Panchagavya (3%) spray, N_4: Biodynamic manure, N_5: Panchagavya + Biodynamic manure and N_6: Control in sub-plots to evaluate the efficacy of various on- and off-farm produced organic sources of nutrients/formulations on productivity and soil health. Based on previous results (2005-08), the best established organic nutrient source for maize crop i.e. integrated application of $^1/_2$ FYM + $^1/_2$ vermicompost was selected as base and applied on N-equivalent basis. P requirement was adjusted by applying mussoorie rock phosphate (MRP). Maize + soybean intercropping was adopted in 1:1 ratio during *kharif* season. Soybean crop was used as *in-situ* green manure at earthing up in standing maize crop. Maize crop grown in maize- French bean cropping sequence was harvested as green cob to facilitate timely sowing of succeeding French bean whereas, under maize- toria cropping system it was harvested as grain crop. Maize stalk was recycled back in the same plot under both the cropping systems

Results indicated that integrated application of FYM + vermicompost + Panchagavya recorded significantly higher grain yield of maize compared to other treatments. Whereas, integrated application of FYM + vermicompost + Panchagavya and FYM + vermicompost recorded comparable green cob yield of maize, seed yield of toria and pod yield of French bean (Table 3). Improvements in soil physico-chemical properties were observed due to application of organic manures. Population of beneficial microorganisms viz, *Rhizobium, Pseudomonas* and *Actinomycetes* were also found more in treatments where FYM + vermicompost + Panchagavya was applied.

Soil fertility management in important vegetable crop based using organic amendments

Field experiment was conducted in split plot design with treatment combination consisted of three cropping systems viz. CS1: Maize + soybean (2:2)-tomato, CS2: Maize + soybean (2:2) - potato and CS3: Maize + soybean (2:2) – French bean in main plot and four organic sources of nutrient viz., Farmyard Manure (FYM), Vermicompost (VC), integrated nutrient sources (½ of FYM+ ½ of VC) and control in sub plots to study the performance of vegetables under different cropping systems and to evaluate efficiency of various on farm and off farm produced organic sources and their effect on productivity and soil health.

Significant increase in crop growth and grain yield of maize was recorded in all the three cropping sequences followed as uniform liming was done @ 2.0 t/ha prior to the start of the experiment (Table 4). Integrated application of FYM and VC recorded maximum increase in grain yield of maize and green pod yield of French bean, however, sole application of FYM produced comparable yield with that of

Table 3. Yield (t/ha) of crops under maize based cropping systems as influenced by various sources of nutrient supply

Nutrient sources	Maize-Toria (seed)		Maize-French bean (green cob-pod)	
	Maize	Toria	Maize	French bean
FYM+ Vermicompost	3.8	0.31	8.4	9.1
FYM+VC+Panchagavya	4.4	0.34	8.6	9.5
Panchagavya (3%) spray	2.8	0.20	6.7	7.1
Biodynamic manure	2.8	0.22	5.1	7.3
Panchagavya+ Biodynamic manure	3.0	0.27	7.3	7.5
Control	1.9	0.18	4.2	1.5
CD (*P*=0.05)	0.52	0.08	0.79	0.61

Table 4. Yield of crops under different cropping systems as influenced by various sources of organic nutrient

Nutrient sources	CS1			CS2			CS3		
	Maize	Soybean	Tomato	Maize	Soybean	Potato	Maize	Soybean	French bean
FYM	54.0	10.2	440.2	57.4	10.1	298.6	58.9	9.7	246.2
V.Comp	52.4	8.2	423.9	55.9	8.5	306.7	54.4	7.9	239.2
FYM+VC	60.1	9.5	431.4	59.4	12.9	244.9	55.2	8.6	259.9
Control	32.4	5.7	200.4	33.1	5.7	171.1	32.4	5.0	214.9
CD (*P*=0.05)	6.95	2.7	9.1	9.2	3.0	9.7	6.1	1.7	10.9

integrated nutrient source in case of maize and tomato. Maximum yield of potato was recorded with sole application of vermicompost and was found at par with sole application of FYM.

Improvement in soil health was noticed as pH increased up to 5.0 from the initial value of 4.8 and organic carbon content increased to 2.4 % from the initial of 1.8 % because of application of organic inputs. Likewise, available nutrient (N, P & K) content also increased from the initial status. Maximum microbial population and soil microbial biomass carbon (SMBC) were recorded with integrated nutrient management. Dehydrogenase enzyme activity of soil was also recorded maximum (109.4 µg/g dry soil) under integrated management practice.

Evaluation of organic, chemical and integrated management practices on soil health and crop productivity

Upland rice under 100% organic management practice exhibited better yield over inorganic and integrated management practice irrespective of cropping system followed. Lowland rice varieties registered slightly higher grain yield in integrated management practices than organic management practice.

There was improvement in soil health in terms of soil physico-chemical and biological properties. Porosity (58.7%) and maximum water holding capacity (57.8%) was increased from the initial value due to application of organic manures. Soil microbial biomass carbon and microbial counts were also recorded significantly higher in 100% organic management practice followed by integrated treatment. Dehydrogenase enzyme activity of raised bed soil was found more (112.5 µg/g soil) in organic treatment followed by integrated (100.2 µg/g soil) Fig 1.

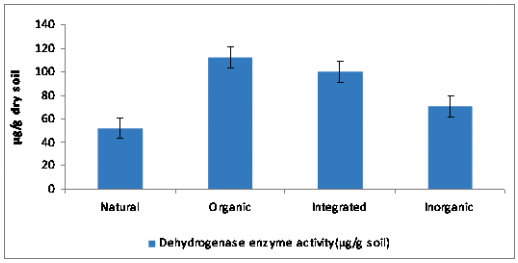


Fig 1. Dehydrogenase enzyme activity under different management practices

Pest and Disease Management

Insect-pest and disease management in maize + soybean-tomato cropping systems under organic farming

During the *kharif* season, only one major disease Turcicum Blight caused by *E. turcicum* was observed in case of maize. Soybean intercropped with maize was affected by frog eye leaf spot, caused by *Cercospora sojina*. Application of panchgavya along with lantana leaf extract and vermiwash produced higher grain yield in maize compared to other pest management practices (Table 5), However, application of Derisom @ 3ml/ lit recorded significant increase in grain yield of maize followed by Anonine application. Percentage stem borer and cob borer damage of maize under integrated application of Panchagavya, lantana and vermiwash was recorded less. Hence, panchgavya can be used as effective disease management source for common disease of maize and soybean crop of the region.

Application of Panchagavya alone or in combination was found to be effective in controlling diseases and producing subsequent higher yield in tomato (Table 6). Maximum fruit yield of tomato (14.4 t/ha) was recorded when Panchagavya was

Table 5. Yield (t/ha) and percent insect damage in maize as affected by various insect-pest management practices

Pest/disease management	Grain yield of maize(t/ha)	% damage of insects	
		Stem borer	Cob borer
Control	2.9	15.2	22.5
Neem oil @ 5 ml/lit.	3.3	6.8	0.0
Panchgavya 3%	3.5	13.9	0.0
T. roseum + *Beauveria bassiana* @ 4 g/lit.	3.2	9.6	0.0
Compost tea (10 ml/lit.)	3.2	8.4	20.0
Trichocards (50,000/ha)	3.4	9.7	0.0
Derisom @ 3 ml/lit	3.7	7.5	20.0
Anonine @ 3ml/lit	3.7	9.4	0.0
Botanicals 3%	3.0	11.9	0.0
Panchgavya 3% +lantana leaf extract 10% + vermiwash 10%	3.8	13.1	0.3
CD (*P*=0.05)	0.4	1.9	2.4

Table 6. Yield of tomato as affected by various organic disease management practices

Pest management practices	Fruits/ plant	Av. Fruit wt (g)	Fruit yield (t/ha)	Stover yield (t/ha)	Early blight (PDI)
Control	9.1	56.5	10.4	0.81	22.2
Neem oil @ 3ml/lit	11.3	51.8	13.0	0.77	20.2
Panchgavya 3%	13.0	51.5	14.1	0.90	18.9
Beauveria bassiana (4 g/lit)	12.1	42.7	11.7	0.85	20.9
Derisom @ 3ml/lit	18.6	40.8	11.7	0.85	19.3
Anonine @ 3ml/lit	17.2	47.6	13.4	0.91	18.8
Botanicals 3 %	18.3	45.7	12.2	0.83	19.7
Panchagavya 3% + lantana leaf extract 10% + vermiwash 10%	14.5	39.5	14.4	0.93	15.3
Derisom + Panchagavya	13.3	42.6	13.1	0.82	17.7
Deris om + Panchagavya +cowurine	21.5	44.5	13.3	0.83	14.8
CD (*P*=0.05)	-	-	0.47	0.14	3.0

applied in combination with lantana leaf extract 10%+ vermiwash10% followed by sole application of Panchagavya (14.1 t/ha). Derisom when applied alone, it couldn't produce higher yield, however it produced comparable yield when combined with Derisom + Panchagavya + cow urine (13.3 t/ha) and Derisom + Panchagavya (13.1 t/ha).

Minimum percentage of disease index (PDI) of early blight of tomato was recorded in Derisom + Panchagavya + cow urine (14.8%) treatment followed by Panchagavya+ lantana leaf extract+ vermiwash (15.3%) treatment and Derisom + Panchagavya (17.7%).

Management of leaf miner and fruit borer in tomato

Application of organic insecticide like Derisom, Anonine etc. and Panchagavya was found effective against two major pests of tomato viz. leaf miner and fruit borer. Population of leaf miner was found decreasing compared to pretreatment situation after 15 days of treatment which continued to be at minimum till 30 days after treatment (Table 7). Maximum reduction (from 5.9 nos. before treatment) was recorded with Derisom treatment (to 2.8 no at 15 DAT & 2.4 no at 30 DAT). 26.1% reduction of leaf miner attack at 15 DAT and 58.6% reduction at 30 DAT was recorded when Panchagavya was applied along with lantana leaf extract+ vermiwash (Table 7).

Although, maximum number of fruit borers (18.4) were found in Derisom treated tomato plants, however no. of infested fruit/plant recorded less (0.3) in that particular treatment with lesser percentage of damage to fruits. On the other hand, application of Panchagavya + lantana leaf extracts

Table 7. Effect of various insect-pest management practices on leaf miner and fruit borer attack on tomato

Pest management practices	Leaf minor per plant			Fruit borer		
	Pretreatment	15 DAT	30 DAT	No.of borer/ plant	No.of infested fruit/ plant	% damage
Control	4.9	6.2	6.3	9.0	0.6	6.4
Neem oil @ 3ml/lit	5.6	3.9	4.2	11.3	0.3	3.2
Panchgavya 3%	5.2	3.7	2.1	12.9	0.2	1.7
Beauveria bassiana	5.3	3.9	3.0	11.9	0.6	4.9
Derisom @ 3ml/lit	5.9	2.8	2.4	18.4	0.3	1.9
Anonine @ 3ml/lit	5.8	2.7	2.2	17.3	0.2	1.8
Botanicals 3 %	5.3	3.9	2.6	17.8	0.4	2.8
Panchagavya 3% + lantana leaf extract 10% + vermiwash 10%	4.6	3.4	1.9	13.2	0.1	1.0
Derisom + Panchgavya	5.6	4.2	3.6	14.6	0.3	1.9
Derisom + Panchagavya +cow urine	5.2	3.9	2.4	17.8	0.3	2.0

10% + vermiwash 10% recorded lesser no. of infested fruit by fruit borer with only 1% of damage in tomato fruits.

Weed Management

Weed management in maize-toria cropping system

Experiment on weed management under organic farming in maize-toria cropping systems (Fig 2) was carried out during *kharif* season. Mulching with fresh *Ambrosia/ Eupatorium* @ 10 t/ha after earthing up followed by one hand weeding at 60 DAS was found effective in reducing weed growth and produced significantly higher seed yield (4.02 t/ha) compared to all other treatments except mulching with fresh *Ambrosia / Eupatorium* @ 10 t/ha after earthing up without weeding. Mulching reduced the weed population in the early crop growth stage and resulted higher yield in maize crop under that particular treatment. Mulching with fresh Eupatorium/Ambrosia also showed a positive effect on yield of succeeding toria crop and gave maximum yield (1.14 t/ha) that was significantly higher than other treatments (Table 8).

Table 8. Yield of maize (t/ha) and population of weed species at different crop growth stage as affected by various weed management practices

Treatment	Weed population/m²				Seed yield (t/ha)	
	30 DAS		60 DAS			
	Broad leaf	grass	Broad leaf	grass	Mustard	Maize
Mechanical weeding + Hand weeding once	66.5	35	26.5	9.0	0.96	3.12
Mulching with fresh *Eupatorium/Ambrosia*	236	17.5	82	17	1.14	4.02
Aqueous leaf extract spray of lantana & pine	165	20	44.5	39.5	0.97	3.59
Hand weeding twice	132.5	18	42	8	0.83	2.55
Aqueous leaf extract spray of lantana & pine + Hand weeding twice	280	79.5	83.5	18	0.95	3.39
Soybean GM incorporation in situ	208.5	51.5	67.5	28.5	0.94	3.04
Weed free check	-	-	-	-	0.93	3.17
Weedy check	314.5	51	87	11.5	0.71	2.71
CD (*P*=0.05)					0.16	0.40

Fig 2. Toria (var. M-27) with maize stalk mulch in maize- toria cropping system

FARMING SYSTEM RESEARCH PROJECT

Dairy based farming system (FSW-1)

Dairy based farming system was evaluated in a micro watershed of 1.39 ha area including 0.45 ha forestland. The area under planned land use is 0.94 ha of which 0.22 ha terrace area is under annual fodder crops and remaining under broom and guinea grass. The average slope of the watershed is 32.02%. The bottom 1-10 terraces were utilized for production of annual fodders with cropping sequence of maize + cowpea – cowpea and maize – cowpea. The riser area was utilized for the production of guinea grass. Four milch cows along with their calves were maintained in the system. Fodder crops/ grasses were grown in the micro-watershed, produced fodder for year round availability. The crop wise green fodder yield was recorded (Table 1) total of 38.32 t green fodder production form the watershed of which maximum green fodder of 17.5 t recorded from broom leaves followed by mixed grass which produced 32.64 % of total fodder production.

Cultivated fodder crops like maize, cowpea, rice bean and perennial guinea grass were utilized as green fodder from June to November. During lean period, broom grass was available for dairy animal for 4 months i.e., December to March. The remaining 2 months were without green fodder, only paddy straw was used to feed the animals. An analysis of fodder production and requirement revealed that total dry matter utilization from forage crops and concentrate was 6.17 and 6.30 t respectively, while the requirement for the dairy animals was 16.2 t showing a deficit of 3.73 t dry matter which was met by providing paddy straw to the animals. Keeping in view farmer's family staying in the watershed, no wage was considered for farm labourers, only concentrate and paddy straw was procured from the market and milk yield was considered to be the farmer's income. The income from milk yield and fodder balance sheet (Table 2) indicated total green fodder production of 38.32 t, and the requirement of 30.84 t resulting into surplus green fodder.

The milk yield obtained from the system was 8,262L (assuming farmer's requirement was 415 L) giving gross return of Rs. 1, 63, 325/-. Besides 30 t of FYM produced from cow dung, urine, crop residues and weed biomass in the system. The production of 70 kg of broom spikes and two calves (sold) increased income of the dairy based system. Considering family labour as a system of employment for dairy based farming, total cost of feed, concentrate and medicine was Rs. 78,607 with annual income of the system was Rs. 1,63,325/- registered net income of Rs. 84,718. To increase nutritional quality of fodder, cowpea varieties were evaluated in the watershed. Among them, Bundel Lobia-1 registered the highest green fodder yield of 29.66 t /ha followed by Bundel Lobia-2 (24.86 t/ ha) and UPC-9202 (23.33 t/ha). The lowest green fodder yield of 14.18 t/ha was obtained with UPC-5286. Seven varieties of oats for green fodder during February and March were grown in the watershed. Highest green fodder yield of 23.75 t/ha was obtained with AOSC –3 followed by AOSC –7 (20.0 t/ha). Lowest green fodder was obtained with AOSC – 1(Table 3).

Table 1. Fodder production

Name of fodder	Yield (t)
Maize	3.10
Cowpea	1.15
Rice bean	0.20
Guinea grass	3.80
Broom grass	17.50
Mixed grass	12.58
Total green fodder	**38.32**

Table 2. Balance sheet of dairy based system

Particulars	Area	Production (t)	Requirement (t)	Surplus/ Deficit	Value (Rs)
A. Green fodder					
(a) Annual fodder	0.12 ha	4.45	-	-	-
(b) Perennial grass	1.27 ha	33.86	-	-	-
Total (A)	**1.39 ha**	**38.32**	**30.84**	**(+) 74.65 q**	**(+) 3,732.00**
B. Feed, Dry fodder and medicine					
(a) Concentrate	-	-	70.04	(-) 70.04 q	(-) 71,301.00
(b) Paddy straw	-	-	42.90	(-) 42.90 q	(-) 6,306.00
(c) Medicine	-	-	-	-	(-) 1000.00
Total (B)	**-**	**-**	**112.94**	**(-) 112.94**	**(-) 78607.00**
C. Output					
(a) Milk	4 cows	8,262 lit	415.00	(+) 7,847.00	(+) 1,49,093.00
(b) Calves (sold)	2 calves	-	-	(+) 9,800.00	(+) 9,800.00
(c) Cowdung		30 t	30.00 t	-	-
(d) Broom spikes		70 kg	-	(+) 70 kg	(+) 700.00
Total (C)					**(+) 1,59,593.00**
Gross income (A + C)	-	-	-	-	**(+) 1,63,325.00**
Net income (A + C – B)					**(+) 84,718.00**

Table 3. Green fodder yield of oat

Variety	Productivity (t/ha)
AOSC 1	6.25
AOSC 2	15.00
AOSC 3	23.75
AOSC 4	10.00
AOSC 5	16.50
AOSC 6	7.50
AOSC 7	20.00

Mixed forest block (FSW-2)

Mixed forest block was established in 3.89 ha area with 3.05 ha area under natural forest with 0.84 ha area under planned land use. The average slope of the micro-watershed is 38 %. The area under micro watershed was utilized for plantation of forest tree species viz. *Acacia auriculiformis*, *Michelia oblonga* and *Symingtonia populnea* for timber and fuel purpose. Among these species, maximum plant height was attained by *Symingtonia populnea* (26.25 m) and lowest was recorded with *Michelia oblonga* (18.33 m). The circumference of tree trunk also followed the similar trend. The maximum plant- spread was with *Acacia auriculiformis* followed by *Symingtonia populnea*. (Table 4)

Silvi-pastoral system (FSW-3)

Silvi-pastoral system has been established on 2.95 ha area with forestland 2.05 ha with planned land use 0.90 ha. The average slope of the area is 32.18%. The top portion of the micro-watershed was utilized for broom grass to fulfill the requirement of fodder for the animal during lean period and fuel woods in the form of stick. An area of 0.74 ha was planted with broom, recorded green fodder of 37.73 t out of which 4.31 t green leaves were used for cow and goat from November to February.

Fourteen goats (4 adult males, 3 adult females, 5 male kids and 2 female kids) were maintained in this system. The goats were allowed to graze for 3

Table 4. The growth and development attributes of tree species in FSW-2

Name of tree species	Plant height (m)	Circumference at basal height (m)	Circumference at breast height (m)	Spread (m)	
				NX S	EXW
Acacia auriculiformis	24.91	0.96	0.77	7.00	8.19
Michelia oblonga	18.33	0.75	0.55	6.66	7.19
Symingtonia populnea	26.25	1.02	0.83	6.47	7.30

hours per day and green fodder @ 3 kg per adult along with 250 g of concentrates per adult were given. The goats consumed a total of 3.6 t guinea grass, 2.16 t *Symingtonia* leaves and 0.46 t of concentrate. Poultry (400 broilers) chicks were also reared in two cycles as subsidiary source of income. The total body weight was 338.52 kg with average body weight 1.8 kg per bird during 1st cycle while during 2nd cycle the average body weight was recorded to be 2.4 kg per bird. Cost benefit analysis of silvi–pastoral model is shown in Table 5 showed a gross income of Rs. 78,363 with expenditure of Rs. 46,935 on feed, concentrate and price of day old chicks resulting into a net profit of Rs. 31,428 from the watershed.

Table 5. Cost benefits analysis of Agro-pastoral model

Particulars	No.	Weight	Value (Rs.)
A. Output			
Goat	14	300.00	21,000.00
Poultry	400	819.47	57,363.00
Total			**78,363.00**
B. Input			
Feed and concentrate for goat		4.60 q	5,235.00
Feed for broiler		17.84 q	31,600.00
Price for day old chicks	400		9,600.00
Medicine			500.00
Total			**46,935.00**
Gross income			**78,363.00**
Net income			**31,428.00**

The lower half portion of the watershed was planted with fodder trees such as *Symingtonia populnea*, *Bauhinia purpurea* and *Ficus* spp and forest trees species like *Schima wallichii, Indigofera indica* and wild cherry to provide green leaf fodder to the goats during lean period which provide 2,820 kg green leaf fodder. The growth and development attributes of tree species are shown in Table 6. The data revealed that the tallest plants were observed with *Bauhinia purpurea* (10.48 m) and lowest plant height was recorded with *Symingtonia populnea* (2.32m) which might be due to frequent lopping of plants for green leaf fodder for goats. The circumference at basal height was maximum with *Bauhinian purpurea, Schima wallichii*. While at breast height the circumference was more with *Bauhunia purpurea* followed by *Symingtonia populnea*.

Mixed perennial grasses had been planted in between the fodder trees to conserve the soil and water by covering the surface and to provide fodder for goats for grazing purpose. Green fodder yield of 5.28 t with productivity level 21.4 t/ha was recorded for the grasses grown in between fodder trees.

Agro –pastoral system (FSW-4)

Agro-pastoral system was developed in 0.64 ha area having an average slope of 32.42 % with forest land 0.06 ha and planned land used area of 0.58 ha. Terracing enhanced surface area by 28.2 %, resulting in 0.49 ha area of terraced land and 0.33 ha terrace risers, respectively. The terrace area was utilized for growing cereals, oilseeds, spices and vegetables. About 50 % of the area was brought under 200 % cropping intensity which resulted in to production of 1,885.42 kg rice equivalent yield (REY) from the system (Table 7).

Table 6. Growth and development attributes of trees species in W-3

Name of tree species	Plant height (m)	Circumference at basal height (m)	Circumference at breast height (m)	Spread (m)	
				NX S	EXW
Bauhinia purpurea	10.48	0.47	0.40	4.39	4.06
Schima wallichii	6.85	0.47	0.32	2.45	2.34
Indigofera indica	5.30	0.23	0.19	3.51	3.33
Cherry	5.11	0.22	0.15	2.19	2.27
Symingtonia populnea	2.32	0.38	0.34	-	-

Table 7. Cropping pattern and production in Agro-pastoral system

Terrace No.	Cropping system	Area (m^2)	Production		System Productivity REY (kg)
			Kharif (kg)	Rabi (kg)	
1-5	Moong – Toria	380.44	11.90	9.57	128.72
6 – 13	Groundnut – Toria	659.90	97.57	22.75	223.15
14 – 16	Ginger	386.58	173.30	-	231.06
17 - 20	Soybean	338.05	27.30	-	60.66
21 – 25	Turmeric	494.65	418.50	-	930.00
26 – 38	Maize – Toria	764.81	112.50	61.10	265.72
39 – 44	Maize -	283.92	41.50	-	46.11
Total REY – (Rice Equivalent Yield)			1,885.42		

Among the crop ginger and turmeric registered the maximum yield and income (65.60 %), oilseed production was next to spices registering 24.60 % of the total income. Pulse crops (mung) grown in small area could not contribute much (1.70 %). In an integrated approach, crops and livestock income revealed that maximum income was realized from cow milk (Rs. 76,539.00), which was 73.90 % of the total income of the system. The crop component contributed only 15 % while the sale of calves contributed 11.00 % of the total income. Considering farmer's family labour, no labour cost was included but the expenditure made in different items (Table 8) worked out to be Rs. 54,738 with gross and net income of Rs. 1, 02,324 and Rs. 47,586, respectively giving an output -input ratio of 1.86. The cow dung produced in the Agro-pastoral system (32.5 t) was utilized for the production of crops. Production of guinea grass on terrace risers in the lower and middle part of the watershed and broom on the top portion of the watershed provided green fodder sufficient for 8 months for the dairy unit without any extra input/ management cost. Production of grasses on terrace risers, although reduced the yield of main crop but the yield reduction was compensated with the continuous availability of green fodder for the animals in the micro-watershed.

Table 8. Yield, income and input-output ratio in Agro-pastoral system

Particulars	Yield / unit	Value (Rs)
A. Crop		
Mung	11.90 kg	261.80
Toria	96.04 kg	1,920.80
Ground nut	97.57 kg	1,658.69
Ginger	173.30 kg	1,733.00
Soybean	27.30 kg	218.00
Turmeric	418.50 kg	8,360.00
Maize	154.00 kg	1,232.00
Total (A)		**5,384.29**
B. Animals		
Milk (3 cows)	3,981 lit	75,639.00
Sale of calves	2 nos	11,300.00
Total (B)		**86,939.00**
Grand total (A+ B)		**1,02,324.00**
C. Input cost		
Fertilizer	5.73 q	983.00
Concentrate	40.00 q	4,5320.00
Paddy straw	55.00 q	7,435.00
Medicine		1,000.00
Total (C)		**54,738.00**
Gross income (A + B)		**1,17,708.00**
Net Income (A + B – C)		**47,586.00**

Agri-horti-silvi-pastoral system (FSW-5)

Out of total area of 1.58 ha, 0.55 ha was under forest and 1.03ha under planned land use. The average slope of the micro-watershed is 41.77 %. In this system 0.13 ha of foothills was used for agricultural use, 0.25 ha for horticulture use and for silvi-pastoral crops (0.44 ha). In the lower terraces, crops like cucumber + ash gourd, bitter-gourd + pumpkin, cucumber + pumpkin, lady's finger, chillies, maize were grown during *kharif* season and radish, Frenchbean, knol-khol, cauliflower and cabbage were grown during *rabi* season. The middle portion of the system was utilized for fruit crops like Assam lemon, orange and guava. On terrace risers, *Guinea* and *Congosignal* grasses were planted to arrest soil erosion and to provide green fodder. Pineapple was planted in double row system as an inter crop with Assam lemon. Forest block of the system

consisted of *Alnus napalensis* and *Schima wallichi* for timber and fuel wood were also used as staking black pepper plants, while *Ficus* and *Symingtonia populnea* for green leaf fodder during lean period and in between tree species, broom grass was grown as companion crop to conserve soil and water and to get fodder. The system productivity was 1,182.26 kg rice equivalent yield (REY). The cropping pattern of the system (Table 9) revealed maximum REY of 375.55 kg with guava followed by bhindi – radish sequence (333.00 kg). Lowest REY was recorded with orange; this might be due to young plantation. Chilli – radish sequence also produced more REY (232.76 kg) in the system. The gross income from the system was worked out to be Rs. 10,640.

Silvi-horticultural system (FSW-6)

The total area of this system was 3.13 ha with forestland of 2.17 ha and planned land use of 0.96 ha. The average slope of the area is 53.18 %. Lower terraces having an area 508.87 sq m were utilized for growing spices and vegetables based cropping system like ginger + bottle gourd – cluster bean and bottle gourd + colocasia – cluster bean. The middle portion of the system was utilized for fruit crop of guava. Upper portion of the system was covered with forest trees *Alnus nepalensis*. The productivity of the system is depicted in the Table 10 showed a gross income of Rs. 5,135 from the system.

Natural forest block (FSW-7)

There was 1.03 ha in natural forest block with 0.08 ha under forest and 0.95 ha under planned land use. The average slope is 45.87 %. The watershed area was dominated by common weed flora viz. *Eupatorium adenophorum, Arundinella bengalensis, Solanum khasianum, and Ageratum* ssp. Two tree species are commonly grown in the natural forest in the watershed. The growth and development attributes of tree species revealed that *Pinus kesyia* attained more plant height and development as compared to *Schima wallichii* (Table11). The plant spread was also highest with *Pinus kesyia*.

Table 9. Area, production and total system productivity of cropping sequence and fruit crops

Cropping system	Area (m^2)	Production (kg)				System productivity REY (kg)
		Kharif		*Rabi*		
Bhindhi – Radish	265	90.00		420.00		333.00
Chilli – Radish	200	31.00		295.00		232.76
Maize – Frenchbean	230	35.00		12.00		21.10
Cucumber – Cauliflower	200	46.00		26.00		54.43
Bittergourd – Cabbage	106	28.00		40.00		53.33
Cucumber – Radish	125	30.00		125.00		86.10
Assam lemon	488	-	42.00	-		23.33
Orange	1187	-	12.00	-		2.66
Guava	834	-	338.00	-		375.55
Total REY – (Rice Equivalent Yield)						**1182.26**
Gross income				**Rs.**		**10,640.00**

Table 10. System productivity of vegetable-spice sequence and fruit in FSW-6

Cropping system	Area (m^2)	Production (kg)			Value (Rs.)
		Kharif		*Rabi*	
Ginger + bottlegourd – cluster bean	312.00	128.00 +	78.00	2.84	1,706.00
Bottlegourd + colocasia – cluster bean	197.00	56.00 +	46.00	5.00	529.00
Guava	4,313.00		290.00		2,900.00
Total					**5,135.00**

Table 11. Growth and development attributes of tree species in W-7

Name of tree species	Plant height (m)	Circumference at basal height (m)	Circumference at breast height (m)	Spread (m)	
				NX S	EXW
Pinus kesyia	21.45	1.18	1.05	8.56	8.37
Schima wallichii	17.60	1.29	1.02	6.89	6.47

Timber –based farming system (FSW-8)

The area of timber-based farming system was on 0.52 ha with 0.02 ha was under forest and 0.50 ha under planned land use. The average slope was 41.35 %. The planned land use system was covered by tree species of *Michelia champaka* and *Michelia oblonga*. The growth performance of planted trees and their development attributes (Table 12) showed better growth and development of *Michelia oblonga* than *Michelia champaka*.

AGRICULTURAL MECHANIZATION

Commercialization of farm tools and machinery

The NEH Region still lacks in availability of improved farm tools in the local market although there are many farm tools and equipments, which are suitable for the farming system prevailing in the region. To meet the local requirements the following improved agricultural tools and equipments (Fig 1)

Fig 1. Prototypes manufactured in the workshop

were manufactured under Revolving Fund Scheme "Commercialization of Farm Tools and Machinery for Hill Agriculture" and sold to government/non-government organizations and farmers of this region (Table 1).

Table 1. Agricultural tools & equipments manufactured & sold during the year

Item	Quantity
Maize sheller	8
Garden rake	11
Hand fork	1
Hand operated winnower	4
Adjustable row marker	81
Hand grass slasher	23
Paddy thresher pedal type	2
Manual trolley	2
SRI Row marker	27
Animal drawn M. B. Plough	1
Fruit harvester (crown type)	2
Cono weeder	37

Rain-shelter and LDPE lined pond for strawberry cultivation

Mr. T. Marbaniang of Umroi Madan village, Ri Bhoi district of Meghalaya, started cultivation of strawberry crop on raised beds in 400 m^2 area. The planting was done in July 2008 and mulched it with paddy straw. This farmer faced the problem of fruit damage during July - October and water scarcity after mid October to March. Due to heavy rain and long wet spells about 15-20% fruits were damaged

Table 12. Growth and development attributes of tree species in W-8

Name of tree species	Plant height (m)	Circumference at basal height (m)	Circumference at breast height (m)	Spread (m)	
				NX S	EXW
Michelia champaka	14.60	0.82	0.64	3.74	3.92
Michelia oblonga	14.73	0.83	0.64	4.06	4.04

by fungal infection (Fig 6) and bird. Mr. Marbaniang,s home is in our adopted watershed so he approached us for remedy. The entire hill region experienced high rainfall from May to mid October so cultivation of strawberry in open condition is a problem and challenge. Low cost bamboo framed Rain-shelter and LDPE lined water harvesting tank were suggested (Figs 4 & 5). The Institute under the aegis of AICRP on APA provided 200 micron thick UV stabilized transparent LDPE film for rain-shelter and LDPE black coloured film of 250 micron thickness for lining pond with 48 m3 capacity from the SWPAL project. The rain-shelter and lined pond was constructed under the technical guidance of APA scheme. Rise in the air temperature inside the rains-helter was about 3-4^{0}C as compared to the open area. Due to slightly higher temperature under the rains-helter, vegetative growth of the plants was vigorous which resulted in increase in number of fruits per plants and size of the fruits. The average number of fruits per plant inside the rains-helter was recorded as 47 whereas in open areas it was 41. The size of fruit was also bigger in case of rain shelter. The average weight per fruit from the rain shelter was 14.5 g while 11.3 g from the open area. On an average form the entire fruiting period from November to March, about 682 g of fruits per plant were obtained from the rain shelter which is about 47% more as compared to open area. Due to rain-shelter the quality of fruits was also improved a lot. In open area, soil particles adhering on the fruits due to rain splash caused undesirable spots on the fruits. Rain-shelter provided blemish free fruits (Fig 7) which fetched higher price. The cost of construction of the rain-shelter was Rs 80 per m^2 which increased the yield by 1.10 kg per m^2. Harvested water stored in the LDPE lined pond was utilized for irrigating the crops. The pond was located at higher elevation therefore water for irrigation was applied through flexible PVC pipe by siphoning. Surface rainwater and wastage of government water supply was diverted to the pond for storage. The produce was sold at the rate of Rs 120/- to Rs. 140/- per kg. The beneficiary Mr. Marbaniang earned a profit of Rs. 30,000/- in 2009 from strawberry cultivation under rain-shelter and using harvested water in LDPE lined pond.

Figs 4 & 5. Rain-shelter and LDPE lined pond for strawberry cultivation

Fig 6.Fruits damaged by fungal disease in open area

Fig 7.Blemish free good quality fruits

Plastic lined pond for harvesting water for homestead farming

Shri S. Nengnong, Umdoh Byrthieh, Umroi, Ri-Bhoi was having approximately 200 m^2 area in his kitchen garden which was hardly utilised for winter season cultivation due to scarcity of water. Mr. Nengnong approached us through our Watershed Association Chairman, Mr. L. R. Lyngkhoi. A silpualin (250 GSM) lined pond (Fig 8) of 40 m3 capacity for harvesting and storing water was provided to him under the aegis of AICRP on APA Barapani centre. The farmer is using stored water for strawberry cultivation. He sold approximately 80 kg strawberry at the rate of Rs 120 to Rs 140 per kg. The farmer also reared grass carp in the pond and harvested 25 kg of fish in 2009. Mr. Nengnong earned a profit of Rs 9000 in a year. Beside this he is also able of produce winter season vegetable for his home consumption ensuring nutritional security.

Fig 8. Plastic lined pond for harvesting water

Training of progressive farmers of NAIP clusters

A 7-days training on application of plastic in agriculture for enhancing income was organized for beneficiaries of the NAIP clusters at the Institute from 15 to 21 March, 2010. Total 23 farmers from NAIP clusters located in Nagaland, Meghalaya, Manipur, Arunachal Pradesh and Sikkim attended the training programme. The trainees were exposed to the various plasticulture technologies, namely, low cost poly house, plastic lining of water harvesting tank, drip irrigations, sprinkler irrigation and sustainable farming systems on hill slopes.

EXTENSION AND DISEMINATION OF TECHNOLOGY

Farmers training programme

A day long farmers training was held on the 9th of September 2009 in collaboration with the State Bank of India (Fig 1). The training was attended by 162 farmers from the nearby villages. The program started with the welcome address by the Deputy General Manager (RB), SBI. The Director ICAR Dr S.V. Ngachan delivered a lecture on "Agro Based Entrepreneurship: Value addition, Entrepreneurship Development", followed by Dr A. Singh from ICAR who delivered a talk on "Strawberry Cultivation" and Dr A.K. Jha from the department of Horticulture of ICAR Umiam spoke about turmeric and ginger cultivation. The program ended with the distribution of seeds and the certificates by Sh. D.N. Balodhi, Director Central Board, SBI, New Delhi..

Fig 1. Dr. S. V. Ngachan, Director, ICAR, Umiam along with D G M (RB), SBI, and Dean CPGS in the inaugural function

Summer school on conservation of natural resources

A summer school (21 days) was organized by this division during 25th August to 14th Sep 2009 on the topic entitled "Conservation of Natural Resources for Sustainable Hill Agriculture". The objective of the course was to familiarize the participants with the natural resources and their importance, various approaches and technologies, socio-economic aspects and policy interventions for conservation of natural resources in hill agriculture

A total of 25 participants from ICAR institutes, SAUs and CAUs from different parts of the country participated in Summer School. The course consisted of lectures, tutorials, laboratory and field exercises. Total of 63 lectures including field and practical exercises, besides presentation from various participants were covered by a total number of 44 resource persons. The course was formulated with themes; a. familiarize with soil, water, plant and animal resources for sustainable hill agriculture b. understand the principles and practices of conservation agriculture c. know the present status of natural resources in NEH region.

Enhancing livelihood of rural women through pig husbandry

The interaction with the farmers had helped to produce and through enormous light into the study conducted in accordance with its formulated objectives. The study revealed information which would have been impossible without personal interview of the respondents. The majority of the families are headed by male and few by female unless there is absence of an elderly male in the family.

The state and the society following a matrilineal system, the ownership rights of fixed assets are entitled to female. The dominant family structure is composed of nuclear type as per the traditional concept. A major component of the population is dependent on agriculture as the main occupation for livelihood and next come the service holders and then farm labour as the landless farmers make

their earnings by working in others farm. Livestock production serves as subsidiary occupation providing some sort of financial security to them as keeping livestock animals when they are financially stable and selling the animals gather them enough amount during the cultivating season for planting materials and schooling of children. Organizational membership system exists which includes NGOs, village council, women's organizations, student's union, local federations and Self Help Groups (SHGs) where high participation is seen in the SHGs and the farmers benefit from the revolving fund while working in association. Many of the respondents lived in a mixed type of housing. Poultry and piggery (Fig 2) are the largely adopted livestock farming systems since it is believed to be easily manageable and hence, gain more experience in it. Lack of awareness among the people and high cost has resulted in less adoption of modern technologies and machineries.

Fig 2. Improved pig husbandry demonstrated to farmers

Facilitation centre on medicinal Plants

A decision support system on Medicinal Plant was created where information on 164 important species of MAPs of the region, along with their taxonomy, habit and habitat, plant description, parts used, medicinal properties, chemical composition and production technology were collected and compiled into a catalogue and developed into a web page. Besides individual crops, information about the MAP species of the state, their importance, status, uses, trade within and outside the state, etc. Knowledge on quality control and assurance for development of the MAP sector in the state had also been described. Updating and up gradation of both the catalogue and the web page will be taken up from time to time.

Fig 3. Promotion of medicinal and aromatic plants

Besides, this four numbers of trainings were conducted on topics like 'Promotion of medicinal and aromatic plants', value addition and community participation and training for nursery growers. Both in the institute and on the field where almost 250 farmers were trained and given exposures on different medicinal plants some of the trainings were done in collaborative manner with organizations like Botanical survey of India, state Bio resource centre and Meghalaya Rural development Society

Intellectual property right

A project entitled "Intellectual Property Management and Technology Transfer/ Commercialization" is underway in Agricultural Extension Division. The Intellectual Technology Management Unit (ITMU) under the project has to make a comprehensive analysis of the inventions taking place in the institute and identify the ones need to be secured by IPR protection. At present data on Intellectual assets is being collected and compilation work is under progress.

ATIC website

A website had been developed with the help of NIC about the various activities of the ATIC centre and the different facilities that the centre can provide to the farmers. It will also highlight the important technologies that the institute has generated. The website will be up dated from time to time as and when required.

Farmers visit

About 1167 (one thousand one hundred sixty seven) number of farmers visited the institute under different projects as exposure visits during this period. The farmers hailed from different parts of the northeast.

Almost all the visitors visiting the Institute also visit the ATIC cell and as a result the institute had distributed around 500 copies of leaflets on various subjects free of cost to the farmers. About 861bulletines and 62 books on various subjects were also sold during the period.

RAIN WATER HARVESTING AND WATER MANAGEMENT

Resource conservation in rice-based system

Conservation tillage was evaluated in lowland rice in combination with residue management. Conventional tillage (CT), zero tillage (ZT) for *rabi* crop, zero tillage for all crops and reduced tillage were tried as main plot treatments, where residue was removed in conventional tillage, retained in zero tillage and incorporated in reduced tillage. No mulch and straw mulch were the sub-plots treatments. The conservation tillage recorded higher soil microbial biomass carbon (SMBC), dehydrogenase activity and earthworm population (Table 1), which in turn resulted in higher growth and yield of all crops under zero tillage (Figs 1a-d).

In general, zero tillage with residue retention proved to be superior in yield (Table 1). CT gave the lowest yield attributes as well as seed yield of crops. ZT in rice was found to be favourable for

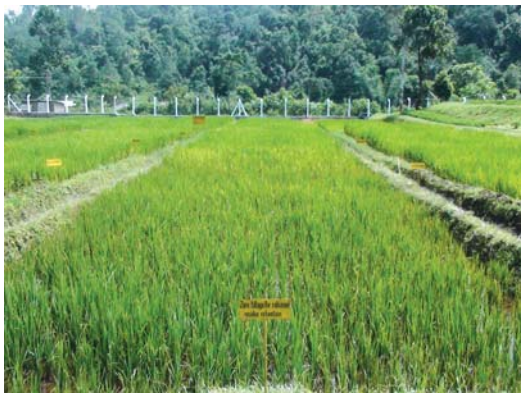


Fig 1a. Rice under zero tillage

Fig 1b. Conventional rice under tillage

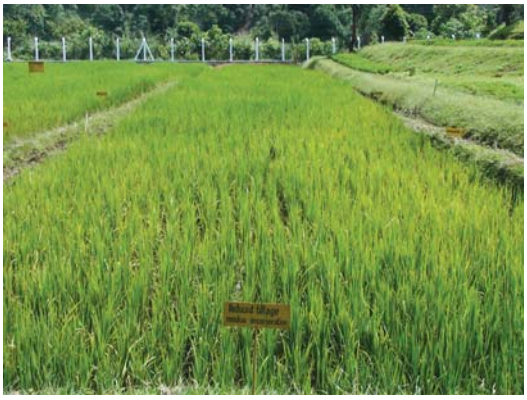


Fig 1c. Rice under reduced tillage

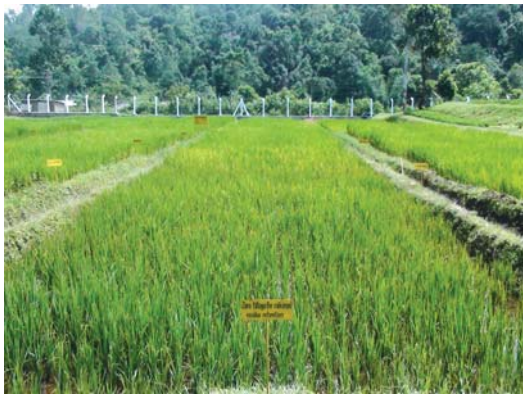


Fig 1d. Rice under zero tillage (*rabi* crop only)

Figs 1a-d. Rice crop under different tillage and residue management practices

Table 1. Soil properties and yield under different tillage system

Treatments	OC (%)	SMBC (µg/ g soil)	Dehydrogenase activity (g/kg)	Grain yield (t/ha)
C.T. Residue removal	1.52	124.23	24.27	3.33
Z.T. For all crops Residue retention	2.68	135.96	154.48	4.12
Z.T. For *rabi* crops Residue retention	2.57	128.24	120.58	4.10
Reduced tillage Residue Incorporation	2.01	125.87	98.32	3.67
CD (*P*=0.05)	0.84	14.21	20.98	0.25

rice growth as evident from the performance of rice under zero tillage for all crops as well as for *rabi* crop only. Further, reduced tillage was also found to be favourable for rice growth and even surpassed that under conventional tillage.

Conservation agriculture in rice for enhancing input use efficiency and crop diversification

A field experiment was conducted with four main plot tillage treatments (T_1-Conventional (*Kharif*)-conventional (*Rabi*), T_2 – Furrow & raised bed (FRB) (*Kharif*) –FRB (*Rabi*), T_3 – Conventional (*Kharif*) - FRB (*Rabi*) and T_4 – Conventional (*Kharif*) - Zero tillage (*Rabi*), along with two sub-plots treatments (straw mulch and no mulch), to evaluate the performance of rice under different tillage and land configurations aimed at conserving the resources. (Table 2)

Table 2. Yield attributes of rice as influenced by tillage practices

Tillage treatments	No. of tillers/ hill	Length of panicle (cm)	seed wt / panicle (g)	1000 seed wt. (g)
Conventional-Conventional	5.0	21.0	1.35	22.5
FRB- FRB	7.2	21.8	1.74	23.1
Conventional- FRB	6.03	20.9	1.47	25.4
Conventional-Zero Tillage	5.2	21.1	1.75	25.9

The FRB-FRB showed superior results compared to the other treatments and was followed by conventional- FRB and then by conventional-zero, with conventional-conventional tillage giving the lowest performance (Table 2). This resulted in a similar trend in the yield of the crops (Fig 2) where FRB-FRB was the highest yielder followed by conventional- FRB, conventional-zero and conventional-conventional tillage.

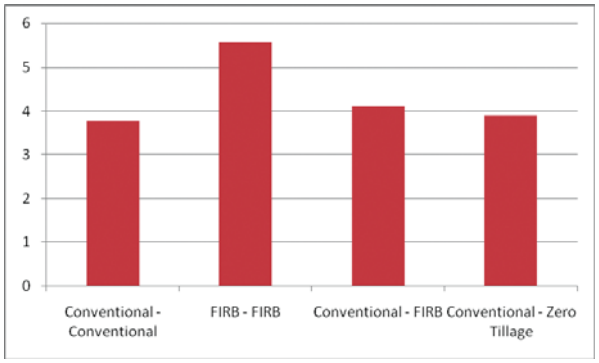


Fig 2. Yield of rice under different tillage treatments

In-*situ* residue management for carry over soil moisture conservation

A technology of in-*situ* residue management has been developed with the objective of taking mustard crop on completely residual moisture during *rabi* season. Treatments comprising of two tillage combinations of zero tillage and conventional tillage in main plot, and six mulch treatments *viz* M_0– control, M_1 – Maize stalk cover (MSC), M_2 – MSC + *Ambrossia sp.* @ 5t/ha, M_3 – MSC + *Ambrossia sp.* @ 10t/ha, M_4 – MSC + poultry manure@ 5t/ha + *Ambrosia* @ 5t/ha and M_5 – MSC + FYM @ 10t/ha+ *Ambrosia* @ 5t/ha as sub plots treatments were tested in split plot design and replicated thrice. In general, zero tillage practice performed much superior over conventional tillage practice. However, crop grown under various residue management treatments exhibited higher RLWC (72.5 to 88.12%), highest being with M_4 both under conservation and conventional tillage (88.12 and 86.51%, respectively). These might be attributed

to increased water absorption at critical stages due to greater root-soil contact under conservation tillage, which creates favourable soil environment for crop growth. Seasonal net changes in total water content of the soil profile (0-60cm) depicted that the total stored water of the profile in all the treatments depleted continuously with the advancement of crop growth periods due to extraction of water from the profile by the crops. However, throughout the growth period of mustard, water storage (%) of the profile was the highest in MSC + poultry manure @ 5t/ha + *Ambrosia spp.* @ 5t/ha (M_4), irrespective of tillage system (Fig 3).

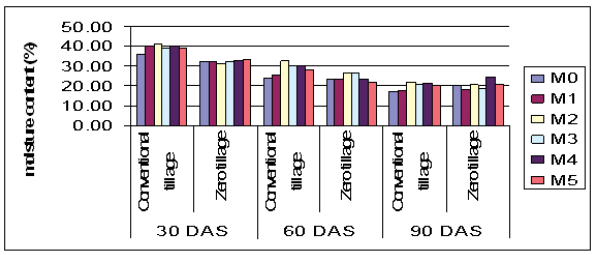


Fig 3. Soil moisture (0-60cm) under mustard crop

In general, all the residue management practices recorded good seed yield of mustard which was many fold higher than control (M_0), where only negligible yield was observed (Table 3). The treatment MSC + Poultry manure @ 5t/ha + *Ambrosia spp.* @ 5t/ha (M_4) recorded highest yield (737.6 kg/ha), which is almost 6 fold higher than the mustard yield under control plot (144.4 kg/ha). Similar trend was obtained in conservation tilled plot with such treatment. The combined use of the weed (*Ambrosia* sp) and maize stalk enhanced the inherent moisture retention capacity as well as nutrient supplying capacity of the soil, which, in turn improved seed yield under residue management treatments.

Selection and evaluation of water-efficient cropping systems

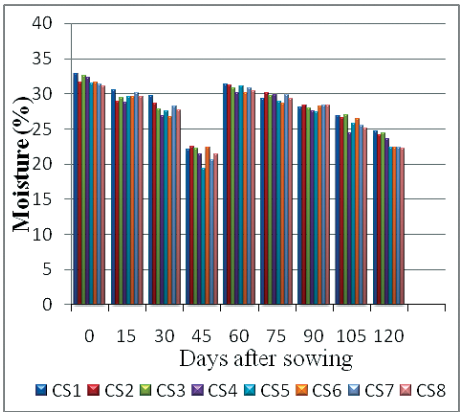
An experiment was conducted with two main plot tillage treatments (T_1 – Conventional tillage without crop residue and T_2 – Conservation tillage with residue incorporation) with eight cropping systems as sub plots Viz. CS_1 = Maize-mustard, CS_2 = Maize-pea, CS_3 = Rice-mustard, CS_4 = Rice-pea, CS_5 = Ricebean-mustard, CS_6 = Ricebean-pea, CS_7 = Soybean- mustard and CS_8 = Soybean-pea. Therefore altogether there were 4 *kharif* crops (Rice bean, maize, upland rice and soybean) and 2 *rabi* crops (mustard and pea). The main objective was to find out water efficient cropping system for rainfed terrace situation of Meghalaya. The respective varieties of the crop were: ricebean (RCRE-1-6), maize (Vijay Composite), upland rice (Bhalum-I), soybean (JS 80-21) and mustard (TS-36), pea (Azad P-1). The 50% depletion of available soil moisture was calculated based on the initial soil moisture with relation to the periodical soil moisture status.

The periodical soil profile moisture status (0-45 cm) under various cropping sequence were depicted in Fig. 3. It showed that the profile moisture content decreased with cropping season with a major fluctuation at 45 days after sowing due to drought like condition at this particular period of crops growth as a result of delayed monsoon. Little fluctuation

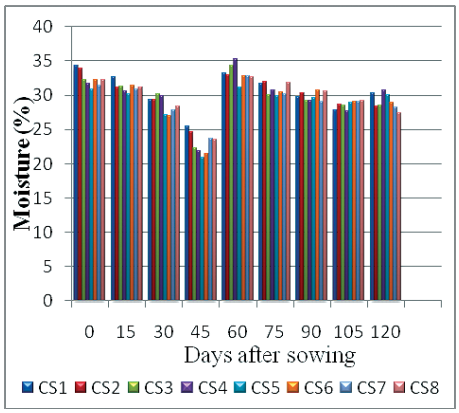
Table 3. Yield and WUE of mustard as influenced by tillage and moisture conservation measures

Residue management treatments	Tillage Treatments (T)					
	Conservation tillage	Conventional tillage	Mean	Conservation tillage	Conventional tillage	Mean
	Seed yield (kg/ha)			*Water-use efficiency (kg/ha-mm)*		
M_0	105.5	183.3	144.4	0.6	0.9	0.8
M_1	244.4	308.3	276.4	1.2	1.5	1.3
M_2	355.5	455.6	405.6	1.7	1.9	1.8
M_3	552.8	655.6	604.2	2.2	2.5	2.3
M_4	741.7	733.4	737.6	24.3	22.8	23.4
M_5	447.2	530.6	488.9	13.8	15.7	14.7
CD (P = 0.05)	63.2	66.13	-	2.14	2.45	-

was shown in some cropping sequence because of intermittent precipitation during crop growing season. During sowing of the *Kharif* crop, soil profile moisture content varied in between 31.08 to 32.85 % (w/w) and 31.45 to 34.25 % (w/w) and at harvesting between 24.67% to 22.15% and 30.32% to 27.38% in conventional and conservation tillage, respectively. It is noticeable that conservation tillage had higher soil moisture than under conventional tillage in any cropping system having tremendous effect on soil moisture recharge and uptake. Among all the systems, maize-mustard was found to be most suitable cropping system for soil moisture recharge.



Conventional tillage



Conservation tillage

Fig. 4. Soil moisture status under different tilage and cropping sequence

Soil moisture conservation through broad leaf vegetables and maize intercropping in terrace situation

The experiment was initiated in 2008 *kharif* season with three broad leaved vegetables viz. pumpkin, cucumber and ash gourd. The vegetables were intercropped with maize in terrace. The main objective of the experiment was to evaluate the effectiveness of broad leaf vegetables in soil moisture conservation. A distance of 2 meter was kept both row to row and plant to plant for pumpkin and ash gourd, while 1.5 meter for cucumber. Maize population was maintained to 50 % of the recommended. The data showed that in maize the percentage moisture was the highest when intercropped with pumpkin, followed by ash gourd and then cucumber (Table 4). Further, pumpkin + maize intercrop also had the higher soil moisture content compared to all the other treatments throughout the growth of the maize crop.

Table 4. Biomass of maize as influenced by intercropping with broad leaf vegetables

Cover crops/ Intercrops	Dry wt /plant(g)	Root dry wt /plant (g)
30 days after sowing		
Pumpkin	9.14	2.08
Cucumber	5.33	0.78
Ash Gourd	6.65	1.45
Control	4.75	0.63
60 days after sowing		
Pumpkin	70.11	9.82
Cucumber	55.84	6.89
Ash Gourd	51.08	6.18
Control	47.41	5.08
Harvesting		
Pumpkin	211.33	45.78
Cucumber	195.15	36.62
Ash Gourd	203.91	38.87
Control	187.63	32.42

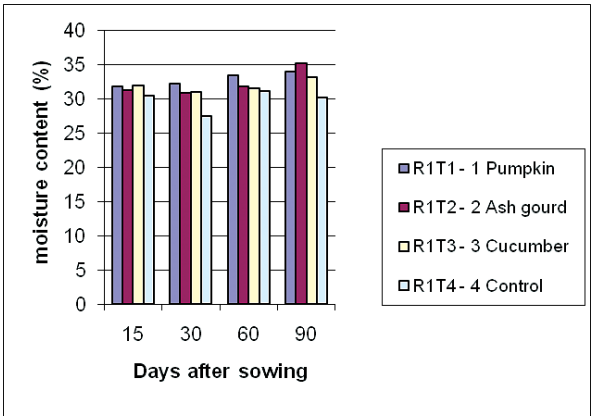


Fig 5. Soil moisture content (0-45 cm) under *rabi* crops

Scaling up of water productivity in agriculture

A total of 17 farmers' training programmes (7 days each) and 3 trainers' training programmes (14 days each) were conducted during the year 2009-2010 for up-scaling water productivity and improving livelihood of farmers. In each farmers training, 50 farmers and in each trainers training 25 extension personnel were trained from different part of Meghalaya as well as from other North Eastern States. Out of 17 farmers' trainings, 10 trainings were conducted in Meghalaya, 2 trainings each at Tripura and Arunachal Pradesh and 1 each at Sikkim, Nagaland and Manipur. Most of the farmers training programmes were conducted in remote areas e.g. Mawtari, Mawlasnai, Marmain villages of Meghalaya which are very difficult to access and the farmers hardly had any exposure to modern technologies. During each training programme a demonstration on constructing a low-cost rain water harvesting structure (*Jalkund*) were given in order to make awareness among the farmers. Field/ exposure visit were also arranged for the farmers which will make them aware about the latest technologies of farming system. There was good participation from the farmers and they were very much enlightened by the lectures/demonstrations given by the resource persons and many farmers have come up with their queries. Inputs like seeds, bio-organic and silpualin were also distributed to the farmers which will help them to overcome different cultivation problems in their villages. The significant aspects were that the trainings were conducted in the villages itself and as a result a large number of farmers especially women participated in the programme.

Two trainers' trainings were successfully conducted at ICAR Research Complex for NEH Region, Umiam, Meghalaya and one at Sikkim centre where officials from KVKs, NGOs, and State Government participated in the programme. Besides lectures, field/exposure and practical classes, visits were also arranged during the programme. The following are some of the pictorial depiction (Fig 6-25) of the training programmes conducted:

Farmers' Training Programme

Fig 6. Dr. A. Sikka, Member, NRAA, Govt. of India alongwith the Dr. S.V. Ngachan, Director, ICAR Research Complex for NEH Region attended Farmers' training on "Enhancing Water Productivity in Horticultural Crops through Rain Water Management" at Mawphlang Village, East Khasi Hill District, Meghalaya

Fig 7. Farmers' training on "Production Technology of Horticultural Crops Grown Under Rainfed and Irrigated Condition" at Umsaw Khwan Village, Meghalaya from 23rd – 29th June, 2009

Fig 8. Farmers' training on " Livelihood based integrated farming system development in different WM Regimes" at Mawpat/ Mashunam village, Meghalaya from 3rd – 9th Oct., 2009

Fig 9. Farmers' training on "Watershed Based Integrated Resource Management for Sustainable Development" at Kumargath, North Tripura from 7th – 13th Oct., 09

Fig 10. Farmers' training on "Diversified use of collected & conserved water" at Liarbang Village, Ri-Bhoi District, Meghalaya from 30th Sept. – 6th Oct., 2009

Fig 11. Farmers' training on "Water Management in Horticultural Crops" at Umroi Umktieh village, Meghalaya from 3th – 9th Oct, 2009

Fig 12. Farmers' training on "Rain water harvesting techniques" at Marmain village, Meghalaya from 11th – 17th January, 2010

Fig 13. Farmers' training on "Water Management in Rice under Different Land Situation" at ICAR Research Complex for NEH Region, Manipur Centre, Imphal from 5th to 11th February, 2010

Fig 14. Farmers' training on "Rain Water Management and System of Rice Intensification (SRI)" at Patharkhmah village, Meghalaya from 3rd – 9th March, 2010

Fig 15. Farmers' training on "Water Harvesting for Livelihood Enhancement" at Mawtari village, Ri-Bhoi District, Meghalaya from 16th – 22nd March, 2010

Fig 16. Farmers' training programme on "Livelihood Based Training Programme for Development of Integrated Farming System in Different Water Management Regions", Molvom Village, Nagaland from 22nd to 29th March, 2010

Fig 17. Farmers' training programme on "Enhancement of Water Productivity in Horticultural Crops through rain water Harvesting" at ICAR Sikkim Centre, Tadong from 24th – 30th August, 2009

Fig 18. Inaugural Function of Farmers training programme "Integrated Input Management for Higher Production and Water Productivity" from 26th Oct – 1st November, 2009 by Hon'ble Minister of Science & Technology & Environment, Govt. of Tripura

Fig 19. Farmers from Umksih and Mawtari village, Ri-Bhoi District visited the Water Management Farm, ICAR, Umiam

Fig 20. A Jalkund filled with rain water in Umsaw Khwan made as a part of SWPAL demonstration

Fig 21. Farmers participating in excavation of the selected site for Low-cost rain water harvesting structure (Jalkund) in Umsaw Khwan and Patharkhmah village, Ri-Bhoi District

Fig 22. Trainers' training programme on "Natural Resource Management under moisture stress and Climate Change Scenario" at ICAR Research Complex for NEH Region, Umiam, Meghalaya from 7th – 20th January, 2010

Fig 23. Trainers' training programme on "Water Resource Management and Planning for Horticulture Crops in Hilly Area in North Eastern Region" at ICAR Research Complex for NEH Region, Umiam, Meghalaya from 10th – 23rd February, 2010

Fig 24. Trainers' training programme on "Rain water management for Resource Development and Enhancing Water Productivity" at ICAR Research Complex, Sikkim Centre from 15th-28th Mar, 2010

Fig 25. Participants of the trainers training programme visit RRTC farm (NGO) and Agronomy, ICAR Research Complex, Umiam

CLIMATE CHANGE STUDIES

The North Eastern Region (NER) of India, by virtue of receipt of heavy rainfall, falls in low rainfall variability category and it ranges from 8-15%. For the North Eastern states of India, the normal annual rainfall ranges from 200-300 cm. Green vegetation, big water bodies and the nature's beauties and mega-biodiversity are the attraction of the NER. But of late, the region is loosing its nature's gifted fame. In high rainfall areas distribution of rainfall is of more concern as compared to its amount received. Erratic nature of rainfall, its intensity and frequency often makes crop planning a difficult task in rainfed areas. The world highest rainfall area Mawsynram / Cherrapunjee also falls within the region. But even so, under the influence of global climate change, high rainfall areas are facing drought like situations in the current years. Unprecedented drought-like situation adversely affected the whole NER in general and Assam in particular during 2006. According to IMD records, the amount of rainfall received by the NER in 2006 monsoon season stands to be the scantiest for a period of 25 years, since 1982.

Worst was in the year 2009, where, most of the NE states were affected by drought like situations. Manipur, Nagaland, Meghalaya witnessed severe meteorological drought. Other states have recorded moderate drought. Till July, 20, 2009 Manipur recorded 67 % rainfall deficiency followed by Nagaland (63%), Meghalaya (56%), Assam (34%), Mizoram (32%), Tripura (31%) and Arunachal Pradesh (29%). Assam - Meghalaya Division has recorded a deficit of 45% this year compared to 32 % in 1986 making it highest rainfall deficit year in last three decades. Arunachal Pradesh (6 districts), Assam (3 districts), Nagaland and Sikkim (1 district in each) remained very severely affected by Drought, which has received less than 55 mm of rainfall in consecutive 4 previous weeks (NESAC, 2009). This has severely affected the transplanting and sowing of rice in the drought affected areas. Only four years saw normal or above normal rainfall in NER between 1991 and 2000,

To study the climate variability long term climate data of Meghalaya were collected from India Meteorological department (IMD), Shillong centre and ICAR Research Complex (Observatory), Umiam, Meghalaya. These data included all weather parameters such as rainfall, relative humidity, evaporation, sunshine and temperature. The data collected were based from the collection and observation of the above two centers for a period of 25-27 years i.e. 1983 to till date. Analysis of the weather data is on the process to analyze the trends of climate and their impact on agriculture in NEH Region.

Analysis of soil properties under different eco-systems and resource conserving technologies were also done. These analysis included parameters such as pH, bulk density (BD), available nitrogen (N), available phosphorous (P), available potassium (K), organic carbon (OC), soil microbial biomass carbon (SMBC), Dehydrogenase activity (DHA) etc. The results of soil pH and dehydrogenase activity of soil (DHA) from the collected samples are shown in figure 2 and 3. The sites for soil sampling and analysis were selected from on-going field experiments of ICAR Research Complex on resource conserving technology as well as traditional land use patterns like:

- Conservation tillage
- Organic farming
- In-*situ* residue management
- Shifting cultivation (control)
- Forest (BSI)

The water flux or water balance of 26 years (1983-2009) at Umiam showed that there was maximum rainfall in July and lowest in January. Evaporation takes place maximum in April and lowest in January (Fig 1). This shows that there was a period of drought in the pre-monsoon period and a period of wet spell in the monsoon and post-monsoon period. Water deficit occurs in the pre monsoon period. The average of 26 years of

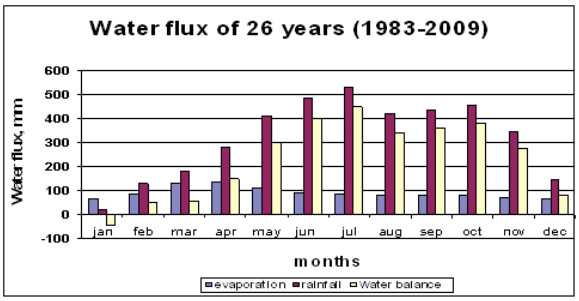


Fig 1. Climatic water flux for 26 years (1983-2009) at Umiam

climatic water balance also reflects that except in the month of January (-70mm) there is a surplus of water (> 500 mm) during the entire years. The analysis of 26 years rainfall data also recorded that the year 1998 was the scantiest year (1808 mm) whereas the year 1988 (3321 mm) was the wettest year.

In the studied soils of different land use systems, pH varied from 4.9 to 6.2 at the surface layer (0-20 cm) and 5.1 to 5.9 at the sub surface layer (20-40 cm). Among all the land uses, RSB (raised and sunken bed) recorded the highest pH and lowest in MZ ZT (maize under zero tillage) at both the layers. Relatively higher pH in RSB is was due to the prevailing saturated condition which increased pH in acid soils (Fig 2). Since maize is a heavy feeder crop, therefore, continuous cultivation might have removed significant quantity of bases from the soil resulting in more acidic pH. However, irrespective of land uses, pH reflected negligible variation along the depths.

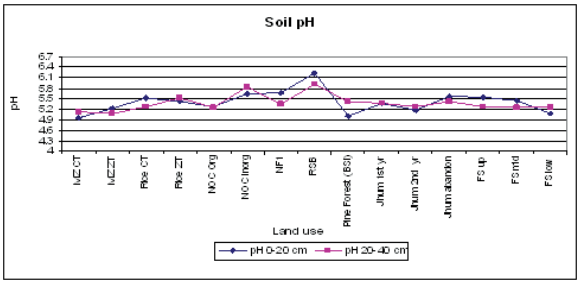


Fig 2. Soil pH as influenced by different land use systems

In the studied soils of different land use systems, DHA varied from 23 ug/g soil to 216 ug/g soil at the surface layer (0-20cms) and 25 ug/g soil to 100 ug/g soil at the sub surface layer (20-40 cms) (Fig 3). Among all the land uses, DHA maize under zero tillage (MZ ZT) recorded maximum in both the layers whereas rice under conventional tillage (RCT) recorded the lowest in both the layers. Dehydrogenase activity of soil is better in MZ ZT because of better environmental condition for growth and proliferation of microbes brought about by the adoption of conservation tillage along with residue management. However, MZ ZT is better than RCT because of the difference in the land conditions.

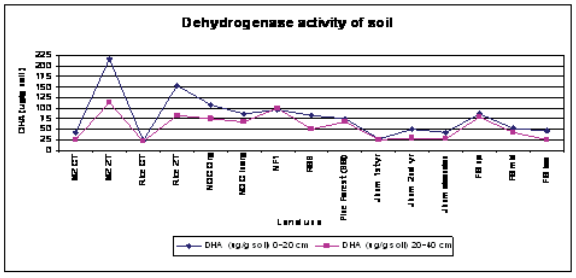


Fig 3. Dehydrogenase activity (DHA) of soil under different land

A farmers' awareness programme (Fig 4) on climate change was also conducted on the 24th of November, 2009 at the Conference Hall, ICAR Research Complex for NEH Region, Umiam, Meghalaya, where, about 37 farmers and 50 experts, scientists and technicals attended the awareness programme, to create awareness among the farming community regarding the adverse impacts of climate change on agricultural production systems and the need to initiate measures to adapt and slow down the rate of change.

Fig 4. Farmers attending the awareness programme on climate change

SOIL HEALTH MANAGEMENT

Liming of acid soils equivalent to extractable aluminium to neutralize its toxic concentration and lime requirement indices

Eight bulk soil samples (0-15 cm depth) were collected from the Nongkhrah, Kyrdem, Sohkhwai, Killing, Mawlong, Mawsyntai, Klew and Pyllun villages of the Re-Bhoi district of Meghalaya to study the effectiveness of Al extracted by different extractants to neutralize the soil acidity applied in equivalent amount and lime requirement indices for liming taking wheat as a test crop.

Liming showed significant positive effect on shoot biomass production of wheat. The lime rate equal to 0.2 M $LaCl_3$ was found to be the best which could predict the optimum shoot yield of wheat (1.81 g pot^{-1}, 62 % more as compared to control). The efficiency of different extractants for predicting the optimum shoot yield of wheat followed the order: 0.2 M $LaCl_3$>0.33 M $LaCl_3$>0.2 M $CuCl_2$>0.5 M $CuCl_2$>N NH_4OAc (pH 4.8)>1 M KCl.

Soil pH increased progressively with increase in the rate of lime application based on different extractable Al. The lime rate predicted by 0.5 M $CuCl_2$ was the most effective in increasing pH around 6.0 almost in soils. The lime rate based on 1 M KCl increased the least soil pH (mean pH 4.80).The intensity of increase in soil pH after liming varied depending on the initial properties of soils used. Both exchange acidity and exchangeable Al were drastically reduced with increasing rates of lime and almost followed the reverse trend of soil pH increase where as exchangeable calcium, base saturation of ECEC increased and per cent Al saturation of CEC decreased.

The critical limits of pH, exchange acidity, exchangeable Al, per cent Al saturation of effective CEC (ECEC), and per cent base saturation of ECEC with per cent shoot yield were determined by the method of Cate and Nelson (1965). The critical limit of above lime requirement indices were 5.3, 1.0 [cmol (p^+) kg^{-1}], 0.75 [cmol (p^+) kg^{-1}], 10% and 66%, respectively. This study indicated when acid soils drop below pH 5.3 and per cent base saturation is less than 66% of ECEC, there is a probability to get the response of lime.

Fineness of agricultural lime and soil reaction

The lab incubation study was carried out in laboratory with agricultural lime (dolomite limestone) in 2 plastic pots. It can be seen from the fig 1 and 2, soil pH increased with increasing lime rates. The soil pH initially increased around 6.5 in soil treated with < 0.1 mm size of dolomite limestone up to 30 days irrespective of lime doses (Fig.1) and thereafter slightly decreased and remained almost constant throughout the period in limed soils treated with fineness lime below 0. 8 mm. The soil treated with lime fineness of 2-3 and 0.8-2 mm the increase of soil was slow and tended to increased with incubation periods up to 90 days thereafter negligible increase occurred and soil pH remained below 5.5. This study indicated that coarse lime can increase the soil pH very slowly and continuously and for quick results liming must pass through sieve less than 0.8 mm openings. From fig 2, it appears that lime rate equivalent to 25% lime requirement is sufficient to raise the soil pH around 5.5 to eliminate the Al toxicity to get optimum productivity of crops in acid soils. It also appeared that doubling of the lime could not increase the soil pH as 25% LR increased the soil pH more than one unit over control.

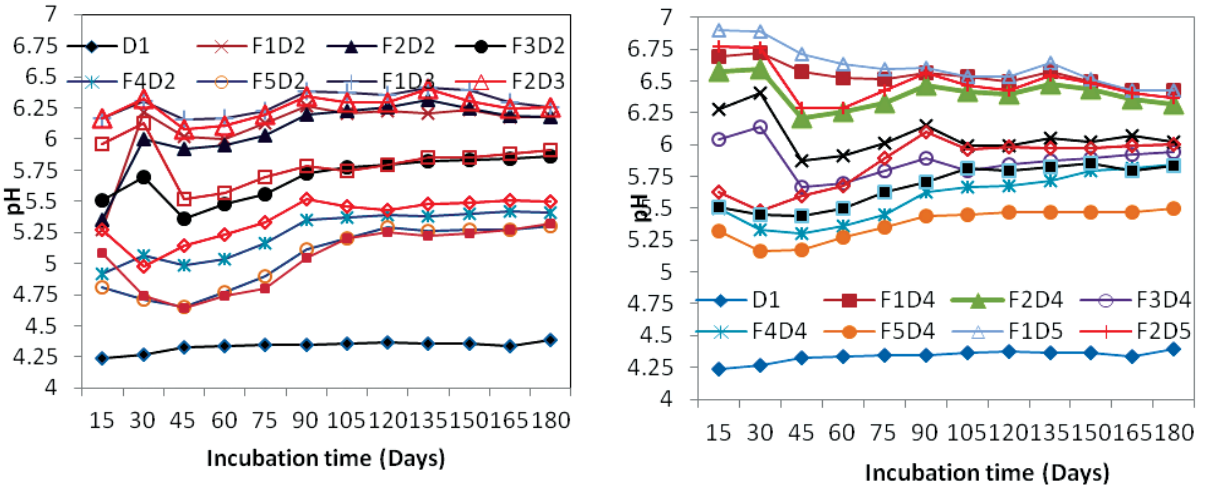


Fig 1. Effect of lime fineness and its dose (%LR) on soil pH (D1: o% D2: 25%; D3: 50%; D4: 75%; D5: 100%; F1:< 0.1mm; F2:< 0.1- 0.25mm; F3: 0.25- 0.8mm; F4: 0.8- 2mm; F5: 2-3mm

AGROFORESTRY

Plus tree selection of *Parkia roxburghii*

Superior provenances of *Parkia roxburghii* (Fig 1) were selected from different states of northeast i.e., Manipur, Mizoram and Meghalaya. Seven provenances were collected viz. Bilkhawthlir, Kawnpuii, Kezenglwa, Kangpokpi, Khaibung, Thingkhangphai and Mawkiang. The variations were observed in growth parameters of different provenances of *P. roxburghii* in the field during 2009-10. The maximum plant height (227.33 cm) and maximum number of primary branches (5.00/ plant) were recorded with Kangpokpi provenances. While maximum collar diameter (4.70 cm) and number of secondary branches (0.38) were recorded with Bilkhawthlir provenances. Maximum canopy diameter (132.76 cm) was recorded with Kezanglwa provenances.

Fig 1. ***Perkia roxburghii***

Integrated development of *Jatropha*

Thirteen provenances of *Jatropha curcas* (Fig 2) were evaluated for their growth and yield traits during 2009-2010. Growth performance was recorded for different provenances, maximum plant height was observed in TFRI-2 provenance (335 cm) and the minimum in Mawlasnai (159 cm), highest collar diameter was recorded for TFRI-2 (8 cm), followed by TFRI-1 (7.5 cm). The number of primary branches were maximum in Mawhati (8.33 nos.) followed by TFRI-1 (8 nos.), PJS- 1 (8 nos.) and Nagpur (8 nos.). Maximum dry weight of seeds was obtained from PJS-1 (57 g/plant) followed by PJS -2 (33.7 g/plant) and Byrnihat (29.69 g/ plant).

Fig 2. ***Jatropha***

Evaluation of *Mucuna* germplasm

Mucuna pruriens is one of the important medicinal species of the north east region. The species contains an active ingredient called LDPOA which has got wide use in the allopathic system of medicine. The species has much ethnomedicinal use as well. Therefore, efforts were initiated to collect germplasm of *Mucuna* species from the north east region and compare its performance with the germplasm from few other regions of the country.

Fig 3. ***Mucuna pruriens***

Seeds from different plants have been collected from Meghalaya (30 collections), Sikkim (17 collections), Assam (29 collections), Nagaland (20 collections), Manipur (8 collections), Uttaranchal (15 collections). Twelve accessions from NBPGR, New Delhi and five accessions from Indian Institute of Horticulture were also included for evaluation. Collection of germplasm from the north east region is still continuing.

Development

A nursery for forest tree species, a herbal garden and a home garden having utility species are under establishment to meet the seedling requirements for small scale plantations.

Linkages

The Division over the last one year has been able to establish linkages with several non-governmental organizations for popularizing agroforestry systems in the hill region of northeast India. Some of the NGOs are Bethany Society, Vista Agritech Pvt. Ltd, Meghalaya Rural Development Society, Bioresoure Development Centre, North East Network, Foundation for Social Transformation, Union Christian College, Deccan Development Society, etc. The Division is also closely working with the State Forest Departments and Medicinal and Aromatic Plants Board for various system research and development and policy making.

BIODIVERSITY

Biodiversity of plant pathogens in NEH region

Under a project on biodiversity of plant pathogens, many diseases have been documented, few new reports have been made and Institute herbarium (ICARHNEH, ICAR Herbarium for North eastern hills) is being maintained and enriched (Total specimens 114). True identity of powdery mildew pathogens on pulses and cucurbits has also been established. Scanning electron microscopy has been conducted for confirmation of different pathogens (Figs 1 & 2).

New reports

Pseudoperonospora cubensis on *Sechium edule*

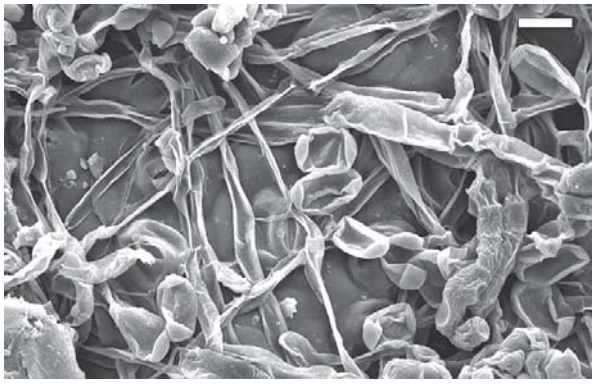


Fig 1. Anamorph of *Podosphaera xanthii* on cow pea (*V. unguiculata)*

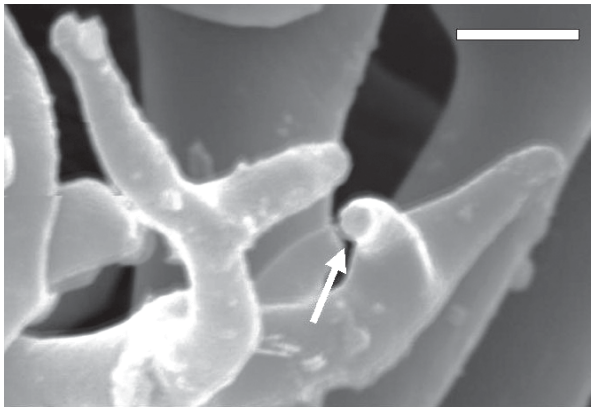


Fig. 2. Ultimate branchlets of *Peronospora variabilis* on *Chenopodium murale*

Anamorph of *Podosphaera xanthii* on *Gerbera jamesonii*

Anamorph of *Podosphaera* sp. on *Prunus nepalensis*

Anamorph of *Golovinomyces cichoracearum* on *Rudbeckia hirta*

Anamorph of *Erysiphe australiana* on *Lagerstroemia speciosa*

Anamorph of *Podosphaera* sp. on *H. sabdariffa*

Peronospora variabilis on Chenopodium murale

MUSHROOM

Wild germplasms collection, identification and conservation

Under AICRP on mushroom, *Termitomyces* sp., *Macrolepiota* sp. and *Scleroderma* sp. from Barapani and *Amanita* sp., *Boletus* sp. from Mawpat, Shillong were collected. Market survey

was also done twice and available mushrooms i.e. *Lactarius* sp., *Ramaria* spp., *Laccaria* sp. *Gomphus* sp, *Cantherellus* sp. and one unidentified species were collected. The photographs and dried specimens were sent to DMR Solan, HP. The samples were preserved in FAA solution. *Amanita* sp. was cultured on PDA and sent to DMR Solan, HP.

Strain evaluation of oyster mushrooms (*Pleurotus sajor caju* and *P. florida*)

P. sajor caju strain coded as PSC 01, 02, 03, 04 and 05 were grown on paddy straw substrate. The spawning was done during 9-11 June 09. PSC 04 recorded the highest yield (81.0 kg/100 dry paddy straw). The lowest yield was in PSC 05 (19.9 kg). PSC 01, 02 and 03 recorded 54.2, 57.5, and 42.8 kg fresh mushroom / 100kg dry paddy straw respectively. During cultivation period, minimum mean temperature was 21.8^{0}C and maximum was 27.1^{0}C. Relative humidity (RH) in morning was 85.5% and evening 84.9%. *P. florida* strain coded as PF 01, 02, 03, 04 and 05 were planted on paddy straw in winter during 25-27 Nov. 2009. The highest yield 77 kg/100kg straw was recorded in PF 01 closely followed by PF 04 (71.8 kg) and PF 02 (66.7 kg). The yields were statistically (P=0.05) at par in PF 01, PF 02 and PF 04. Similarly, PF 03 (50.9 kg) and PF 05 (58 kg) were also statistically (P=0.05) at par. Minimum mean temperature was 9.6^{0}C and maximum was 19.1^{0}C during cultivation period. Average RH in morning was 80.3% and evening 76.1 %.

Cultivation of shitake mushroom *Lentinula edodes*

Sal wood saw dust supplemented with 5% and 10% wheat bran (WB) was tried as substrate @. 1.25 kg dry substrate / bag. Sawdust + 5% WB recorded 106g yield only once. Fruiting did not occur in other treatment.

Survey and surveillance of diseases and insect pests in mushroom farms

A survey was done in Laitdiengsai village, East Khasi hills district on 3/8/09 in collaboration with Meghalaya State Dept. of Horticulture. A few button mushroom farms were visited and wet bubble disease (Fig 2) was observed in severe form (score 7 on 1-9 scale). There was very high humidity and inadequate ventilation. The farmers used LMC prepared by green maize plants and wild grasses .The pig dung was used as casing material. The watering was done by pipe and not by sprayers. All these factors contributed in disease spread. Preventive measures were suggested. In experiments on *P. sajor caju* a few fruits were affected by sciarid fly. The severity was of score 4. During June -July the damage due to slug (Fig 3) was also observed.

Fig 1. Fruiting of *Lentinula edodes*

Fig 2. Wet bubble disease affected button mushrooms

Fig 3. Slug damage in oyster mushroom

AGRICULTURAL ECONOMICS AND STATISTICS

Growth of livestock population in Meghalaya

Study was undertaken to estimate the growth of livestock population in Meghalaya for estimating the availability of meat in the state. Secondary data from the period 1982-2003 (Economic Review of Meghalaya and Livestock Census, 2003) were collected and growth was estimated. In absolute term, increase in pig population and increase in slaughter number of pigs in the state increased by more than double.

The increase in cattle population was only 39% whereas in goat it was 75%.

Decline in the population of sheep, and buffalo was observed. In poultry, increase in population (taking 1997 as base year) was found to be 52%. The demand of the slaughtered animal including poultry increased tremendously from 1355 to 3764 thousand number. Decline in animal meat yields from goat, buffalo and sheep were observed during 1983-84 to 2003-04. During the same period meat yield from pig increased from 36.15 kg to 43.36 kg. The reason for the decrease in meat yield may be because of reduced body weight at the time of slaughter.

Projection of requirement of major livestock food items

Time series data on meat production was compiled for the years 1983-84 to 2003-2004 from various issues of Basic Statistics of North Eastern Region and various Annual Reports of Directorate of Animal Husbandry, Govt. of Meghalaya. The ordinary least square method was used to fit exponential function in order to compute annual compound growth. To analyze trends and instability in meat production, log linear and log quadratic functions were used.

Projection study on the requirement of meat in the coming years in northeastern states was carried out to estimate the demand of livestock products. The state wise populations for the years 2010, 2015, etc. were estimated by using compound growth rates (CGR) of population of different states based on the population of 1991 and 2001 (Basic Statistics for NER, 2002). Requirement of major livestock based food items was estimated by multiplying the recommended amount of per capita milk, meat, poultry, and fish with the population at that point of time (say, 2010, 2015) on the basis of Rao et al. (2003). Total requirement of meat + poultry for the seven states of northeastern India for the years 2010, 2015, 2020 and 2025 were projected to be 505.74, 560.89, 623.21 and 693.89 thousand tons respectively (Table 1). The same figures were projected for the total requirement of fish in the aforesaid years.

Table 1. Requirement of meat + poultry (, 000 tons) in NE Region

State	2010	2015	2020	2025
Arunachal	14.70	16.49	18.51	20.77
Assam	340.38	370.86	404.07	440.25
Manipur	33.04	37.62	42.83	48.77
Meghalaya	31.87	36.27	41.28	46.97
Mizoram	12.25	13.90	15.77	17.90
Nagaland	33.69	42.94	54.73	69.75
Tripura	39.81	42.80	46.02	49.48
Total	505.74	560.89	623.21	693.89

Diversification pattern of agricultural crops in northeast India

To assess the market opportunity and scope of diversification in agricultural sector, secondary data of the agricultural crops excluding horticulture for the three periods viz. 1991-1992, 1995-1996 and 2000-2001 were collected. The extent of diversification at state level was estimated by using Sympson Index which is most commonly used for accessing the magnitude of the diversification.

In northeast, the extent of crop diversification was very low (0.37 only) with 79% area under rice. Low crop diversification was observed in the state of Tripura (0.16-0.21) and Manipur (0.17-0.18). Extent of diversification was comparatively more in Arunachal Pradesh (0.59-0.62) and Meghalaya (0.57-0.58). Moderate crop diversification was observed in the states of Nagaland (0.44-0.57), Mizoram (0.42-0.46) and Assam (0.33-0.34).The diversification pattern for northeast as a whole was found to be 0.69. The reason for the less diversification as a whole was because of more area under the rice crop (76%).

Diversification pattern in horticultural crops in northeast India

To assess the impact on the diversification pattern in horticultural crops which is considered to be the most important subsector in agricultural development in northeast India, the data for the study purpose from the year 2001-2002 to 2007-2008 were taken. The study revealed that the area under horticultural crops increased from 934.65 thousand hectare to 1088.20 thousand hectares and absolute term increase in area was 16% whereas, in Sympson Index it was less or more the same. The Sympson Index at the start of the Horticulture Mission Programme was 0.70 and during 2007-2008 it was calculated to be 0.69. The reason for the no significant change in the diversification pattern is mainly due to the increase in area in the crops occupied larger portion.

Change in diversification pattern in horticultural crops in the districts of Meghalaya from 2001-2002 to 2007-2008

The diversification pattern was worked out and found to be similar as that of state level (2001-2002). The analysis revealed no significant change in diversification index between the two periods among the districts. The overall diversification index at base year (2001-2002) was 0.72 and 0.73 during 2007-08 for the whole state. The district having higher diversification index (Jaintia Hills) at base year (0.73) continued to be leader in diversification index having almost similar index of 0.74 during 2007-08. Among the districts the district Ri-Bhoi showed significant change in diversification index which increased from 0.39 to 0.51. It was mainly due to the reduction in the area of main crops like pineapple and increase in area of new crops like tomato, capsicum, beans, etc.

Diversification pattern in the districts of Meghalaya based on the primary data

Primary data were also collected from the farmers' field of all the seven districts of Meghalaya for the year 2007-2008 and diversification pattern was worked out by using Sympson Index to correlate the analysis which was worked out on the basis of the secondary data. The diversification index at farmers' level across the districts was found very high, which ranged from 0.84 to 0.89. It was mainly because farmers were growing on an average 10 to 12 crops including both agriculture and horticultural crops. The marginal and small farmers were more diversified, growing a variety of horticultural crops with allocation of smaller area (0.01 ha) despite small operational holding. Among the horticultural crops, marginal and small farmers allocated the area in the range of 60-75% for the vegetable crops and 5-7% for fruit crops to the total area under horticultural crops. All together the share on vegetables includes cereals, pulses, oilseeds, all agricultural crops in marginal and small farmers ranges as low as high 12.9% to 44.5% which indicates the marginal and small farmers prefer to take the vegetables as cash crops to meet their day to day demand for the food and other obligations resulting the magnitude of the diversification is very high in small and marginal farmers but the total value of the crops are very low.

Constraints in organic production

Data were collected from the farmers of all the seven districts of Meghalaya through the conventional and non-conventional methods.The farmers opinion were collected through focus group discussion and unstructured questionnaire. The farmers expressed their opinion about constraints encountered with organic production. The study showed that the absence of the high premium price of organic product in the market, higher certification cost, non-availability of certification agencies and non-availability of organic inputs were the major constraints as majority of the farmers (80-100%) expressed their views for these constraints to be the limiting factor for popularizing the organic production in Meghalaya. Among them absence of the premium price of the organic product was the most important constraint. The farmers also had apprehension about the reduction of the yield due to organic input use. Absence of the effective marketing system for organic production was also realized as a major constraint. They expressed that at least one certification agency and quality control laboratory in each state of the northeast will reduce the cost involved in certification and other quality control considerably. Although the farmers are growing the crops by tradition as organic but they do not have the confidence due to lack of knowledge of improved organic farming technology. Hence

there is need to provide the comprehensive production technology for various agricultural crops and certification and quality control measure to be adopted in organic production. More than 95% farmers also expressed their opinion that the procedures of certification, quality control and standard for the production as well as for export are complicated that need to be simplified. The absences of the storage, and processing units were found as another constraint. The absence of the financial support from the financial institutions and other govt. organizations was also identified as constraint (Table 2).

Impact study of rice technology on production and productivity in adopted village under mid hill condition

The study was conducted in two villages i.e. Saiden and Kyrdemkulai of Ri-Bhoi district where the rice technology, both in upland and lowland was validated and demonstrated under the project "*Managing Rice Landscape in Marginal Upland for Household Food Security and Environmental Sustainability*". The two criteria, production and productivity were taken in to consideration from the base year (2005) and terminal year of the project (2009). Data were collected from both the adopted and non-adopted farmers of the whole village through the conventional and non-conventional methods.

Evaluation and dissemination of the new varieties of rice in the target areas helped to realize more than 1.0 t/ha productivity increase. Production increase in the upland and lowland ecology over a period of three years (2007-2009) in Kyrdemkulai and Saiden village is presented in Fig.1.

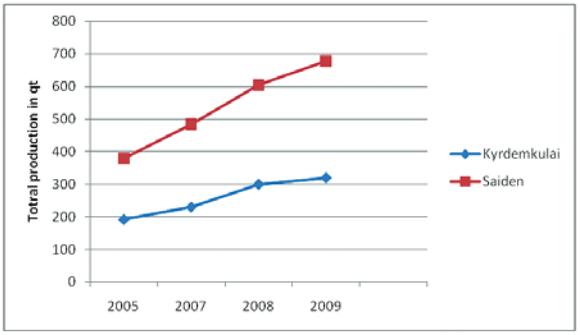


Fig 1. Increase in total rice production at the test sites

The study indicated that the total production in Saiden during the base year (2005) was 38.0 q which is further increased up to 68.5 q in the terminal year

Table 2. Constraints in organic production perceived by the various categories of farmers in Meghalaya

Particulars	Small %	Medium %	Large %
Non-availability of organic inputs and quality seeds	95	95	80
Non-availability of organic production technology	95	95	90
Lack of knowledge on organic production, certification and quality control procedures	80	72	65
No premium price of organic products at local market	100	100	80
No compensation for the reduction in yield due to organic production	100	100	100
Very less internal demand	85	80	75
Non-availability of the infrastructure facility	100	95	90
Higher certification cost	100	100	80
Long procedure for the certification & quality control	100	100	100
Absence of the processing/value addition	80	80	72
Lack of storage facilities	80	75	70
Higher risks in production and marketing system of organic production	72	68	60
Absence of effective marketing system for organic production	95	90	77
Lack of approach road and high charges of transportation	75	72	60
Absence of the financial support and incentive for organic production	90	90	85
Market information			
a. Lack of reliable source of information	80	68	60
b. Inadequate and misleading information	70	60	50
c. Lack of regulated market.	70	60	50

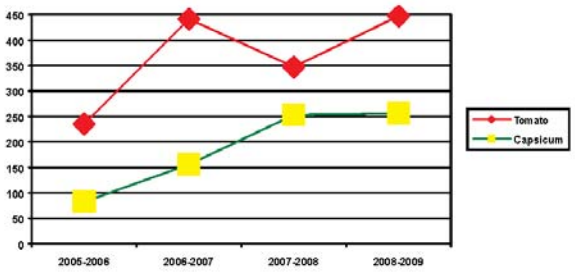


Fig 2. Tomato and capsicum production figures at Saiden

whereas, in Kyrdemkulai the increase in the total production was from 19.8 q to 30.5 q. The increase in total production over the period was mainly due to the increase in the productivity of rice both in upland and lowland. The contribution of the area in the total production was less than 10%. Yield gains achieved can reduce the hungry period by 4 months for an average household. In case of tomato and capsicum the study was conducted in Saiden, which indicates that the increase in total production has gone to 25.0 to 45.0 q. in tomato and 8.0 to 25.5 q in capsicum (Fig 2) in adopted farmers. In the rice and tomato cropping sequence identification of the proper varietal combination lead to an additional profit of Rs. 30,000/= per hectare.

Production and marketing of organic input vermicompost – a case study from Ri-Bhoi district of Meghalaya

The data were collected from 30 farmers' fields that were trained and producing vermicompost regularly and also from research organizations. The result revealed that the net income from farmers' unit was Rs 1081.23/ m^2/year whereas, in research unit it was 2123.63/m^2/year. The reason for the low income from the farmers field was mainly due to the less number of earthworm applied at the time of start against the required level (2000/m^2) which not only reduced the production but also the earning from the sale of earthworm multiplied during production. It is estimated that if the farmers maintain desired level of earthworm in production system and follow the improved production technology a minimum net income of Rs 16,000 could be obtained from 6.6 m^2 per year. No proper marketing system was observed. The production was mainly for own consumption and if excess was sold to the consumers. The marketable surplus in vermicompost was found very low at the farmers' field (20 to 30% at farmers' unit) whereas, the other agency involved in production and marketing mostly on demand basis had higher surplus (82 to 82.6 %). The producers' share in consumer rupee was found to be in the range of 93.02 to 95.20 per cent. The constraints faced by the farmers were examined. The main constraint realized by the farmers in production was to maintain desired level of earthworms and also lack of financial support for extending vermicompost units in a large scale. Due to the uncertainty of demand of vermicompost and non-awareness of marketing operative system, farmers were unwilling to take the risk of the vermicompost production which is viable in the Ri-Bhoi district. This major constraint identified need to be addressed with joint effort of the stakeholders and the government.

Impact of training on production and marketing of ginger in Ri-Bhoi District of Meghalaya

The study was undertaken to assess the impact of the training programme conducted by ICAR on ginger production and marketing. Data were obtained from 60 trained farmers. Data were also collected on production, marketing, technological gap and knowledge status towards the improved technology. Data were obtained before organizing training programme and after the raising of ginger crop as well as marketing done by participants. Both conventional and non-conventional methods were used for collecting data (well structured questionnaire/group discussion/PRA). The purposive sampling was followed since the impact of the training programme was to be measured from participants who attended the training.

The study revealed that there was substantial increase in income of the farmers after attending the training. Before the training programme, the yield of ginger crop was 8.650-8.925 t/ha whereas, after application of knowledge gained in the training programme, the yield was high (18.920 to 22.500 t/ha). The production cost was reduced from Rs. 6.83-7.2 to 2.89-3.38/kg with 118- 56% increase in net income.

Sperm motility, acrosomal integrity and fertility of preserved boar semen at 18 °C

A total of 16 ejaculates from four Hampshire boars (four ejaculates from each) were used for the study. After evaluation, semen samples were diluted in BTC (Beltsville Thawing Solution) and preserved up to 96 h at 18°C. Sperm motility was assessed from day 0 to day 5 at 24h interval under 40X phase-contrast microscope by wet-film method. Acrosomal integrity was assessed by fluorescein isothiocyanate-conjugated peanut agglutinin (FITC-PSA)/PI staining. The stained sperm cells (Fig 1) were analyzed under fluorescent microscope and at least 200 spermatozoa per sample were evaluated**.** To evaluate the fertility of preserved semen, oestrus sow/gilts were inseminated by golden pig catheter (IMV) during standing heat with liquid semen stored from 0 to 96h at18°C. Results revealed that there was linear reduction in the sperm motility from day 0 to day 4. The sperm motility was significantly ($P<0.01$) lower on day 3 when compared to day 0. The sperm abnormalities like bend tail, coiled tail, detached head and tail and acrosomal abnormalities like swollen, ruffled and lost acrosome were observed during preservation. Acrosoaml abnormality was significantly ($P<0.05$) higher on day 3 compared to day 0. FITC-PSA/PI assay revealed that there was a linear increase in acrosome reacted sperm population from 0 to 96h. The acrosome reacted sperm population was significantly ($P<0.05$) higher at 48h and 72h compared to 0h of preservation. The average pregnancy rate was 80.4, 78.45, 76.34, 68.45 and 62.45 percent respectively on day 0, day 1, day 2, day 3 and day 4 of preservation. The pregnancy rate on day 4 was significantly ($P<0.05$) lower than that of on day 0. The pregnancy rate was positively correlated with sperm motility ($r=0.78$) and acrosoaml integrity($r=0.67$). The present study showed that preservation of boar semen at 18°C tended to induce acrosome reaction and reduce acrosomal integrity. Further, the fertility of liquid boar semen was reduced after 72h of storage at 18°C in BTC.

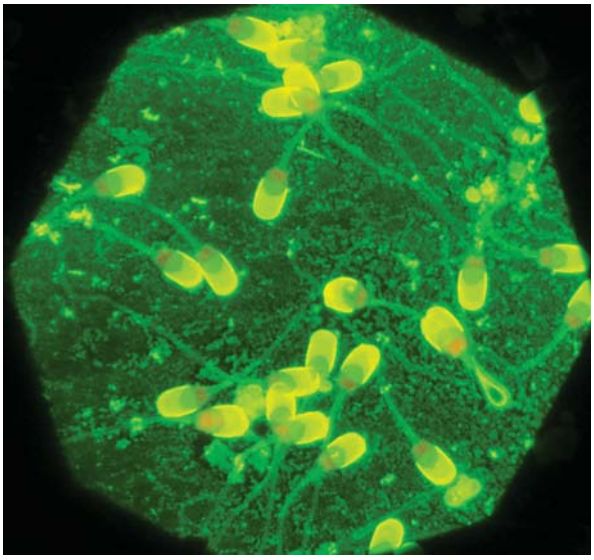


Fig 1. Acrosomal Integrity by FITC-PSA/PI assay

Productive performance of Ghungroo pig under agro –climatic conditions of Meghalaya

A total of 12 (9 female and 3 male) Ghungroo pigs were purchased from national research centre on pig and reared under standard management condition. The productive performance of F1 generation was evaluated under standard housing, feeding and breeding management condition. The body weight gain of Ghungroo pigs at different ages were recorded and shown in the Table 1. The growth rate and body weight gain at different ages was compared with different genetic group of Hampshire with Khasi local crossbred pigs. The study revealed that there was significant difference between upgraded Hampshire and Ghungroo pig in body weight gain at different ages. While, 87.5% Hampshire cross with Khasi local had significantly higher body weight gain at 6, 7 and 8 months of age, however, there was no significant difference at early age from 3-5 months. Reproductive traits like litter size at birth and weaning percentage of the Ghungroo pigs were also evaluated in the 1st generation and it is shown in the Table 2.

Artificial insemination in pigs through trained unemployed youth in the field condition

To produce sound artificial insemination delivery personal, total of 33 educated unemployed youth were selected in different villages and trained on artificial insemination technology and breeding management in pig. After training in the Institute, these youth were also trained in the filed conditions

Table 1. Comparative body weight gain of upgraded cross bred, T&D and Ghungroo at different age (kg)

Age	Ghungroo	75%	87.5%
4 months	13.66± 1.64	19.67± 2.54	20.23± 2.34
5 months	17.33± 2.43	22.34 ± 3.23	25.45±3.45
6 months	26.67± 2.75	33.67 ± 3.48	34.56±3.87
7 months	34.76± 3.67	40.12 ± 4.67	44.45 ±5.67
8 months	39.43± 4.34	50.32 ± 6.89	55.67±7.83
Litter size at birth	8.3 3 ± 1.34	9.46± 1.23	10.12± 1.09
Ind. litter wt at birth	0.557 ± 0.38	0.885± 0.23	0.985± 0.32
Litter size at weaning	7.67 ± 0.33	8.53± 0.44	9.23± 0.56
Ind. litter wt at weaning (kg)	6.86 ± 0.47	9.74± 0.43	10.34± 0.53
Weaning percentage	85.51 ± 2.66	88.67± 1.87	87.63± 1.23

under supervision. The good quality semen was extended in BTS media and preserved at 18°C for insemination in field condition. A total of 33 good quality semen doses were supplied to the trained youth for insemination under village condition on request. The youths carried the semen in a thermo-cool box and inseminated the sow/gilts at farmers door step. A total of 21 sow and 12 gilts were inseminated by the youth under village condition. The details of pregnancy rate, farrowing rate and litter size after insemination by the trained youth is given in the Table.2.

Tabel 2. Reproductive parameters after insemination by trained unemployed youth in the field condition

Parameters	
No. of pigs inseminated	33
No. of pigs pregnant	24
No. of pigs farrowed	23
Pregnancy rate (%)	72.7
Farrowing rate (%)	69.6
Average litter size at birth	7.32
Average litter weight at birth/piglet (Kg)	0.917
Still birth (%)	Nil
Weak piglets (%)	0.47
Average individual litter weight at weaning (kg)	7.54

Skilled personnel produced from the youth group shall help door-to-door delivery of the technology thereby ensuring the continuity of the programme with less dependence on government machinery. The well trained youth will then act as "Inseminator" at the village level, key informants and link between Institute and farmers.

Fig 2. Insemination by trained unemployed youth at farmers' doorstep

Study on estrogen receptor gene in pig

Experiment 1: Pig population of *Khasi* local, Ghungroo and upgraded varieties (Khasi local X Hampshire) were selected to study the relationship of ESR gene with the litter traits. The genomic DNA is being isolated from whole blood using Phenol- chloroform –Isoamyl alcohol method. The PCR standardizations for amplification of ESR gene (120 bp) with the following primers are being carried out.

Forward primer :
5'- CCTGTTTTTACAGTGACTTTTACAGAG-3'

Reverse primer :
5'-CTTCGAGGGTCAGTCCAATTAG-3'

Experiment 2: The study is carried out to identify and select piglets at the early age for increase litter size. Genomic DNA is extracted and standardized the PCR protocol for selection of piglets using following primers.

Primer 1:
5'-GTCAGTCCAATTAGAATAGGGCGGGA ATGGGGACTTG ACAAGAAACGT-3'

Primer 2:
5'-GTGGAATGGGACTTGACAAGAACACC-3'

Primer 3:
5'-CCTGTTTTACAGTGACTTTTACAG AGTATA-3'

Piglets with 90 bp bands will be identified as prolific genotypes, those with 110 bp as non-prolific and piglets with both the bands (90 and 110 bp) as hetero-genotypes. Out of 10 piglets screened so far, 02 nos. of samples showed 90 bp, 06 nos. of samples showed 110 bp, and 02 nos. with 90 and 110 bp. Further study has to be taken to select the animals after their farrowing.

Soil-plant-animal continuum in relation to mineral status and fertility in dairy cattle in Meghalaya

A total of 492 dairy cattle have been screened for the fertility status in Ri-Bhoi and East Khasi Hill District of Meghalaya. Out of total animals screened, 356 (72.35%) were normal cyclic/ pregnant and rest 136 animals (32.50%) showed reproductive disorders. Fertility status of dairy cattle was assessed in terms of age at puberty, age at first conception, gestation period, age at first calving and inter-calving interval etc. Out of total infertility cases, repeat breeding and anoestrous were two major reproductive disorders observed at farmer's field as well as on State Govt. Cattle Breeding Farms, which comprised of 43.38% and 33.90% respectively.

A total of 125 blood samples were collected from normal cyclic cows (n=30), anoestrus (n=40) and repeat breeder cows (n=55) to estimate plasma total protein, albumin, cholesterol, glucose and micro minerals levels to correlate with fertility status.

85 soil samples, and 74 fodder samples were collected which are under process for estimation of macro and micro minerals.

Assessment of fertility

A total of 492 animals were screened in Ri-Bhoi and East Khasi Hill District of Meghalaya. Fertility status of dairy cattle was assessed based on the analysis of the data obtained from Govt. Cattle Breeding Farms as well as from farmer's field. Mean ± SE of various reproductive parameters in crossbred dairy cattle in Meghalaya is presented Table 3.

Incidence of reproductive disorders dairy cattle of Meghalaya

To assess the incidence of reproductive disorders in dairy cattle, survey has been conducted in Ri-Bhoi and East Khasi Hill District of Meghalaya. Based on gynecological examination of cows and reproductive history, animals were classified into normal cyclic/ pregnant, repeat breeder, anoestrous and infertile. Out of 492 animals screened, 136 (32.50%) showed reproductive disorders (Table 4). These cases were further divided into different categories. Maximum incidence was found to be of repeat breeding, which comprised of 43.28% of the total reproductive disorders. Incidence of anestrous was next to the repeat breeding i.e. 33.90 %. Other reproductive disorders recorded were retention of fetal membrane (15.44%), abortion (2.20 %), pyomettra (2.94 %), vaginal prolapse (1.47 %), dystocia (2.20 %) and mummified fetus (0.07 %) respectively.

Table 3. Reproductive parameters in crossbred dairy cattle in different parities

Parameters		No. of observations (n=400)		Days (Mean ± SE)	Range (days)
Age at puberty		116		812.75 ± 34.35	680-1125
Age at first conception		96		861.75 ± 33.65	742-1170
Gestation period		92		275.72 ± 0.33	270-282
Age at first calving		96		1138.48 ± 33.62	1020-1445
Parameters	**P-I**	**P-II**	**P-III**	**P-IV**	**P-V**
Post-partum estrus interval	127.62 ± 6.77	122.84 ± 7.04	118.949.4	112.71±5.99	113.41±7.49
Service period	160.87±8.39	148.00±8.82	145.299.84	150.19±8.84	148.63±10.05
First service conception rate (%)	50.00	42.10	41.17	47.61	36.84
Service per conception	2.25 ± 0.35	2.00 ± 0.17	1.88 0.08	2.00 ± 0.19	2.05 ± 0.18
Inter-calving interval	456.31±16.56	484.68±23.46	451.0536.46	463.95±41.36	472.21±52.98

Table 4. Incidence of reproductive disorders in Ri Bhoi and East Khasi Hill districts

Reproductive disorders	Incidence (%)
Animals examined	492
Animals with Rep. Disorders	32.50 % (136/492)
a. Repeat breeding	43.38 % (60/136)
b. Anestrous	33.90 % (42/136)
c. Retained placenta	15.44 % (21/136)
d. Abortion	2.20 % (3/136)
e. Pyomettra	2.94 % (4/136)
f. Vaginal prolapse	1.47 % (2/136)
g. Dystocia	2.20 % (3/136)
h. Mummification of fetus	0.07 % (1/136)

Effect of castration age on carcass yield

Thirty castrated Assam hill goats maintained under semi-intensive managemental conditions of the Farm complex of Animal Production Division had been slaughtered on 12th months of their age, irrespective of their age at castration, to see the effect of age at castration on the carcass yield. The animals were castrated with Burdizzo method of castration at 1st, 3rd, 4th, 5th and 6th months, and a group of non- castrated as control. Study revealed that age at castration had an effect on the live weight and hot carcass weight of the castrates (Table 5). The live weight and hot carcass weight shows a significantly decreasing trend of gaining weight with the advancement of castration age. The present study can be concluded that castration at early age gives more yield than that castrated at the later stages. However, the dressing percentages of the animals were found to be non-significant among all the groups.

From the present study it could be revealed that the average daily weight gain (gm) was found to be more when the animals were castrated at an early age (Fig 3). The ADG of the control group was found to be slightly more than that of all the treatments.

The present study revealed a highest contribution of neck and shoulder cuts on hot carcass yield followed by the leg portion (Fig 4). However, leg cut shows a significant difference between goats castrated at 1 month and 3 months, loin cuts between goat castrated both at 1 and 2 months with 6 months group, breast cuts between control group with 4 months and 6 months group, neck and shoulder cuts between control with 3 month, 4 months and 6 months group.

Fig 1. Average daily weight gain (gm) of goat castrated at different ages

Semen collection and evaluation in Assam hill buck

Facilities for semen collection from Assam hill bucks were created. The breeding bucks were trained for ejaculation in artificial vagina. Semen was collected (Fig 5) from 04 breeding bucks at

Table 5. Effect of age at castration on carcass traits of Assam hill goat

Parameters	Weight of different cuts castrated at different ages					
	1 month	3 months	4 months	5 months	6 months	Control
Live weight (kg)	16.1 ± 0.31^{a*}	15.58±0.61^{a}	13.6±0.24^{bc}	15.17±0.42^{ac}	13.02±0.53^{b}	16.13 ±0.32^{a}
Hot carcass weight (kg)	7.55 ± 0.24^{a}	7.167±0.28^{ab}	6.5±0.26^{b}	6.97±0.26^{ab}	6.27±0.20^{b}	7.58±0.17^{a}
Dressing percentage (%)	46.86 ±0.82^{ns}	46.09±1.23 ^{ns}	47.74±1.32 ^{ns}	45.93±0.98 ^{ns}	48.34±1.31 ^{ns}	47.07±0.99 ^{ns}
Leg (kg)	2.67±0.07^{a}	2.6±0.08^{ab}	2.198±0.16^{b}	2.35±0.09^{ab}	2.23±0.14^{ab}	2.52±0.07^{ab}
Loin (kg)	0.92±0.06^{a}	0.89±0.10^{a}	0.76±0.03^{ab}	0.79±0.04^{ab}	0.59±0.04^{b}	0.74±0.03^{ab}
Rack (kg)	0.47±0.01^{ns}	0.44±0.04 ^{ns}	0.43±0.06 ^{ns}	0.43±0.05 ^{ns}	0.38±0.06 ^{ns}	0.47±0.02 ^{ns}
Breast (kg)	0.70±0.03^{ab}	0.71±0.03^{ab}	0.61±0.03^{a}	0.70±0.04^{ab}	0.61±0.01^{a}	0.74±0.03^{b}
Neck and Shoulder (kg)	2.79±0.09^{ab}	2.53±0.14^{a}	2.51±0.11^{a}	2.70±0.14^{ab}	2.46±0.08^{a}	3.11±0.15^{b}

*Means bearing different superscripts within the same row differ significantly (P<0.05)

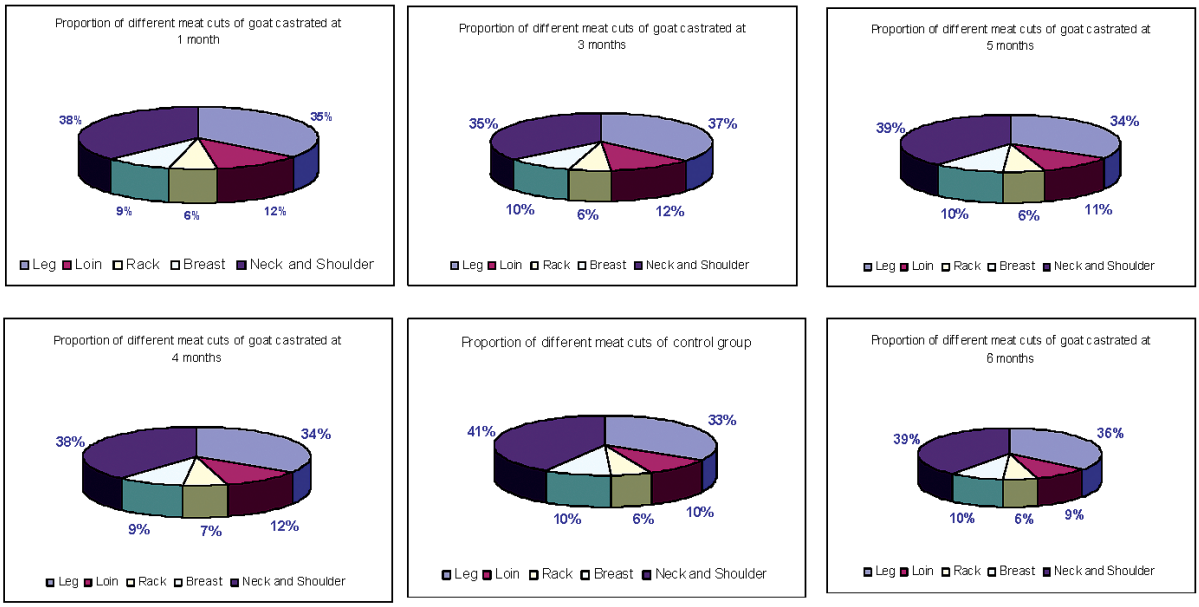


Fig 4 Variation of yield of different meat cuts at different age of castration

weekly interval. A total of 36 semen samples were collected and evaluated for physical and morphological characteristics Table 6). The ejaculate volume averaged 0.55±0.27 ml .The colour of semen was creamy with yellowish tint and consistency was thick. The sperm concentration ranged from 2230 $x10^6$ to 3220 $x10^6$ with an average of 2682.45 ±358.56$x10^6$ per ml of semen. The salient findings of seminal characteristics are as follows.

Fig 5. Semen collection in Assam hill buck

Table 6. Seminal characteristic of Assam hill goat

Seminal parameter	Value
Volume of ejaculate (ml)	0.55 ± 0.27
Colour	Creamy with yellowish tint
Consistency	Thick- 93.08% Thin – 6.92%
Mass activity (0-5 scale)	4.25±0.55
pH	6.72±0.25
Sperm concentration (millions per ml)	2682.45±358.56
Initial motility	86.27±10.32
Live sperm %	84.12±12.13
Dead sperm %	13.68 ±4.55

Estrus induction, estrus synchronization and artificial insemination in Assam hill goat

Preliminary studies on estrus induction, estrus synchronization and Artificial Insemination (Fig 6) in Assam hill goats with extended liquid semen were

Fig 6 Artificial Insemination in Assam hill goat

initiated. Estrus was induced (n=06) using tiaprost trometamol (225µg/animal I/M) in randomly selected anoestrous goats with 50% success rate (n=03) in treated group compared to 16.66% (n=01) in control group (n=06). Estrus synchronization in goats was attempted (Group-1, n=06) using either intra vaginal progesterone sponge for 12days or subcutaneous injections of 125 mg hydroxy-progesterone at three days intervals three injections followed by removal of sponge or withdrawal of progesterone therapy and subsequent administration of 225µg/animal I/M injection of tiaprost trometamol. The observations were recorded and compared with control group (Group-2, n=06). Four estrus synchronised animals were inseminated artificially twice at 24 hour interval after 12 hrs after onset of estrus with extended liquid buck semen. One goat conceived and one male kid weighing 1.7 kg was born. The results are summarised in Table 7.

ANIMAL HEALTH

Surveillance, monitoring and investigation of disease outbreaks in the region

Clostridial infection in animals

Clostridium perfringens is a cause of economically important disease in livestock such as cattle, swine, sheep, goats and poultry. The pathogenicity of the organism is associated with several toxins. *C. perfringens* isolates recovered from different sources were typed on the basis of their toxin gene detection by PCR. A total of 10 *C. perfringens* isolates were recovered from diarrhoeic samples of cattle and goat. The isolates were confirmed by morphological, biochemical characteristics and reverse CAMP test (Fig 2) with *Streptococcus agalactiae*. All the isolates were positive for alpha toxin gene *cpa* (324bp) and 2 isolates from goat were found to be positive for beta2 toxin gene *cpb*2 (567bp) (Fig 1). The isolates were identified as *C. perfringens* type A.

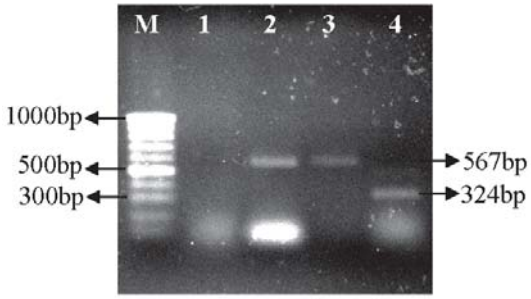


Fig 1. PCR based detection of toxin gene *cpa* (324bp) & *cpb*2 (567bp) of *Clostridium perfringens* isolated from cattle & goat. Lane M: 100bp Marker; Lane 1: Negative control; Lane 2-4: Isolates

Isolation, identification and characterization of *Listeria monocytogenes* recovered from animal and environment samples

A total of 608 samples including blood (45) , intestine (121), vaginal swab (34), nasal swab (87), faecal (200), water (78), soil (30) and sewage (13) were collected and screened for *Listeria monocytogenes*. Out of these, 7 (15%) blood, 11

Table 7. Effect of estrus synchronization in Assam hill goat

Groups	No. of animals (n)	No of animals showed estrus (%)	Interval between PG adm. and estrus (hrs)	Estrus duration (hrs)	Prominent signs of estrus	Animals inseminated	Pregnancy rate / kidding (%)
Treated group 1	06	04 (66.66%)	69.50 ±9.50	29.50 ± 6.50	Wagging of tail seeking of male frequent micturation intense vulval swelling	04	01 (25%)
Control group 2	06	01 (16.66%)	—	26.0 ±0.0	Seeking of male slight vulval swelling frequent micturation	01	0.0 (0.0%)

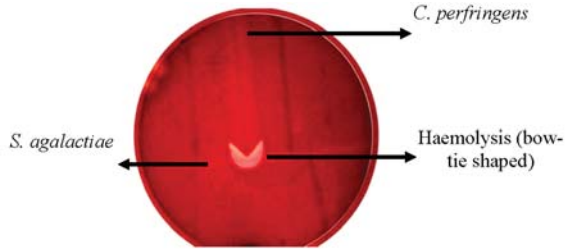


Fig 2. Reverse CAMP test for *Clostridium perfringens* on 5% sheep blood agar

(9.1%) intestine, 8 (10.2%) water and 2 (15.3%) sewage samples were found positive for *L. monocytogenes,* with an overall prevalence rate of 4.4%. The 27 *L. monocytogenes* isolates were confirmed through morphological, biochemical and detection of 16S rRNA gene (Fig 3). Virulence associated genes *hly*A (234bp) and *iap* (131bp) were detected through standardized PCR methods (Fig 4).

Fig 3. PCR based detection of 16S rRNA (1200bp) gene of *Listeria monocytogenes* isolated from environmental samples. Lane M: 1kb DNA Marker; Lane 1-19: Isolates

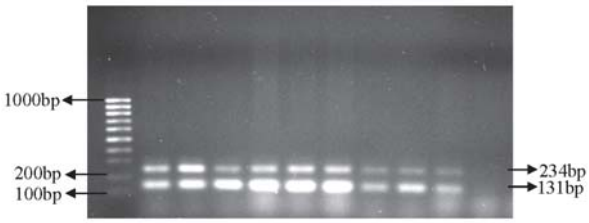


Fig 4. PCR detection of *hly*A (234bp) & *iap* (131bp) genes of *L. monocytogenes*. Lane M: 100bp DNA Marker; Lane 1-9: Isolates; Lane N: Negative control

PCR Serogrouping of *L. monocytogenes* isolates: Serotyping of *L. monocytogenes* is an important criterion to identify and characterize the different strains responsible for various diseases in animals and human. Conventional serotyping methods are time consuming and laborious. Since, facilities are not easily available in the region, it is of utmost important to standardize serotyping protocols for *L. monocytogenes*. PCR serotyping methods were standardized to identify and separate major *L. monocytogenes* serovars into different groups: group1 (serovars 1/2a, 3a), group2 (serovars 1/2c, 3c), group3 (serovars 1/2b, 3b, 7) and group4 (serovars 4b, 4d, 4e). A total of 11 confirmed *L. monocytogenes* isolates were subjected for serovars grouping by PCR technique, based on the detection of different genes such as *lmo*0737 (691bp), *lmo*1118 (906bp), ORF2819 (471bp), ORF2110 (597bp) and *prs* (370bp). Out of 11 isolates, 9 were positive for ORF2819 (471bp) gene indicating group3, 3 were positive for *lmo*0737 (691bp) indicating group1. All the isolates were positive for *prs* (370bp) gene (Fig 5).

Fig 5. PCR amplification of serovars specific genes of *L. monocytogenes* strains to separate into deferent groups. Lane 1-6: positive for *prs* gene, Lane 7-11 for ORF2819, Lane 12-14 for *lmo*0737 and Lane M: 100bp marker

Collibacillosis in poultry: Four shiga toxin genes (st*x*1) positive *E. coli* strains were isolated from the five intestinal samples collected during the post mortem of quails and turkey birds (Fig 6). A total of 50 rectal swabs of quails and turkey birds were collected for regular screening of *E. coli*. Out

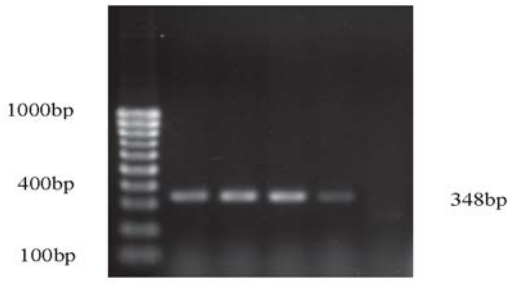


Fig 6. PCR based detection of *stx1* gene (348bp) in *E. coli* isolated from poultry. Lane M: 100bp Marker; Lane 1-4: suspected organisms; Lane 5: Negative control

of these samples, 9 *E. coli* were isolated but the isolates were negative for toxin genes. The *E. coli* isolated from quails were sensitive to ceftriaxone, co-trimoxazole, gentamycin, neomycin, tetracycline and chloramphenicol. The isolates from turkey were sensitive to ceftriaxone, gentamicin, chloramphenicol and amikacin.

Mastitis in dairy cattle: Sixty milk samples were collected from suspected cases of mastitis in cow and subjected for bacteriological examination. Three *S. agalactiae* were isolated from these samples, and confirmed by biochemical and CAMP test (Fig 7 & 8). Antibiogram studies revealed for highest sensitive to cefotaxime, ofloxacin and cephaloridine followed by cloxacillin, ceftriaxone, amoxicillin, colistin and sulphadiazine and resistant against penicillin, streptomycin, ampicillin, cefazolin and polymyxin. The cases were treated accordingly and guidelines were given for most effective treatment. *S. agalactiae* is gram positive cocci which inhibits ducts and cisterns of the gland. It causes an inflammation which blocks the ducts, leading to decreased milk production, increased somatic cell count, and eventually to involution. *S. agalactiae* is associated with contagious mastitis.

Fig 7. *Streptococcus agalactiae*, gram-positive cocci in chains, isolated from mastitic milk of cow

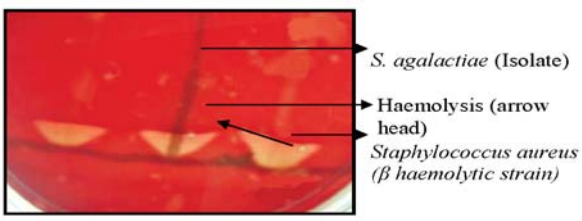


Fig 8. CAMP test for *Streptococcus agalactiae* on 5% sheep blood agar

Characterization of *Pasteurella multocida* isolates from pigs

Thirteen samples (7 lung tissue & 6 nasal swabs) were collected from pigs showing respiratory symptoms in two organized farms. Out of these, *P. multocida* was isolated from 5 lung tissue samples and 1 nasal swab sample. The isolates were confirmed based on cultural, morphological, biochemical tests and PCR based detection of *P. multocida* specific KMT1 gene and identified as serotype D by detection of *dcbF* gene. Genomic DNA extracted from *P. multocida* isolates were digested with H*ha*I and H*pa*II restriction enzymes for strain differentiation studies. Here, REA using H*pa*II enzyme revealed 4 distinct patterns in isolate 1 and 4, whereas, isolates 2 and 3 resulted in 2 RE profile (Fig 9). The entire distinct banding patterns were in the range of 21-1.9kb. Unlike, H*pa*II, REA using H*ha*I revealed almost same banding pattern in all the 4 isolates examined but the RE profile was entirely different from that of H*pa*II and undistinguishable (Fig 10).

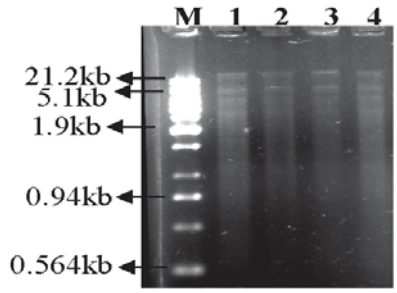


Fig 9. REA profile of serogroup D *P. multocida* isolates using H*pa*II. Lane M: marker (λ DNA/EcoRI + Hind III digest); Lane 1-4: Serogroup D *P. multocida*

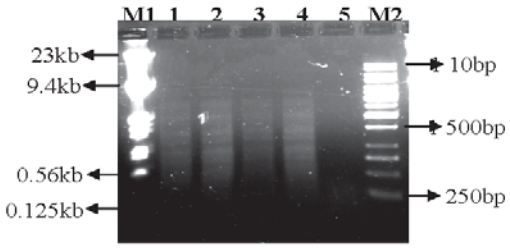


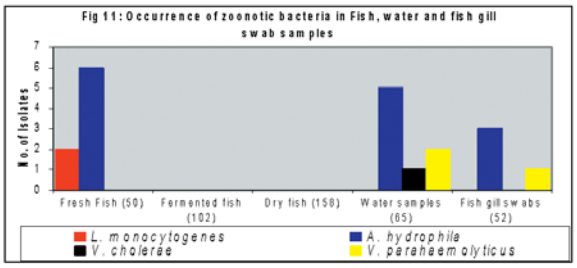
Fig 10. REA profile of serogroups D *P. multocida* isolates using H*ha*I. Lane M1: (λ DNA/EcoRI + Hind III digest) Marker; Lane M2: 1kb DNA Marker; Lane 1-4: Serogroup D *P. multocida* isolates; Lane 5: Negative control

Screening of cattle serum samples for Brucellosis and IBR

A total of 462 cattle serum samples collected from Manipur were screened for Brucellosis and IBR by employing the ELISA kit. Out of these samples, 50 (10.8%) were found to be positive for Brucellosis and 104 (22.5%) for IBR.

Occurrence of zoonotic organism in foods of animal origin

A total of 427 samples comprising 310 fish, 65 water and 52 fish gill swab samples were collected from different parts of NE region and were screened for the presence of food-borne bacterial pathogens. Two *L. monocytogenes*, fourteen *A. hydrophila*, one *V. cholerae* and three *V. parahaemolyticus* were isolated from these samples (Fig 11). The *L. monocytogenes* isolates were resistant to metronidazole (4mcg) and showed varying sensitivity pattern to ciprofloxacin (5mcg), chloramphenicol (30mcg) and ampicillin (10mcg). All the 14 *A. hydrophila* isolates were resistant to Ampicillin (10mcg), Cloxacillin (10mcg) and Amoxycillin (10mcg). Plasmid profile of the *A. hydrophila* isolate revealed six different plasmid types (approx. size 2-23kb, 23kb plasmid common in all the isolates).



RAPD Analysis of *A. hydrophila*: Random primers of OPH series, OPH-1 was found to produce the most reproducible and scorable amplicon profiles in *A. hydrophila*. OPH-1 primer revealed 4 banding profiles ranging between 250-1750bp (Fig12).

Pulse field gel electrophoresis study of *Campylobcater jejuni* isolates

Fifty *Campylobacter jejuni* isolated from chicken intestines (175) were analyzed for strain differentiation of the isolates. Pulse field gel electrophoresis using two enzymes; *sam*I and *kpn*I was performed. Restriction digest of the whole DNA showed the variation in the strain of *Campylobacter*. Isolates showed different restriction digest pattern. Four different type of restriction pattern were observed using *sma*I enzyme and five different restriction patterns were observed using *kpn*I enzyme showing the strain variation among *Campylobcater jejuni*.

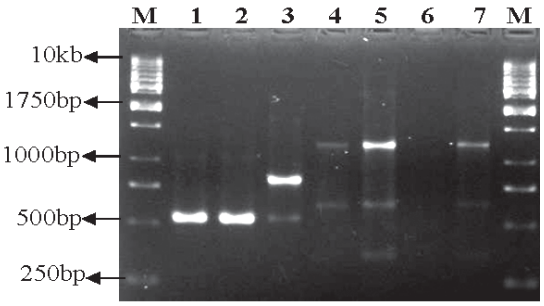


Fig 12. RAPD profile of *A. hydrophila* isolates with primer OPH-1. Lane M: 1kb molecular marker; Lanes (1-7): *A. hydrophila* isolates from fish

ANIMAL NUTRITION

Feeds and fodder

Quantification of fodder bio-mass under hot, humid and high rainfall condition for ruminant feeding

Fodder production under cultivable low land

From the 8 years old Parari plants (2500 plant density per ha), average yield of leaf fodder @ 16±1.73kg per plant with 22.40% DM was recorded. The additional fodder yield of 83.75 t/ha with 15.70% DM in two cuttings was obtained from native grass which was grown between the parari plants. From four cuttings of improved varieties of perennial grasses viz. Congo signal, Napier, Hamil and Guinea, average cumulative fodder yield (75 t/ha) and average DM content (18.94%) were recorded.

Fodder yield from up land terraced area

Soybean (cv. MOUS-98-2), rice bean (cv. RCRB-10) and sun hemp (*Crotalaria tetragona* L.) were grown as annual legumes where as maize as annual cereal fodder in Kharif season. At 60 days fodder yields were 19.37, 23.13, 15.00 and 51.25 t/ha from soybean, rice, sun hemp and maize respectively. Additional bio-mass yield as fodder (22.50 t/ha) at 145 days from sun hemp and soybean grain (2.22 t/ha) at 140 days were recorded.

Legume fodder production under tree

Total fodder yield of 41.23 t/ha in 3 cuttings with average 24.50 percent DM content was recorded from the perennial groundnut of which rhizomes were transplanted 8 years back in the shed under the tree in cultivable low land.

Quantification of available bio-mass for swine feeding

Banana pseudo stem, sweet potato vine with leaves and tuber, alocacia stem with leaves, cho-cho *(Sechium edule)* tender leaves, fruit and tuber, pumpkin tender leaves and fruits as well as other locally available herbs were generally included as feed in swine ration by the farmers of north-eastern region. Therefore, a study was made to quantify the availability of these feeds for swine feeding. One cho-cho plant yielded 125kg fruit, 9kg tuber and 75kg tender leaves. Total 22 tubers were found from one plant and diameter and length varied from 6-22cm and 23-32cm, respectively (Fig 1). Similarly, one banana plant having a height of 2m yielded 14 kg edible pseudo stem. The forage yield from

Fig 1. Cho-cho tubers

alocacia stem with leaves was recorded 95 t/ha with planting density of 20,000 plants/ha. Sweet potato vine with leave forage yield was recorded 37.5 t/ha when one cutting of forage taken during 90-100 days from transplanting. In addition to this, tuber yield at 145 days was recorded 23.9 t/ha. The nutrient composition revealed that most of feeds were low in DM but good to rich in protein and minerals contents (Table 1). Therefore, considering yield potential of these feeds, it is recommended for vertical and horizontal expansion to grow in large scale and evaluation in swine ration for resource based feeding.

Resource based feeding management of crossbred dairy animals

In the existing experimental dairy unit of animal nutrition division, 13 lactating crossbred (HF) cows with average 423 kg BW, maintained on 1.0 ha

Table 1. Nutrient composition of locally available swine feeds

Feeds	DM (%)	Nutrient (g/100g DM)						GE (cal/g)
		CP	CF	EE	TA	Ca	P	
Banana pseudo stem	4.63	9.93	21.30	1.16	17.59	0.70	0.26	3375
Sweet potato vine & leaves	9.50	15.64	18.45	2.42	14.69	1.03	0.27	3834
Sweet potato tuber cv. Sankar	29.10	5.77	3.68	1.65	4.20	0.63	0.18	3865
Sweet potato tuber cv. K. Red	29.91	3.85	3.98	1.41	2.57	0.44	0.12	3933
Alocacia stem & leave	8.83	10.24	15.45	3.15	16.95	1.40	0.29	3619
Cho-cho fruit	8.65	15.14	8.50	0.76	6.28	0.50	0.34	4008
Cho-cho tuber	21.71	14.12	5.80	0.20	6.25	0.48	0.38	3934
Cho-cho tender leaves	9.78	22.57	11.70	3.03	13.44	1.30	0.74	4020
Pumpkin tender leave	9.60	27.13	13.17	2.23	12.87	1.29	0.69	4007

fodder production area, were evaluated for their economics of feeding for the year 2009-10. Out of total fodder production area, improved perennial grasses and annual fodder crops were grown in 0.7 and 0.3 ha respectively. A total 54.6 t green fodder was produced during the period of 210 days, when forages remained available. Another quantity of 15.5 t of paddy straw to meet the requirement during lean period and 24.5 t concentrate feeds were procured from outside. The productive performance and economics of feeding is given the Table 2.The present study revealed that maintaining 13 crossbred lactating cows on 1.0 ha cultivated land with procurement of concentrate and dry fodder is economical and same in the sub tropical climatic conditions of NEH region may be remunerative.

Table 2. Productive performance and economics of herd comprising of crossbred cows

Attributes	Value
Herd performance	
No of cows	13
Average BW (kg)	413
Average number of cows in lactation	8.08
Average milk yield (l/d/head)	8.38
Total milk production of herd (l)	**24,765**
Expenditure on Inputs (Rs)	
Concentrate feed (24.5 t @Rs14.54/kg)	356230
Paddy straw (15.5 t @ Rs 2000/t)	31000
Total Expenditure (Rs)	**387230**
Earnings from the out put (Rs)	
Milk (@Rs20/l)	495300
Farm yard manure, 33.21 t (Produced @ 7kg/d/head with 50% DM, sold @Rs 1000/t)	33210
Calves (8 nos @ Rs 1900/ head)	15200
Sale of empty bags	500
Total earning	**544210**
Gross profit (Rs) for the year 2009-10	**156980**

Goat nutrition

Study was made to evaluate the nutritive value of five promising forages viz. soybean, sun hemp, native grasses, broom and parari leaves in Assam local goats through digestion trail (Fig 2).

The nutrient composition of these forages is given in Table 3. The sun hemp (T1) or soybean (T2) forage was offered to goats in the morning and available native grasses in the evening in *ad-libitum* and compared with goats received only native grasses (T3), broom leaves (T4) or parari leaves (T5).

Fig 2. Production and feeding of sun hemp to goat

Table 3. Nutrient composition in selected forages

Particulars	DM (%)	Nutrient (g/100g DM)				
		CP	CF	TA	Ca	P
Soybean	24.71	19.60	19.40	6.11	1.06	0.22
Sun hemp	16.21	21.30	22.49	6.28	1.18	0.36
Native grass	16.79	8.67	28.52	9.63	0.74	0.16
Broom leave	31.88	8.46	31.41	8.39	0.48	0.10
Parari leave	22.40	9.23	21.86	10.14	0.67	0.15

The intake and digestibility of nutrients from forages are given in Table 4. The results indicated that supplementation of soybean to native grasses significantly increased DM intake, digestibility of

CP, Ca and P, digestible crude protein (DCP) and digestible energy (DE) value of the ration. Goat consumed 58.35±2.06 percent DM from soybean. Similarly, the impact of supplementation of sun hemp to native grasses was obtained for improved P digestibility, DCP and DE only since low intake of DM from sun hemp (21.75±2.36 percent). Amongst the broom and parari leaves that were fed to goats alone, DM intake was at par to group T2; however, the overall nutrients digestibility was low. But the DCP and DE value of parari forage was equivalent to native grasses supplemented with sun hemp. Thus, it is concluded that nutritive value of native grasses can be improved through supplementation of soybean as well as parari can also be used as sole forages for goats during winter season.

Dairy cattle nutrition

To find out the effect of feeding complete feed blocks (CFB) having 1:1 roughage to concentrate ratio, an investigation was carried out in the crossbred HF lactating dairy cattle (Fig 3). Roughage portion was comprised of paddy straw alone while the concentrate having estimated 16% DCP and 70% TDN was comprised of maize-25 parts, wheat bran-16 parts, rice polish-16 parts, groundnut cake-18 parts, mustard oil cake-12 parts, molasses-10 parts, mineral mixture-2 parts and common salt-1 part.

In a switch over design, three groups of two animals each were randomly given different treatments. Control group was given intact paddy straw and concentrate separately (T1), while other groups were given CFB comprised of chopped (T2) and ground (T3) paddy straw. Apart from above all the animals were given 3 kg mixed grass fodder. Complete investigation was extended for 3 observation periods and each period lasted for 21 day preliminary feeding followed by digestion trial

Fig 3. Preparation and feeding of complete feed blocks to dairy cattle

Table 4. Intake and digestibility of nutrients in goats fed on various forages

Particulars	Treatments					SEM±
	T1	T2	T3	T4	T5	
DMI (kg/100kg BW)	2.15^{ab}	2.49^{abc}	1.94^{a}	2.55^{bc}	2.76^{c}	0.56*
DMI (g/kg $BW^{0.75}$)	39.89^{a}	52.94^{bc}	41.45^{ab}	56.74^{c}	56.84^{c}	12.57**
DMD (%)	64.82^{b}	61.55^{b}	61.70^{b}	49.74^{a}	62.82^{b}	6.18**
CPD (%)	60.27^{b}	66.49^{b}	46.17^{a}	40.12^{a}	62.95^{b}	7.05**
CFD (%)	62.41^{c}	54.93^{b}	61.66^{c}	56.39^{bc}	45.22^{a}	6.07**
CaD (%)	52.81^{cd}	58.37^{d}	48.33^{bc}	43.61^{ab}	41.24^{a}	6.17**
PD (%)	49.38^{c}	55.45^{d}	39.20^{a}	41.05^{ab}	46.60^{bc}	5.62**
DCP (%)	6.25^{b}	10.38^{c}	4.04^{a}	3.40^{a}	5.81^{b}	1.27**
DE (Kcal/kg)	2450^{b}	2422^{b}	2314^{b}	1958^{a}	2292^{b}	252**

*Significant at 5%; **Significant at 1%

of 7 days plus 3 days of sampling for rumen fermentation study. The results (Table 5) indicated an increase in the daily average milk production and intake of DM with concurrent reduction in the digestibility of nutrients.

Table 5. Effect of feeding paddy straw based compound feed blocks on average DMI, nutrient digestibility, rumen parameters and milk production in crossbred lactating cows

Attributes	T1	T2	T3
BW (kg)	386.5	378.0	383.5
DMI (kg/d)	9.15	9.46	9.88
Digestibility (%) of nutrients			
DM	61.15	60.07	58.13
CP	65.24	63.58	60.84
CF	62.07	60.16	58.92
EE	61.28	60.76	59.74
Rumen pH	6.85	6.94	6.88
TVFA (meq/dl SRL)	14.82	15.67	15.93
NH_3-N(mg/dl SRL)	11.91	12.83	13.02
Milk Yield (kg/d)	8.94	9.64	10.03

Development of probiotics for livestock and poultry

Isolation and *in vitro* probiotic evaluation of bacterial isolates was carried out during the period under report. Seventy two fecal samples from cattle (31), goats (14), swine (10) and birds (17) were used for isolation of bacterial strains by lactobacillus selective culture technique. The samples were suspended in the phosphate buffer (pH 6.8). MRS agar plates were inoculated with 100ul aliquot of each suspension and incubation was carried out under anaerobic conditions for 72 hr at 37°C. Circular and creamy-white colonies (total 161) were picked up and grown overnight in MRS broth.

To maintain their purity, a loop full of individual culture was again inoculated on MRS agar plates and single colony was multiplied in MRS broth. So far 85 fast multiplying isolates were tested for gram reaction, shape, catalase reaction, pH and ox bile tolerance (Table 6). It may be concluded that the isolates which tolerated the acidic pH (<3) and higher (>1.0 %) bile concentration can be potential probiotic bacterial strains. After performing few more tests and biochemical characterization, these can be tested in vivo.

Table 6. General description and, pH and bile salt tolerance of selected bacterial isolates for development of probiotics

Attributes	No. of isolates survived or otherwise indicated
Gram's reaction	85, positive
Cell shape	85, rod shaped
Catalase reaction	85, negative
pH Tolerance for 2 h at	
8.0	85
4.0	67
3.0	48
2.0	11
1.5	02
Bile tolerance for 2 h at concentration (%)	
0.1	85
0.5	69
1.0	42
2.0	15

Pig nutrition and feeding

Performance of CB pigs during grower stage of growth fed on different levels of rice polish with phytase enzyme

A feeding experiment for the period of 118 days was conducted on CB (Hampshire x Khasi local) castrated male piglets (12; 9.73±0.44kg BW; 75±5 days old) having 75% exotic inheritance to study the growth performance and nutrient digestibility on rice polish based feeding regime supplemented with phytase enzyme. Two test diets were prepared by incorporating rice polish (70%) and supplemented with phytonex @ 20 and 40g/100kg feed, respectively to provide phytase activity in the respective diets to the level of 1.00 (T2) and 2.00 (T3) lacs FTU per 100kg feed and compared to diet (T1) having rice polish 50% supplemented with phytonex @ 20g/100kg feed. All diets were made isonitrogenous (CP 17.3%) with the help of soy meal and fish meal. The uniform calcium and total phosphorus levels in diets were maintained with the help of lime and supplivite-M. These rations were offered in weighed quantity, one half in the morning and another half in the evening. At the end of feeding experiment, a digestion trial for the period of 5 days was conducted and the resultant data are presented in Table 7.

Table 7. Growth performance and nutrient digestibility in CB pigs fed on rice polish

Particulars	Treatments			SEM±
	T1	T2	T3	
ADG (g/d)	452[b]	394[a]	423[ab]	10.94*
FCR	2.97[a]	3.34[b]	3.11[ab]	0.08*
DMD (%)	76.84[b]	72.93[a]	73.91[a]	0.74*
CPD (%)	77.89[b]	69.99[a]	71.37[a]	0.77**
PD (%)	54.01[ab]	51.53[a]	55.25[b]	0.64**
DE (Kcal/kg)	3105[b]	2856[a]	2894[a]	17.74**
Feed cost/kg gain (Rs)	36.91	38.97	36.36	0.98

Different superscripts in a row differ significantly (P<0.01)** / (P<0.05)*

The DM and protein digestibility and digestible energy (DE) value of ration decreased significantly (P<0.01) in pigs fed on diets having 70% rice polish irrespective of level of phytase enzyme supplementation. In contrary to this, significantly (P<0.01) highest phosphorus (P) digestibility was recorded in pigs fed rice polish at 70% level with phytase enzyme at 40g/100kg feed (T3) and it was at par to diet T1 and thus, it resulted into similar daily growth rate, FCR and feed cost per kg body weight gain in pigs fed on either 50 or 70 percents rice polish with phytase @ 20 or 40g/100kg feed, respectively. Hence, it is concluded that two lac unit of phytase enzyme per 100kg feed based on 70 percent good quality rice polish was sufficient for proper utilization of P that resultant into better growth performance.

Performance of CB pigs during finisher stage of growth fed on sweet potato tuber based ration

A feeding experiment for the period of 30 days was conducted on CB castrated pigs (8; 62.29±0.92kg BW; 190±5 days old) to study the growth performance and nutrient digestibility. Total 3 isonitrogenous diets (CP 14%) were prepared by including rice polish 50% (T1) as control and two test diets by incorporating sweet potato tuber at 50 (T2) and 70 (T3) percent levels, respectively on DM basis. The sweet potato tubers were harvested, washed, chopped and boiled before mixing in the ration. The weighed quantity of feed was offered twice, half in the morning and other half in the evening. At end to study the nutrient digestibility, a digestion trial for the period of 5 days was conducted. One pig from each group having nearer to average group weight (78.67±1.86kg) was slaughtered to measure the back fat thickness.

The results revealed (Table 8) that the digestibility of DM, P and DE values increased significantly (P<0.01) of the ration as the level of sweet potato tuber increased. However, protein digestibility was not affected due to sweet potato tuber incorporation in the ration and thus resulted into similar growth rate and back fat thickness. The FCR widened as the level of sweet potato tuber increased in the ration and it might be due to more CF (3.72%) and TA (13.46%) contents in the ration T3 than respective values (3.57 and 7.38%) in the ration T1. It is concluded that sweet potato tubers may be utilized as locally available resource for swine feeding and fed to the level of 70% of total DM intake at finisher stage of growth.

Table 8. Growth performance and nutrient digestibility in pigs fed on sweet potato tuber

Particulars	Treatments			SEM±
	T1	T2	T3	
ADG (g/d)	661	625	612	17.17
FCR	3.41[a]	3.85[ab]	4.08[b]	0.11**
DMD (%)	77.82[a]	85.91[b]	89.17[b]	0.84**
CPD (%)	70.55	74.78	75.85	2.24
PD (%)	43.41[a]	67.92[b]	75.77[c]	0.99**
DE (Kcal/kg)	3159[a]	3382[b]	3455[b]	24.91**
Back fat thickness (mm)	18.50	17.50	19.50	0.96

Performance of pigs during finisher stage fed on rice polish with available herbs

A preliminary experiment was conducted for the period of 30 days (4; 61.50±1.75kg BW) to study the feasibility of utilization of locally available herbs in swine ration during finisher stage. Control diet (T1) was prepared by including rice polish 90 parts and soy meal and additive 10 parts. Locally available herbs like cho-cho fruit, banana pseudo stem, alocacia stem with leave and sweet potato vine with leave were collected daily, chopped and mixed in the ratio at 17, 25,33 and 25 percent, respectively and cooked with water (3:1 w/v) for almost 1.5 to 2.0 hours before mixing in concentrate feed (Fig 4). These cooked herbs were incorporated in the control ration to replaced rice polish at 20% level.

Fig 4. Feeding to pig on locally available herbs

Both the diets were made isonitrogenous (CP 14%). The weighed quantity of feed was offered, one half in morning and other half in evening.

The results revealed (Table 9) that the digestibility of CP and P increased in the ration containing locally available herbs but digestible energy (DE) value of the ration decreased significantly that resulted into less growth rate per day. The poor growth rate in pigs fed on locally available herbs with higher DM intake widened FCR value of the ration. It is concluded that more in depth study will be needed for any conclusion.

Table 9. Performance of pigs fed on locally available herbs

Particulars	Treatments		SE ±
	T 1	T 2	
ADG (g/d)	452	336	27.40*
DMI (g/d)	1967	2162	234
FCR	4.33	6.45	0.49*
DMD (%)	69.03	67.46	1.09
CPD (%)	60.05	72.36	2.40*
PD (%)	26.04	34.20	1.44*
DE (Kcal/kg)	3469	3032	38.32**

Economics of CB pig production on rice polish based feeding regime and nutrients dynamics

The data of feeding experiments conducted on rice polish based ration at various stages of growth in CB pigs were pooled to calculate the cumulative growth performances with nutrients dynamics. The dietary protein level was maintained 16 (10 -60 kg body weight range) and 14 (60 kg onwards body weight range) percent with uniform 3000Kcal digestible energy value that costing Rs. 12.44/kg and Rs. 10.83/kg, respectively. The compound mash ration was provided *ad libitum* two times (morning and evening). The performance of CB pigs at various stages of growth is presented in Table 10 and Fig 5. The CB pig gained 72.16 and 136.50 kg body weight in 160 and 300 days, respectively. The dynamics of nutrients was also calculated and values are presented in Table 11. Generally pig excreted N, P and Ca through manure to the extent of 33.8, 71.4 and 38.2 percents, respectively. However, 10 CB pigs in 300 days will provide 5.55tone dry manure, which will equivalent to 105 kg urea, 77 kg P_2O_5, 25 kg K_2O and 63 kg lime.

Table 10. Performance of CB pigs fed on rice polish based ration

Body wt. range (kg)	Duration (d)	Feed intake on room temp. (g/d)	Growth rate (g/d)	FCR	Feed cost / kg gain in BW (Rs)
10 -20	40	620	266	2.33	28.99
20 – 30	30	1160	405	2.86	35.58
30 -60	60	1705	518	3.29	40.93
60 -80	30	2500	610	4.10	51.00
80 – 145*	140	3000	460	6.52	70.61
Cum. average	300	2190	455	4.81	54.71

* Calculated values

Table 11. Nutrients dynamics in CB pig

Particulars	Duration	
	160 days	300 days
Intake		
DM (kg)	213.12	591.30
N (kg)	5.46	13.92
P (kg)	1.71	4.73
Ca (kg)	1.92	5.32
Out-go		
Fresh Manure (kg)	205	555
Dry Manure (kg)	61.44	166.5
N (kg)	1.78	4.83
P (kg)	1.23	3.35
Ca (kg)	0.74	2.02

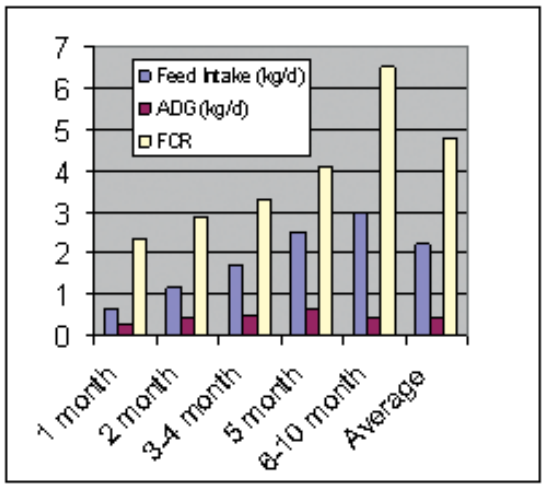


Fig 5. Performance of CB pigs fed rice polish

Performance of CB pig at farmer's house fed on rice milling by-products and available herbs with phytase

Field data was collected for the periods of 3 months from the farmer's house of Ri-Bhoi district in collaboration with KVK, Umiam to study the impact of supplementation of phytase in swine ration. Total six farmers were chosen for the study, 4 farmers with phytase and 2 farmers without phytase. Each farmer was having 2-4 pigs of about 2.5 to 3.5 months old. Farmers generally fed their pig only rice milling by-products with available herbs in cooked form. The ADG of 12.81% more recorded in pigs (203±10.67 g/d) fed with phytase @ 20g/ 100kg feed in comparison to those fed on without phytase enzyme (177±17.00g/d).

POULTRY SCIENCE

Performance of Japanese quail (*Coturnix coturnix japonica*) in Meghalaya

The fertile Japanese quail eggs (Fig 1) were procured from ICAR Research Complex, Tripura, Lembuchera and hatched out in the divisional hatchery. The fertility and hatchability of Japanese quail eggs was recorded as 40.00 percent 36.79 percent respectively on total egg set basis which was very low. The hatchability on fertile egg set basis was 91.96 percent and dead in shell was recorded as 8.03 percent. The morbidity and mortality pattern of Japanese quail chicks (Figs 2 & 3) was recorded to be very high during the first 3 weeks due to cold shock. The age at first egg was recorded as 49.17±days. The average Hen Day Egg Production (HDEP) was recorded as 36.10 percent and egg weight as 9.23±0.24 g at 12th week. The adult male and female body weight of Japanese quail were recorded as 196.50±8.69g and 224.00±5.21g respectively. The body weight and feed consumption of Japanese quail at different weeks is presented in Table 1.

Table 1. Body weight and feed consumption of Japanese quail up to 6th week

Age	Body weight (g)	Cumulative feed consumption (g)	Cumulative FCR
Day-old	8.10±0.20	-	-
1st week	20.80±0.58	42	2.02
2nd week	41.70±1.49	105	2.52
3rd week	89.50±3.42	235	2.63
4th week	132.00±3.15	370	2.80
5th week	137.50±4.21	420	3.06
6th week	151.25±4.92	555	3.67

Fig 1. Japanese quail eggs

Fig 2. Japanese quail chicks in battery brooder

Fig 3. Japanese quail layers in dip litter

Performance of Turkey (*Meleagris gallopavo*) in Meghalaya

The production performance of turkey under agro-climatic conditions of Meghalaya from sexual maturity to 72 weeks of age was studied both under intensive (deep litter) and semi-intensive system of rearing in net house (Figs 4 & 5) and the performance of turkey under semi-intensive system was found to be better. The male and female body weights of turkey at 72 weeks under semi-intensive system of rearing were recorded as 8583.33±357.99 g and 5791.67±156.41 g respectively. The egg weight at 72 weeks was recorded as 79.64±0.78 g.

Fig 4. Turkey growers under deep litter

Fig 5. Turkey layers under net house

Incidence of diseases in Japanese quail and Turkey in Meghalaya

The morbidity and mortality pattern of Japanese quail chicks and Turkey poults hatched out in the divisional hatchery were studied. There was a very high mortality rate due to cold shock.

Table 2. Antibiotic sensitivity pattern of *E. coli* isolates of Japanese quail diarrhea cases

Organism	Antibiogram study		
	Resistant	Sensitive	Less sensitive
E. coli	Ceftriaxone Chloramphenicol Co-trimoxazole Gentamicin Neomycin Tetracycline	Ciprofloxacin Ofloxacin Sulphafurazole Enrofloxacin	Amoxycillin Cefazolin Oxytetracycline Cephalexin Sulphadiazine Metronidazole

Effect of herbal feed additives on the performance of broiler chicken

Feeding trials in commercial broiler chicks were conducted to study the effect of supplementation of herbal powders as feed additives on their

performance as well as serum cholesterol level. The five herbal powders supplemented with standard broiler rations at 0.5% level were *Menta arvensis, Ocium sanctum, Emblica officinalis, Azadirachta indica* and *Spilanthes paniculata.*

One hundred and eighty straight run commercial broiler chicks were randomly allotted to six dietary treatment viz. T0 (Basal diet), T1 (Basal diet plus 0.5% *Menta arvensis* powder), T2 (Basal diet plus 0.5% *Ocium sanctum* powder), T3 (Basal diet plus 0.5% *Emblica officinalis* powder), T4 (Basal diet plus 0.5% *Azadirachta indica* powder) and T5 (Basal diet plus 0.5% *Spilanthes paniculata* powder) groups with three replicates of ten chicks in each and reared on deep litter system under standard management condition up to 49 days of age (Table 3).

Significantly (P<0.05) higher body weights were recorded in *Azadirachta indica* (T_4) supplemented group at 5th and 6th weeks compared to control group (T_0). Significantly (P<0.05) higher serum cholesterol levels were also recorded in *Emblica officinalis* (T_3) and *Azadirachta indica* (T_4) supplemented groups compared to control group (T_0).

Table 3. Performance of broiler in different treatment groups

Traits	Treatment groups					
	T_0	T_1	T_2	T_3	T_4	T_5
Day-old body wt. (g)	46.30 ±0.68	46.03 ±0.69	46.10 ±0.71	45.70 ±0.74	46.00 ±0.52	46.10 ±0.63
1st week body wt.(g)	101.11 ±2.95	103.75 ±2.75	100.00 ±1.67	103.45 ±2.79	104.46 ±1.34	104.07 ±1.41
2nd week body wt.(g)	249.62 ±8.63	249.63 ±9.15	250.00 ±9.13	249.83 ±8.60	259.63 ±6.84	256.92 ±7.33
3rd week body wt.(g)	558.65 ±13.30	557.41 ±10.44	559.26 ±9.23	558.93 ±11.57	583.52 ±7.31	554.23 ±9.29
4th week body wt.(g)	874.81 ±21.66	863.70 ±22.21	873.52 ±18.82	875.00 ±19.90	942.88 ±18.88	862.12 ±19.54
5th week body wt.(g)	1375.96^{bc} ±21.42	1383.33^{bc} ±22.80	1415.19^{bc} ±29.47	1346.43^{c} ±23.70	1527.69 ^{a}±28.94	1457.69^{ab} ±29.70
6th week body wt.(g)	1826.92^{a} ±22.40	1925.93 ^{a} ±27.40	1935.19 ^{a} ±20.12	1876.79 ^{a} ±33.38	1955.00^{b} ±30.39	1935.39 ^{a} ±43.50
7th week body wt. (g)	2276.92 ±30.28	2424.07 ±42.56	2287.22 ±20.92	2310.00 ±50.29	2292.31 ±46.38	2420.00 ±48.00
Cumulative FCR	2.09 ±0.06	2.06 ±0.07	2.10 ±0.06	1.96 ±0.03	2.13 ±0.12	2.01 ±0.04
Mortality (%)	13.33 ±3.33	10.00 ±5.78	10.00 ±5.78	6.67 ±6.67	13.33 ±6.67	13.33 ±3.33
Serum cholesterol (mg/dl)	183.83^{a} ±14.88	173.33^{ab} ±15.20	153.50^{ab} ±16.27	122.33^{b} ±9.90	128.67^{b} ±9.96	168.17^{ab} ±12.99

Means with at least one common superscript in a row do not differ significantly (P<0.05)

VETERINARY PARASITOLOGY

Goat

Studies on gastrointestinal parasitism by examination of faecal samples

A total of 268 faecal samples of goats were screened to detect gastrointestinal parasitic infections. Out of these, 132 (49.25%) faecal samples of goats were found positive for gastrointestinal parasitic infections. Strongyle sp. (53.03%), (11.36%), *Strongyloides* sp. (9.09%), *Moniezia* sp. (0.75%) and *Eimeria* sp. were detected in faecal samples of goats. Mixed infections with Strongyle sp., *Strongyloides* sp., *Eimeria* sp. and *Moniezia* sp. were detected in 25% goats.

Studies on gastrointestinal parasitism by post mortem examination

A total of 213 gastrointestinal tracts of goats were examined and 138 (64.78%) goats were found positive for gastrointestinal parasitic infections. The presence of *Haemonchus* sp. (56.52%), *Oesophagostum* sp. (55.07%), *Trichuris* sp.(19.56%), *Bunostomum sp.* (3.62%) and *Moniezia* sp.(2.89%) were identified from these G.I. tracts.

Pig

Studies on gastrointestinal parasitism

To find out the prevalence of gastrointestinal parasitism in pigs, faecal samples of 432 pigs were collected from organized and traditionally managed pig farms and examined for the presence of gastrointestinal parasitic infection using modified McMaster technique. The prevalence of gastrointestinal parasitic infection was recorded as 20.62% and 48.94% in organized and traditionally managed pig farms, respectively. The pattern of infection was either single (85.27%) or mixed (17.05%) infection with a faecal egg count range 50 to 12,300 eggs per gram of faeces (EPG). Among the helminthes Strongyle spp. were predominant (40.31%) followed by *Ascaris suum* (20.93%) (Fig 1), *Strongyloides* sp. (3.10%) and *Trichuris suis* (1.55 %). Besides helminth, *Eimeria porci* infections were recorded in 19.38% animals.

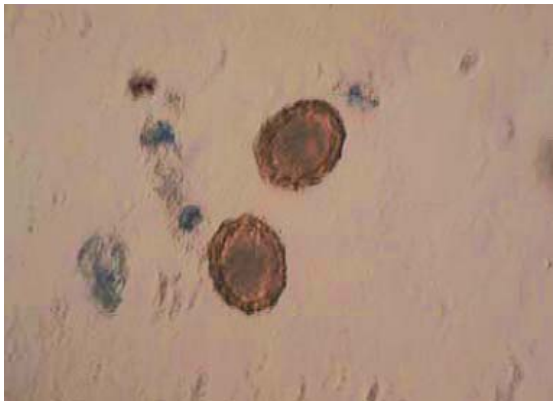


Fig 1. Eggs of *Ascaris suum*

Studies on Sarcoptic mange

Skin scrapings collected from pigs of Mawphlang village, Ri-Bhoi District, were screened to detect mange infestaion and *Sarcoptes scabiei* var. *suis* detected from the pigs of village also.

Cattle

Studies on gastrointestinal parasitism

In all, 248 faecal samples of cattle were examined for presence of parasitic infection. 22.98% were found to be positive for parasitic infection. Strongyle sp. (52.63%), *Moniezia* sp. (21.05%), Coccidia (10.53%) and *Strongyloides* sp. (7.02%) were detected from these faecal samples.

Studies on Haemoprotozoan infections

A total of 48 blood samples were collected from slaughtered house and organized cattle farms of Meghalaya. These blood samples were screened for detection of haemoprotozoan infections by examination of Giemsa stained blood smears and polymerase chain reaction. For detection of *Trypanosoma evansi* infection, mini anion exchange centrifugation technique was used. All blood samples were found negative for haemoprotozoan infections after examination of Giemsa stained blood smears and mini anion exchange centrifugation technique. Three blood samples of cattle, out of 29 collected from slaughter house were found positive for *Theileria* sp. and *Babesia* sp. infection after PCR (Fig 2).

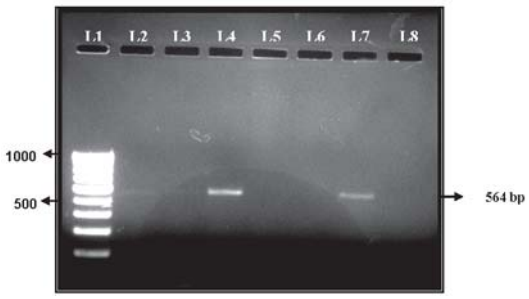


Fig 2. Electrophoresis gel (1.5% agarose stained with ethidium bromide), showing lanes from left to right L1- 100 bp DNA ladder; L4 & L7- Positve for haemoprotozoan infection ; L2, L3, L5, L6 & L8- Negative for haemoprotozoan infection

Rabbit

A total of 140 faecal samples of rabbit were screened to detect parasitic infections. Out of these, 59.29% found positive for coccidial infection. Oocyst per gram (OPG) of faeces ranged from 50-12,450.

Poultry

A total of 32 faecal samples of poultry were screened to detect parasitic infections. Out of these, 28.13% found positive for coccidial infection. Ectoparasitic infestation with *Dermanyssus gallinae* (Fig 3), red mite of poultry was also detected in 100 *Gallus domesticus* birds of about 18 weeks of age. These mites are not only haematophagus but also causes loss of production and act as a potential vector of pathogens responsible for fowl spirochaetosis, chicken pox and encephalitis.

Fig 3. *Dermanyssus gallinae* (red mite of poultry)

Turkey and Quail

Faecal samples of 25 numbers of turkeys and 100 numbers of quails were screened for four months regularly using saturated sucrose floatation technique for presence of any parasitic infection and detected *Ascaridia galli* and *Capillaria* sp. in turkeys and only *Ascaridia galli* in quails.

FISHERIES

Growth performance of gold fish, *Carassius auratus* in aquarium and cage

The growth performance of 72 days old hatchlings were evaluated under cage culture and conventional aquarium conditions. The low-cost cage (L: 2.84´B: 1.13´H: 1.07 mt) was fabricated with bamboo and nylon net. The cage was placed submerged inside a pond (Fig 1). Fishes with initial mean body weight of 0.52±0.18g and mean body length of 3.19±0.58cm were stocked in the cage. On the other hand, fishes with initial mean body weight of 0.02±0.17g and mean body length of 2.17±0.71cm were earlier stocked in aquarium. The fishes in cage were allowed to feed on natural foods only, whereas in aquarium, fishes were partially supplemented with rice polish along with the natural foods (planktons). Samplings were done on 35 and 70 days from the beginning of trial. The study observed that, gold fish reared in cages attained better growth rate and developed bright coloration faster than (Fig 2) the aquarium-reared ones. The details of growth attainment after 70 days of rearing are presented in Table 1.

Fig 1. View of cage

Fig 2. Gold fish from cage

Table 1. Changes in growth parameters of Gold fish reared in cage and aquarium for 70 days

Rearing system	Weight parameters				Length parameters			
	Absolute Growth (g)±SD	Growth Increment (g/fish/day)	Specific Growth Rate (%)	Total Weight Gain (g/fish)	Absolute Length (cm)±SD	Length Increment (cm/fish/day)	Specific Length Rate (%)	Total Length Gain (cm/fish)
Cage	2.57±2.07	0.04	0.03	4.96	1.9±0.9	0.03	0.01	0.6
Aquarium	0.68±0.12	0.01	0.06	0.68	1.4±0.4	0.02	0.007	0.06

Kinetic of enzyme alkaline phosphatase in endangered Chocolate mahseer *N. hexagonolepis* and its nutritional status

The enzyme alkaline phosphatase is widely distributed in nature and is characterized by a high pH in the ecosystem. The physiological role of alkaline phosphatase remains uncertain except for a role in bone mineralization and as stress indicator. In the present study, attempt was made to assess the activity of alkaline phosphatase in different organs of Chocolate mahseer (Fig 3) and its significance in counteracting stress due to captivity or confinement.

Fig 3. Endangered Chocolate mahseer, *N. hexagonolepis*

Further, the study also investigated the nutritional profile of Chocolate mahseer, which is considered as an endangered species. The study revealed that, the activity of alkaline phosphatase is more in kidney followed by liver, intestine and muscle (Fig 4). The increased activity in kidney may be due to the fact that, the phosphatase are very important for regulation of various metabolic process that occurs by phosphorylation and dephosphorylation with kinase, especially during stress condition to meet the energy requirement in the animal. Further, the Chocolate mahseer is found to be rich in crude protein, calcium and phosphorus (Table 2).

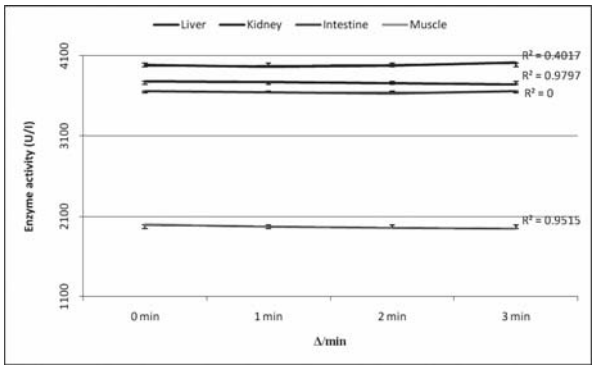


Fig 4. Activities of Alkaline phosphatise in different organs of Chocolate mahseer. Means with a common asterisks significantly differ ($P<0.05$)

Table 2. Nutritional profile of Chocolate mahseer, *N. hexagonolepis*

Nutritional parameters	Percentage
Crude Protein	76.78
Ether Extract	06.48
Dry Matters	31.89
Crude Fibre	00.35
Total Ash	07.50
Calcium	01.03
Phosphorus	01.95
Cholesterol	170 mg/dl

Study on pathogenic fungi in fish culture ponds located at mid-hill altitude

For fungal disease characterization, live infected fish (Indian major carps; n= 10 per species) were randomly collected from farm complex of ICAR Complex, Barapani during 2009-2010. Samples from each infected pond were collected after 2, 6, 10 and 20 weeks from the onset of disease. The cotton-wool appeared on the body surface of fishes (Fig 5) were removed by sterile incubating loop and

Fig 5. Diseased fish recovered from a culture pond

incubated in Sabauravd's dextrose agar plates and store at 22-30°C for 5-10 days inside incubator. The plates were observed everyday at 1000Hrs for growth (Fig 6). For identification of fungus, the cultures were subjected to Lactophenol Cotton Blue stain and were examined under a microscope at magnifications between 10-100X. The microbiological test observed that, the predominant pathogen was *Saprolegnia* sp. (Fig 7). Interestingly, the occurrence of fungal pathogen was directly correlated with the lowest water temperature (8-10°C), pH (4-5) and dissolved oxygen (3-5ppm).

Fig 6. Growth of fungus on a culture plate

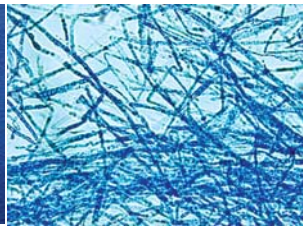


Fig 7. Fungus identified as *Saprolegnia* under microscope

Nutritional profiling of commercially important food fishes

The fishes are the cheap source of easily digestible protein. In north eastern hills, majority of the population are non-vegetarians and prefer fish or meat in every diet. A database on nutritional facts of fishes that are either native to the region or introduced from other states or country will give an idea to the consumers and/or dieticians a preference to choose a fish that is nutritionally sound. With this objective, in the ongoing study, native fishes of NEH region and exotic fish species introduced in the region are screened for their nutritional status. The live fish samples were collected from various sources like lake, river, stream and ponds. Nutritional profile of some of the important cultivable fish species are presented in Fig 8.

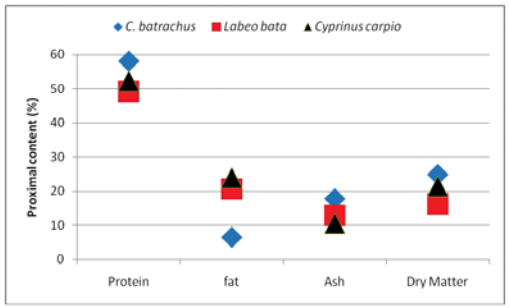


Fig 8. Nutritional profile of commercially important food fishes (in dry weight basis)

Integrated fish cum poultry farming

One station trial on fish cum poultry has been started at the farm complex of the fisheries division to evaluate the growth performance of fish without any supplementary feeding under mid altitude condition. The fishes are solely depended on the poultry droppings and natural fish food organisms produced in the pond. A combination of three indigenous carp species viz. *C. mrigala, L. gonius and L bata* species are stocked in a pond of 0.14 hectare. A low cost poultry house has been erected over the pond to rear 25 nos. of layer birds of Vanaraja variety.

Introduction of improved variety of Common carp in NEH region

Common carp is one of the ideal fish species for aquaculture and is one of the most sought after species especially in the north eastern hill states. However, the growth of the existing variety *communis* is not encouraging due to several factors. Moreover the species attain early maturity resulting in low flesh content.

The Fisheries division of the ICAR Research Complex, Umiam has recently procured a stock of both breeders and growers seeds of this new and improved variety for quality seed production and to test the performance of the variety in the NEH states. An attempt will be made to cater to the needs of the seeds of this improved variety in the NEH states.

ARUNACHAL PRADESH

Weather Report

The Centre has set up a sophisticated meteorology station with the help of IMD, Pune and acting as nodal agency to provide weather forecast for all the sixteen districts and releasing weather based agro-advice bulletin at three days interval for the crops of importance at the given time. The weather data taken at the Research Farm, Gori is presented Table 1. The total precipitation received during the year was 1962.8 mm in 108 rainy days and the maximum rainfall was received in the month of Aug (403.6 mm). No rainfall was recorded during Dec and Jan 2010. This year was a drought year for Arunachal Pradesh. Unlike other years, greater variation in temperature was recorded in this year. The minimum temperature varied from 7.6°C (Jan, 10) to 25.0°C (July, 08) while the maximum temperature ranged from 20.1°C (Feb 10) to 31.0°C (June, 09). Relative humidity was more in the morning hours than in the afternoon throughout the year.

CROP PRODUCTION

Rice

Effect of cultural management practices under low input production system for wetland rice

An experiment was laid out in 36 plots to evaluate the performance of four rice varieties (Lachit, Puja, VL-61 and VL-225) with three cultural management practices (i) One spading at the time of transplanting (CP1) (ii) Two spading-1st before 20 days of planting and other at the time of transplanting (CP2) and (iii) Puddling (CP3). All four varieties were transplanted at spacing of 25cm x 10cm in plot size of 4m x 4m.The FYM has applied @ 5t/ha at the time of field preparation and 20 kg N/ha was given at the time of panicle initiation stage. The observations were taken for growth, yield attributes, yield and weed biomass. The maximum grain yield was recorded with VL61+CP3 was 3.96 t/ha followed by VL61+CP2 (3.73 t/ha) and Puja+CP3 (3.7 t/ha).The maximum plant height 99.1 cm was recorded with Puja+CP3 followed by Puja+CP2 (95.7 cm) and Puja+CP1 (92.7 cm).The highest weed biomass was recorded with Lachit+CP1 i.e.18 kg/plot followed by Lachit+CP2 (13.16 kg/plot).

Evaluation of organic sources of nutrients supplied for rice-pea cropping system in wetland condition

A field experiment was laid out in 30 plots and size 4m x 3m with the use of organic sources for rice-pea cropping system under wetland rice cultivation at ICAR, Basar. Two varieties of rice (Luit and Vandana) and two varieties of pea (TRCP 8 and Azad P1) were evaluated with the treatment of control, green manure of tephrosia, green manure of crotolaria, green manure of weeds and farm yard manure (FYM). All the organic manures were applied @ 80 kg N/ha and the amount was

Table 1. Meteorological parameters at ICAR Research Farm, Gori for the year 2009-10

Month	Maximum temp. (°C)		Minimum temp. (°C)		Relative Humidity (%)		Rainfall (mm)	Rainy days
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon		
Apr	23.8	25.1	16.9	18.3	72.0	60.1	151.6	12
May	27.8	27.5	20.7	21.8	72.4	62.3	184.4	14
Jun	31.0	29.8	23.8	25.3	72.8	64.9	342.5	19
Jul	30.3	31.5	25.1	26.3	73.2	63.1	186.3	12
Aug	28.4	30.9	24.3	25.7	72.6	64.7	403.6	19
Sep	25.0	30.4	22.9	24.7	72.4	62.7	353.5	8
Oct	26.0	28.8	20.3	21.3	73.2	62.2	74.8	5
Nov	19.9	22.9	14.1	15.8	75.4	61.7	59.0	5
Dec	18.90	19.02	12.53	13.25	74.42	63.10	0	Nil
Jan	20.52	20.92	7.67	8.57	75.40	58.53	0	Nil
Feb	20.1	20.1	9.2	10.5	74.5	66.1	15.8	3
Mar	21.3	21.5	15.1	15.8	73.8	66.7	191.3	11
Total							1962.8	108

calculated on the basis of respective nitrogen percentage content (*Tephrosia candida*=3.57%, *Crotolaria tetragona*=3.23%, weeds=1.87% and FYM=0.52% N) to make the equivalent. All green manure crops/weeds were chopped into pieces and applied into respective plots in allotted treatment before at 15 days of transplanting and FYM also applied at the same time.

The maximum grain yield was recorded in Luit+*Tephrosia* (4.25 t/ha)-green pods of TRCP8 (2.33 t/ha) followed by Luit + Crotolaria (3.82 t/ha) green pods TRCP8 (2.3 t/ha) and vandana+ *Tephrosia* (3.8 t/ha) green pods of Azad P1 (1.87 t/ha).The lowest grain yield was obtained from vandana+weeds (3.1.0 t/ha) green pods of Azad P1 (0.9.5 t/ha). However luit+control yielded (3.03 t/ha) green pods of TRCP8 (0.93 t/ha) followed by vandana + control (2.95 t/ha) green pods of Azad P1 (0.77 t/ha).

Studies on suitable cropping sequence in Arunachal Pradesh

A field experiment with rice (var. Vandana) based crop sequence *viz*. rice-wheat (HS-240), rice-pea (Azad P1), rice-French bean (Anupama), rice-potato (K. Jyoti), rice-mustard (TS-38), rice-winter maize (PHEM-2),rice-tomato (Suraksha), rice-cabbage (Pride of India) conducted and tested for their performance with three replications in plot of 4m x 3m. Different crops and their varieties with respective fertilizer doses were applied in upland rice [5t FYM+50% RDF (60:40:40-N:P:K)], maize (120:60:40), wheat (40:30:30), pea (20:60:30), French bean (80:60:40), mustard (50:60:40), tomato (76:60:75), potato (125:120:60) and cabbage (60:60;40). The upland rice var. Vandana was sown on 6th May 2009 and harvested on 10th August, 2009 (96 days) and highest grain yield was recorded by upland rice 4.00 t/ha.

Standardization of agro-techniques for indigenous aromatic rices for enhancing the grain yield

A Field trial was conducted in split plot design in plot size 4mx3m on indigenous aromatic rice var. Kalajoha with 3 dates of sowing (i) 05/05/09 (ii) 16/05/09 (iii) 27/05/09 and 3 dates of transplanting (i) 25/6/09 (ii) 06/7/09 (iii) 17/07/09 (at 10 days intervals) and 5 nitrogen doses i.e. N1=control, N2=50%RDF, N3=100%RDF, N4=50%RDF +50%N through FYM, N5=100% through organic source (vermicompost).The recommended dose of fertilizers (RDF) were applied N:P:K 80:60:40.

Results revealed that highest grain yield (1.78 t/ha) recorded by 1st date of transplanting with 100% RDF followed by 50%RDF+50%N through FYM (1.71 t/ha). Maximum no. of panicles/sq m.(326.6) was recorded under 2nd date of transplanting with 100% RDF followed by1st date of transplanting with 100% RDF i.e.323.3.The highest panicle weight/sq m. was recorded in 1st date of sowing with 100% RDF i.e.215 g followed by 50% RDF+50% N through FYM (206.3 g). However, the highest cost of cultivation (Rs.31820/ha) was estimated in nitrogen (100%) through organic source followed by 50% RDF+50% N through FYM (Rs.25802/ha).

Mungbean

AICRP on improvement of MULLaRP crops

Seventeen varieties of spring mungbean (*Phaseolus radiatus* L.) were planted on 7th April,2009 in RBD replicated thrice in plot size 6sq.m area with planting distance 25cmx10cm for their screening and performance under Basar (mid hill) condition of Arunachal Pradesh. The highest seed yield (932 kg/ha) was recorded by SM9-165 followed by SM9-152 (870 kg/ha) and SM9-163 (859 kg/ha).The maximum days to 50% flowering was recorded 58 days in SM9-160 and minimum 42 days in SM9-159. The maximum plant height (67.86 cm) was observed in SM9-172 followed bySM9-163 (58.00 cm) and SM9-169 (57.40 cm).Whereas the highest 100 seed weight (7.54 g) was found by SM9-172 followed by SM9-152 (5.57 g) and SM9-155 (5.53 g) (Fig 1).

Fig 1. High yielding Mungbean var. SM 9-163

Groundnut

AICRP on groundnut

Nutrient management on bold seeded groundnut

Two varieties of bold seeded groundnut (GG7 and FeSH-10) were planted on 15th July, 2009 in plot size of 2m x 2m at planting distance of 40cm x 20 cm with 8 forms of nutrition to evaluate the performance of groundnut varieties with different treatments under Basar condition. The maximum plant height was recorded with GG7+P50+K100+lime+FYM i.e.36.6 cm followed by GG7+P50+K100+lime+B (35.3cm) and FeSH-10+P50+K100+lime+FYM (34.6 cm).The maximum pod yield 2.88 t/ha was obtained with the treatment of GG7+P50+K100+Lime+FYM followed by FeSH-10+ P50+K100+lime+FYM i.e.2.42t/ha and FeSH-10+ P50+K100+lime+B (2.25 t/ha).

Identification of confectionary/large seeded groundnut varieties

Eighteen entries of groundnut were sown on 18th July, 2009 in plot size of 2m x 2m with planting distance 40cm x 20cm to test their performance. The maximum plant height 44.4 cm was recorded with ICGV-8659 followed by GG21 (39.6 cm), AKG159 and K-134 were at par i.e. 38.6 cm.However, the no. of pods/plant was observed highest in ICGS-76 (39.13) followed by ICGV86031 (36.2) and ICGV-8659 i.e.35.8.The maximum yield was recorded with ICGS-76 i.e. 3.13 t /ha followed by GG-20 (3.00 t/ha) and AKG-159 (2.88 t/ha).

PLANT PATHOLOGY

Collection, screening and improvement of *Jhum* rice for increasing production and productivity of *Jhum* cultivation

Thirteen entries were grown in fields in both Gori and Bam Farm with three replications. No external inputs like manures, fertilizers, plant protection measures except three manual weedings were given. The average yields in both the farms were Pupi-III (3.28 t/ha) Lite (2.24 t/ha), Ampe (2.08 t/ha), Pumik (2.00 t/ha) *Yaber* (1.96 t/ha), Bali Red (1.7.6 t/ha), and Jarli (1.03 t/ha). Bali Red showed severe leaf blast infection followed by *Y*abe, Jarli and SARS-3.

Screening against rice leaf blast

National Screening Nursery 1

Under AICRP on rice with 220 test entries in Uniform Blast Nursery (UBN) pattern were screened against leaf blast. The disease pressure was moderate at Basar with Leaf Severity Index (LSI) 5.0 and only six test entries showed resistant disease reaction while 75 entries showed susceptible reaction in 0-9 scale.

National Screening Nursery Hills

Eighty six test entries were screened in UBN pattern. The disease pressure was low with LSI 4.3.

Screening of collected rice germplasm/ varieties for blast resistance

One hundred fifty nine rice varieties/ local germplasm from different agricultural institutes and local growers of N.E. States were collected and screened for their blast resistance in UBN pattern. The disease pressure was moderate at Basar with LSI 5.60 with only 11 varieties showed resistant reaction, 80 entries recorded as tolerant, 56 entries observed to be susceptible and 20 entries were highly susceptible.

Screening of rice varieties for WRC situation

During *kharif* season, the following groups of rice varieties were grown for screening of adaptability and different plant growth characters:

Twenty WRC varieties were tested in RBD with three replications in plot size 3.0m X 2.5 m and sowing was done on 30-5-09 and transplanting was done on 25-6-09 with recommended dose of fertilizer and spacing. The highest plant height recorded in Rute (160cm), Mipun(133cm), Vandana (104cm), Rime (97.6cm) and maximum tillering was observed in Basmati (21.4nos/hill), Mashuri (20 nos/hill), RCM-10 (18.8nos /hill).The highest EBT

recorded in Basmati (21nos/hill), Mashuri (16.2nos/hill), RCM-10 (15.2nos/hill).The highest yield was recorded in Anjali (3.07 t/ha) followed by Jaya (2.67t/ha), RCM-10 (2.13 t/ha).The highest blast incidence was recorded in Vandana and Mipun .

Four RCRT experiments were conducted, out of which two were in upland situation and two under lowland situation. The RCRT UL1 trial comprised of 11test entries. The sowing was done on 10th June 09. The experiment showed severe incidence of blast with LSI 7.0 in 0-9 scale and almost all the entries produced chaffy grain. RCRT UL2 trial comprised of 10 test entries sown on 10th June 09. The blast incidence was LSI 5.0 in 0-9 scale and RCRT UL1 and RCRT UL2 trials failed

Frontline demonstration on rice during *kharif*

The programme was taken in West Siang district of Arunachal Pradesh during the *kharif* covering 50 farmers with an area of 40 hectares. The programme included varietal trial (Anjali in 5 ha and Lungnilaphou in 10 ha), nutrient management (10 ha), weed management (10 ha) and disease management (5 ha) respectively. The highest yield of tested variety Anjali was recorded as 3.1 t ha^{-1} with a yield advantage of 24 % over the yield of farmer's variety Amlum i.e. 2.5 t ha^{-1}. The highest yield advantage in variety Anjali was recorded as 33.3 % with 2.8 t ha^{-1} over the farmer's variety Pumde i.e. 2.1 t ha^{-1}.

The variety Lungnilaphou, recorded 3.25 t ha^{-1} with a yield advantage of 51.16 % over the yield of farmer's variety Amlum i.e. 2.15 t ha^{-1}. On an average, the yield of Lungnilaphou was recorded as 2.8 t ha^{-1} while that of farmer's variety was 2.09 t ha^{-1}.

In the FLD programme on weed management, the highest yield was recorded as 3.25 t ha^{-1} in FLD practice and farmer's variety Amlum with a yield advantage of 25 % over the farmer's practice and farmer's variety with 2.6 t ha^{-1} whereas the highest yield advantage of 36.36 % was recorded with 3.00 t ha^{-1} over the farmer's practice and farmer's variety Pumde with 2.2 t ha^{-1}. The weedicide i.e. 2, 4-D (Ethyle Ester) was applied at the recommended dose of 2-3 ml/lit of water to cover the field.

In the nutrient management aspect, the highest yield recorded (4.15 t $ha^{-1)}$ in FLD practice and FLD variety Lungnilaphou with a yield advantage of 43.1 % over the FLD practice and farmer's variety Mipun (2.9 t ha^{-1}). In this programme, the locally available poultry and pig manures were applied at the rate of 10 t ha^{-1} in addition to 60:80:50 kg $NPKha^{-1}$ as per recommendation of the state. Further, the highest yield advantage of 75% was recorded with 3.5 t ha^{-1} of FLD practice and FLD variety Lungnilaphou over the FLD practice with farmer's variety Amlum (2 t ha^{-1}).

In respect of the disease management, the highest yield was recorded as 2.90 t ha^{-1} with the application of Indofil M-45 @ 2-3 g/lit of water to control the rice blast disease compared to the untreated farmer's field with 2.45 t ha^{-1} with a yield advantage of 18.37 %. The highest yield advantage was recorded as 25.00 % with a yield 2.75 t ha^{-1} in FLD practice compared to 2.2 t ha^{-1} in farmers' practice.

It was also observed during the programme, that the farmers are interested to apply the organic manures whereas they are hesitant to apply the chemical fertilizers as well as pesticides because of the lack of proper knowledge. However after obtaining significant result through FLD, farmers were convinced about the suitability of technology but non availability of these items in open market remains a major hurdle for its adoption.

Evaluation of toria varieties against location specific diseases

Four entries received from ICAR-RC-NEH, Umiam namely RCRT-1, RCRT-2, RCRT 1-2 and RCRT 1-3 and three entries of AAU, Jorhat namely TS-38, TS-46 and M-27 were evaluated with a plot size of 2.5x2.0sq.m and sown on 12th November'09 maintaining spacing of 30cm between rows and 15cm from plant to plant. The highest plant height observed in RCRT-3(78.76cm) followed by RCRT2 (78.26cm), TS-38 (77.6cm). No of siliqua per plant recorded highest in TS-46 (43.82), TS-38 (40.49), RCRT-2 (35.46), M-27 (34.8) RCRT1-2 (33.64). The highest yield was recorded in TS-38(0.28 t/ha), TS-46 (0.18 t/ha), RCRT1 (0.082 t/ha) and RCRT 1-2 (0.08 t/ha).The yield level in this experiment was low due to moisture stress at the time of flowering. The crop was infested heavily with *Alternaria* blight in both leaf and siliqua invariably in all the entries with disease score <5.0 in 0-9 scale.

FARMING SYSTEM RESERCAH PROJECT

Farming system research project (FSRP) having different components of agricultural viz., Agronomy, Horticulture, Silviculture and bamboorium is running at Gori farm of ICAR, AP Centre, Basar. The experiment consists of 1) Growing of different field crops on terraces 2) Cultivation of different vegetable crops on terraces 3) Evaluation of bamboo species (30 entries) 4) The maintenance of 31 banana varieties under FSRP 5) Growing of MPTs from 2003 6) Growing different fruit plants viz. orange, peach and guava which were planted in 2003 7) Pineapple block is existing in FSRP, planted during 2002 and 2004 and "Queen" variety has been introduced on 2009.

Performance of field crops

As per the suitability of crops, cropping sequence was formulated for terrace land of mid hills of Arunachal Pradesh. In combination of various fields, legumes, vegetables and cucurbits crops were given place. Profitable crop rotations/sequences with less external inputs were evaluated. It was observed that among various cropping sequences cowpea-okra sequence gave the highest returns followed by maize- French bean and maize- ridge gourd. These sequences have highest land utilization efficiency, production efficiency and monetary returns. Cropping sequence was further evaluated on the basis of economics; it was found that among different cropping sequences, cowpea (Kashi Kanchan) – okr (Rs 66000- 125000) is one of the most profitable crop sequence followed by Maize – French bean (Rs 42000- 67500). These two crop sequences could be used by farmers to get maximum returns by using combination of cereals and vegetables. Other than cropping sequences bamboo is one of the important components in FSRP which gives maximum output and it required least care.

Performance of rice

Under wet land rice cultivation nine varieties were tasted, out of which four varieties were collected from Ziro. All the varieties were given with same fertilizer doses (80: 60: 40 kg N, P_2O_5 K_2O ha^{-1}) along with following uniform cultivation practices. It was observed that all the varieties from Zero were very much susceptible to blast and bacterial leaf blight and also leaf spots were observed. Among others RCM-10 recorded the higher yield attributing characters like no. of effective tillers, no. of seeds/panicle, no. of filled grains, test weight were higher and gave the highest yield of 3.2 t/ha followed by RCM-9.

Performance of fruit crops

Among the various fruit trees *viz.* peach, guava and *Khasi* mandarin, peach attained the maximum tree height and basal girth followed by guava. Similarly, no. of fruits was higher on peach but total yield was recorded higher on guava.

Performance of pineapple

'Kew' variety of pineapple was planted in sloppy area 2570 m^2under FSRP during 2002 -04 in paired row on bed with the spacing of 60 x 30 cm and 75 cm spacing between two beds yielded 38000 fruits/ ha during the 2009-10.

Four herbicides were tested along with weed free, 2 hand weeding and weedy check. It was found that broad leaved weeds (*Mikania micrantha, Boreria hispida, Ageratum conyzoids* and *Commelina bengalensis*) were recorded lower in 2, 4-D (1.5 kg a.i. /ha) and glyphosate (1.5 L/ha) and grasses (*Echinochloa crusgalli* and *Panicum repens*) were recorded lower on alachlor treated plots. However, complete weed free plots showed better growth, weed control efficiency and least weed density followed by glyphosate.

Performance of MPTs

Different tree species were planted under FSRP and some species came out naturally. Among different species *Eleocarpus spharicus* (Rudraksh) basal girth and canopy spread was maximum (167.50 cm and 13.85 x 14.9 m, respectively) followed by *Morus laevigata* (96.00 cm and 11.5 x 12.70 m, respectively). However, chlorophyll content was recorded higher in *Ixonanthes khasiana* (42.0 SPAD) followed by *Castonopsis indica* (39.3 SPAD).

Maintenance of bamboo germplasm

Bamboo germplasm of 30 species is being maintained and morphological observations were recorded on the performance of all species of bamboo planted under FSRP. *Bambusa cacherensis* recorded the maximum clump

circumference (28.2 m) followed by *Dendrocalamus hamiltonii* (23.4 m), *Dendrocalamus hamiltonii* –Akashe Ganga Local-1(19.4 m) and *Bambusa balcoa* (17.2 m). The number of culms/clump was observed highest (2200 nos.) in *Chimonobambusa* armata [Ebum (runner type)] followed by *B. multiplex* (1650 nos.) and *B. variegata* (920 nos.). Individual culm circumference was recorded highest 33.40 cm in *D. hamiltonii* followed by *Dendrocalamus hamiltonii* – Akashe Ganga Local-1 (31.30 cm) and *B. arundina* (30.20 cm). The length of internodes was measured highest (58.90 cm) in *Chimonobambusa griffithiana* and lowest (11.3 cm) in *B. khasiana*.

AGRONOMY

Evaluation of intercrop on maize

Growth and yield parameters of maize were recorded. Unit area dry matter accumulation was higher on sole maize. The highest yield of maize was recorded on sole maize and LER was found maximum on inter cropping with cowpea (1:2) followed by French bean (1:2). The weed control efficiency was recorded maximum on sole cow pea and followed by intercropping maize with cow pea (1:5).

Effect of weed mangemnt practices on growth and yield of black gram

Growth and yield parameter of black gram were recorded. Maximum yield was obtained from weed free treatments followed by pendimethalin + 1 hand weeding. Similarly, weed control efficiency was recorded higher on weed free plots followed by pendimethalin + 1 hand weeding.

Nutrient management on cowpea

The higher growth and yield parameters were recorded on 100% P and 100% K followed by 100% P and 75% K which was near to 75% P and 100% K. However, the least yield attributes and yield were recorded on 50% P and 50% K.

Evaluation of tuber crops under mid hills

Tapioca

Eight varieties of tapioca were grown and various growth and yield parameters were recorded. The yield attributing characters were recorded higher on Sree Rekha followed by H-1687 and H-226. The lowest yield attributed and yield was recorded on Sree Jaya.

Colocasia

Nine varieties of colocasia were grown and various yield and quality parameters were recorded. The highest yield was recorded from colocasia local (15.0 t/ha) followed by Muktakeshi (13.0 t/ha) and TRC 1.

Dioscorea

Three varieties of Dioscorea were collected and grown and yield parameters were recorded. TRC local recorded higher yield attributes like number of yam/plant, weight of yam, girth of yam and yield followed by Orrisa elite.

Elephant foot yam

Two varieties of elephant foot yam were collected and grown. The highest yield of 30.0 t/ha was recorded followed by TRCB-1.

Sweet potato

Three varieties of sweet potato were collected and growth and yield parameters were recorded. The highest yield parameters viz. number of tuber/ plant, tuber weight, girth of tuber and yield was recorded higher on ST-12 followed by Sourin.

HORTICULTURE

FRUITS

Integrated nutrient management in *khasi* mandarin

A field trial was executed with 60 kg each of FYM, pig manure and poultry manure along with different doses of sunhemp, *Azotobactor*, PSB and

in combination. Results indicated that highest number of fruits per plant (823) was recorded with 50% RDF + pig manure (15kg) + sunhemp (12.5%) + *Azotobactor* (20g) + PSB (20g). Plant height (6.84 m) and crop canopy (5.9x6.1 m) were also highest with pig manure along with other nutrient sources. Highest fruit yield (75.3 kg/tree) was also recorded with pig manure treatment. The physico-chemical characteristics of fruits showed that peel weight (32.23 g) and thickness (4.7 mm) were more with full dose application of NPK while segment weight (87.16 g) and fruit weight (126.8 g) were highest with pig manure along with other nutrient sources. Development of seeds/fruit (6.13) was lowest with the application of 15 kg poultry manure along with other nutrients

Evaluation of HDP and growth regulators in *khasi* mandarin

GA_3 (25, 50, 75 ppm), 2, 4 D (15, 25, 30 ppm) and NAA (100, 150, 200 ppm) were sprayed in three replications on HDP orchard. It was observed that 3m x 3 m spacing, sprayed with 2,4 D 25 ppm recorded the highest fruit weight (113.06 g), size (5.1 x 5.9cm^2), segment weight (74.07 g) and also juice content (61.2 ml). On the other hand, highest acidity (0.83 %) was recorded in 2m x 2m spacing.

Performance of *khasi* mandarin and guava under drip cum mulching system

The experiment was laid out on split plot design with three replication. Main plots were allotted for irrigation levels (i.e. L_1: 1.0 Epan through drip, L_2: 0.8 Epan through drip, L_3: 0.6 Epan through drip and L_4: 1.0 Epan with flood irrigation (FI)) and sub plots were mulched (i.e. M_1: No mulch, M_2: Black polythene mulch (BPM; 40 µ thickness), M_3: Transparent polythene mulch (TPM; 40 µ thickness), M_4: Paddy straw mulch (PSM; 20 kg/tree). All the crop growth analysis parameters like LAD, AGR, RGR, NAR and CGR were recorded significantly higher on drip irrigation at 1.0 Epan. Least value were recorded when crop was supplied with flood irrigation. Black polythene mulch recorded higher crop growth analysis parameters over other mulches. Yield of *khasi* mandarin was recorded higher when crop was received irrigation water through drip at 1.0 Epan covered with black polythene. Water use efficiency was recorded higher when the water was applied through drip irrigation at 0.6 Epan and BPM.

Performance of micro propagated plants of *Khasi* mandarin

Micro propagated plants of 13 years old were evaluated for their growth and yield characteristics. It was observed that the plants were uniform in height and had similar shaped fruits with good keeping quality. The plants recorded average height (3.42 m), stem growth (6.4 cm), number of primary branches (16.6), number of fruits per tree (678.4), fruit drop percentage (7.1 %), fruit weight (107.2 g), TSS (11.17^0 B) and acidity (0.53%).

Performance of budded citrus

The experiment was laid out with four types of mandarin oranges (*Khasi* Mandarin, Nagpur Santra, Hill Mandarin and Sikkim Orange) and six species of rootstock (*Tanyum*, *C. volkamariana, C. latipes*, Trifoliate Orange, Rough lemon and *Karna Khatta*) during May, 2001. Among different combinations of rootstocks and scions, *Citrus latipes* + Hill Mandarin attained the maximum plant height (2.75 m), root stock diameter (6.9cm) and no. of branches (16). Out of different rootstock - scion combinations, *Tanyum* + *khasi* mandarin produced highest number of fruits (232) after 9th year of planting followed by *Tanyum* + Hill mandarin.

Maintenance of citrus germplasm

Evaluation of germplasm showed that maximum plant height and fruit weight was observed with Mediterranean orange. Zigardio mandarin recorded the highest leaf length, leaf breadth and bigger size fruit. Mandarin cultivars were devoid of thorn however very small thorns were noticed in king theppi and *Khasi* mandarin. *Khasi* mandarin recorded comparatively more segments than other mandarins. Flesh colour of the oranges varied from deep orange in *Khasi* mandarin to yellow in wiliking orange. Nagpur mandarin recorded more number of seeds. The seeds were small, oval and yellow in colour for most of the oranges. Maximum plant height and big size fruits were observed with Washington malta sweet orange. Italian large and vanilla malta recorded the highest leaf length and breadth while the least length was recorded with

ruby blood red. The lower fruit weight was recorded with Italian large. The seed number varied from as low as one in Washington malta to as high as fifty five in *tagu*. *Tanyum* was bushy type with very long and sharp thorns. *C. jawanica* recorded the highest leaf length and breadth. Trifoliate plant with its distinct leaf characteristics has borne very small leaves than other plants. *Karnakatta* recorded comparatively bigger sized fruit while Cleopatra mandarin was smaller in size. The rind colour was deep orange for Cleopatra mandarin to light yellow for *C. latipes*. *Tanyum* had profuse seeds followed by *C. latipes*.

Performance of Kinnow at low hills

Kinnow was evaluated for its performance under mid hills of Arunachal Pradesh. It was observed that fruits were bright orange, oval, glossy and slightly tight skinned. The fruits recorded an average weight of 123.66 g, fruit size 5.28 cm x 6.53 cm, fruit circumference (21.04 cm), juice content of 58.71 ml, peel weight (28.41 g), no of segments (10.33), segment length (4.17), segment breadth (2.78), no of seeds per fruit (18.21), TSS of 9.76 °B and 0.97% acidity.

Standardization of horticulture based farming system for sustainability

Advantageous crop rotations of various crops in different cropping sequences were tried. The cropping sequences evaluated on yield performance were French bean-tomato, pumpkin- pea, water melon- cabbage and okra- potato. It was found that among different cropping sequence, French bean-tomato performed well and fetched more cumulative market price besides enriched soil health. In fruit crops, pineapple gave fruit yield of 22.4 t/ha and banana resulted 18.7 t/ha with individual bunch weight of 12.7 kg/tree. The NPK contents in the field were also increased by adopting this crop rotation.

Establishment of agro techniques for passion fruit

Field study with different organic manure viz., pig and poultry manures, FYM along with 150:200:150 g NPK was conducted. Urea was applied in two split doses. GA_3 was applied with three different doses viz., 25, 50 and 75 ppm. The growth regulators were sprayed after fruit set. Among the different organic manures, pig manure (20 kg/tree) recorded higher fruit yield per tree followed by FYM. The individual fruit weight was also higher with the same treatment irrespective of growth regulator spray. Among the growth regulator concentrations, GA3 50 ppm along with 20 kg pig manure recorded the higher yield. The chemical characteristics of fruits like TSS, reducing sugar were also higher with the same treatment.

Establishment of agro techniques for strawberry

Field study with different mulches viz. transparent polythene mulch (TPM), black polythene mulch (BPM), grass mulch, pine needle mulch and no mulch were tried along with four different organic manure viz. , pig manure, poultry manure, FYM and vermicompost. Manures were applied as per the NPK recommendation of the crop. All the mulches maintained were comparatively higher in soil moisture than unmulched field. Higher moisture regime was noticed with the depth of 10 cm under BPM followed by TPM. Among the organic mulches, pine mulch conserved more moisture than others. BPM conserved the moisture being 34% higher than un mulched field. Temperature of the soil was also increased in BPM followed by TPM. In the morning TPM recorded higher temperature than BPM. Among the manures vermicompost recorded the highest fruit yield followed by pig manure. Number of fruits per plant was 40.28 in BPM. The income was 1.54, 1.38, 1.29, 1.16 times higher respectively compared to control.

Guava

Performance of guava varieties under different spacing

Field trial was conducted with two different varieties viz. Allhabad Safeda and L-49 under different spacings viz., 3x4 m, 3x3m and 4x4m. It was observed that Allahabad Safeda performed better in all the three different spacings. L-49 recorded more number of fruits per tree (686.78) and yield (72.79 kg/tree)) fruit weight (183.27 g) under 4x4 m spacing.

Aonla

Performance of aonla varieties

Six different cultivars viz., Assam Local, NA-6, NA-7, Kanchan, Chakaiya and NA-10 were planted in 2000 to evaluate their performance. It was observed that Assam Local performed better than other improved varieties under mid hill condition. Assam Local recorded early fruiting and higher fruit yield (6.3 kg/tree).

Banana

Thirty germplasm of banana have been maintained at the Research Farm. Karpura Chakrakeli attained maximum vegetative growth. While highest bunch weight (6.2 kg), number of hands (14), finger per hand (18) were recorded in Chinni champa followed by Malbhog and Hatidath.

Evaluation of different banana varieties under high density planting

Four different varieties viz., Dwarf Cavendish, Chinni Champa, Malbhog and Hatidath were planted with four different spacing viz. 3x3 m, 1.2 mx1.2m , 1.5 x1.5 m and 2.5x2.5 m. scientific cultivation practices were followed as per recommendation. Dwarf Cavendish performed better under 1.5x1.5 m spacing followed by Malbhog. Chini Champa came to flowering well earlier than other varieties under wider spacing (1.8x1.8 m). The bunch weight was higher (7.4 kg) with Dwarf Cavendish

Studies on effect of growth regulators on flowering and fruiting of guava and peach

Different growth regulators were sprayed to induce flowering in peach and guava. In guava, NAA 150 ppm advanced the flowering and thereby fruiting in Sardar guava. Tree canopy volume (93.8 m3), fruit length (7.1 cm), fruit breadth (6.4 cm), fruit weight (147.5g) were recorded more in the NAA 150 ppm spray followed by CCC 250 ppm. GA3 50 ppm spray induced early flowering in Sharbati variety of peach.

Performance of peach under mid hills

Three low chilling varieties of peach viz. Sharbati, TA-170 and Flordasun were evaluated for their yield attributing parameters under mid altitude condition. It was noticed that Sharbati recorded the highest yield of 827 fruits/plant followed by TA- 170 (Table 1).

VEGETABLES

Standardization of mushroom production technology

Experiment was conducted to standardize the various additives to reduce the spawn run period and increase the number of sporophores. The addition of rice bran recorded a stimulatory effect on *Pleurotus sajarcaju.* The sporophore appeared within (19.5 days) after spawning. The other yield parameters, viz., weight of sporophore (474g) and biological efficiency (95.8%) were also significantly higher in rice bran supplementation.

Standardization of technologies for off season production of vegetables

Five different varieties of tomato viz., Rocky, Avinash, Cheeranjeevi, Arjuna and PS 225 were grown under polyhouse to find out the best variety for off season (Apr-July) production of tomato. Among different varieties Arjuna performed well followed by Avinash and PS 225. Early flowering (55 days), highest fruit set and more yields (3.2 kg/plant) were recorded with Arjuna. However, Avinash was tolerant to late blight of tomato followed by Arjuna.

Table 1. Fruit quality parameters of low chilling varieties of peach

Varieties	TSS	pH	Acidity (%)	Juice content (ml)	Fruit weight (g)	Reducing sugar (%)	Total sugar (%)
TA-170	8.2	3.6	0.83	38	75	12.5	18.4
Sharbati	8.2	3.9	0.58	44	89	6.8	10.73
Flordasun	7.0	3.5	0.64	41	81	4.67	9.73

Evaluation of cropping sequences for year round production of vegetables under polyhouses

Tomato-French bean-chilli-cabbage; Tomato-bitter gourd- chilli-broccoli; Tomato- cucumber-okra-Knol khol and Tomato- bottle gourd- tomato-cauliflower combinations were tried to evaluate the best cropping sequence planted in Jan- Apr; May-July; Aug-Oct; Nov-Jan, respectively. It was observed that all the cropping sequences enriched the soil health and increased the farm income. Among the different combinations Tomato-French bean-chilli-cabbage recorded highest yield with B: C ratio of 3.2.

Standardization of organic growing of ginger

Ginger var. Nadia was imposed with five different organic treatments. It was found that Rhizozin (1%) treatment recorded the highest rhizome yield per plant 758 g followed by application of piggery manure (612 g/ plant).

Effect of sowing and spacing on growth and yield attributes of broccoli

Broccoli (var. Aishwarya) was planted with row spacing of 30, 40 and 50 cm on 7th Sep, 14th Sep and 21st Sep. It was found that highest curd diameter (17.43 cm), curd length (12.37 cm), number of flowers per stalk (23.33), gross weight (105.92 g), net weight (58.90 g) were observed with the plants spaced at 40 cm and the transplanting done in the 2nd week of Sep. Early transplanting prevented the curd formation and in later transplanting winter restricted the growth. Acidity (0.78 %), pH (6.4), ascorbic acid (16.2 mg/100g), reducing sugar (3.09%), TSS (5.5 B) and total sugar (3.89%) were also recorded in the same treatment.

Knol khol

Knol khol var. Winner was grown under polyhouse as off season vegetable. It attained the plant height of 31.7 cm during its growing season of 95 days after transplanting. No of leaves per plant (11.4), knob length (8.8 cm), knob diameter (10.5 cm), circumference (19.3 cm), gross weight of the knob (276.8 g) and net weight of the knob (240.7 g) were recorded.

Pea

Performance of pea var. Arkel was evaluated for its growth and yield parameters under mid altitude condition of Arunachal Pradesh. The average plant height was 99.4 cm while 21.7 tendrils were produced per plant. It was observed that 50% flowering was recorded after 72.4 days of sowing while it took another two weeks for pod maturation. The total duration of variety was 120 days with the pod yield of 191.4 g/plant of which seed weight was 93.57 g. 14.3 pods/plant and 9.2 seed per pod was recorded. Length and breadth of the pod recorded was 10.1 cm and 1.4 cm respectively. Chemical attributes recorded were total sugar (3.72%), TSS (4.4^{0}Bx), pH (6.3) and acidity (0.27%).

Effect of boron and molybdenum on growth, yield and quality of cauliflower in mid hills

In cauliflower var. Snow Crown boron and molybdenum were applied either as soil treatment or foliar spray (45 and 60 DAP) or combination of both. Boron and molybdenum either individually or in combination were also tried. It was found that both boron and molybdenum had profound effect on vegetative growth either applied individually or in combination. The plant height and number of leaves per plant were highest with 2 kg/ha soil application of ammonium molybdate + 3 kg/ha soil application of borax + 0.3% each of foliar application of borax and ammonium molybdate over control. The same treatment recorded more curd weight, width, length and curd yield.

FLORCULTURE

Standardization of agro techniques for gladiolus

Eight varieties viz., Promise, Red Majesty, Candyman, Rosared, Pusa Chandini, Pusa Jyotsna, Snow Princess and Novalux were evaluated for their performance under mid hill conditions. It was observed that cv. Promise performed better followed by Pusa Jyotsna, Red Majesty and Pusa Chandini. Desirable plant height (115.3 cm), spike length (74.2 cm) and rachis length (43.4 cm) and number of florets per spike (13.6) were recorded with promise.

Standardization of agro techniques for gerbera

Nineteen different gerbera lines were grown in both open and closed condition. Alsemera recorded more plant height (26 cm) while no of leaves was more in black heart (28). Leaf length and breadth was more in Alsemera. Polyhouse grown plants were early in flowering irrespective of cultivars. Among the different lines Alsemera recorded more stalk length (53.5 cm) and the fresh weight of the flower (6.71 g). Line NG-172 recorded the least plant height (13. 5 cm).

Standardization of PGR spray and pulsing solution for corms, cormels and flower production and extending shelf life of gladiolus

Healthy corms were planted at a spacing of 30 x 20 cm and a depth of 10 cm in the mid of October. Corms were dipped in growth regulator solution for two hours and shade dried. Growth regulators were again sprayed at 45 and 60 days after sowing. Control took more days to sprout (38.3) while irrespective of kind of hormone they significantly reduced the days to 50% sprouting of corms. GA_3 sprays drastically lowered the days for sprouting followed by CCC and BA spray. NAA (100 ppm) appeared at par with kinetin (500 ppm) on sprouting percentage. Free GA_3 was active in breaking down the reserved food material by hydrolytic enzymes and hence caused earlier sprouting with enough moisture. GA_3 500 ppm recorded early flowering (75.9 days) followed by GA_3 750 ppm (79.3 days).

Vase life studies on gerbera

Gerbera (var. Alsmera and Black Heart) were kept to study the shelf life characteristics of two varieties. Response Surface Design was followed to optimize the independent variables. Sucrose (2, 4 and 6 %), $AgNO_3$ (0.02, 0.04 and 0.06) and citric acid (0.25, 0.50 and 0.75%) were tried. 5% sucrose concentration, 0.04% $AgNO_3$ and 0.45% citric acid recorded the least reduction in PLW and increased the longevity of fresh cut flower (Fig 2).

Fig 2. Vase life studies on gerbera

POST HARVEST TECHNOLOGY

Standardization of maturity indices and value addition of indigenous fruits

Taktir (*Garcinia lancaefolia*) fruits were harvested at weekly interval starting from the second week of March to last week of April. Physical parameters like fruit weight, visual appearance, easy to detachment were studied. Besides chemical parameters like pH, TSS, acidity, reducing sugar and vitamin C content were also studied. It was found that tree comes to flowering in Oct-Dec. Flowers were pink in colour, perfect and borne in cluster. Fruit mature during April-May with tomato red colour when fully ripen and green at immature stage. It was found that fruits harvested in the second week - third week of April were rich in quality with high TSS (11.5^0Brix), juice content (19.4 ml) and more fruit weight (43.7 g).

Standardization for harvesting maturity for pineapple

Pineapple var. Kew was evaluated (Table 2) to judge the best harvesting maturity for meeting the local market.

Table 2. The physico-chemical changes of pine apple fruit

Parameters	23rd Aug	31st Aug	8th Sep	16th Sep
Fruit weight	1.2 kg	1.10 kg	1.02 kg	1.02 kg
Fruit length (cm)	22.5	23.8	23.9	23.9
Fruit breadth (cm)	9.5	9.7	9.8	9.8
TSS (°B)	12.5	13.7	13.9	13.0
Acidity	0.45	0.41	0.37	0.37
Reducing sugar (%)	5.41	6.67	7.69	7.14
Total sugar (%)	10.98	11.76	14.56	14.21

Standardization of packaging and storage condition in *Khasi* mandarin

Experiment was conducted to increase the shelf life of *Khasi* mandarin by following the existing practice of packaging without any treatment in bamboo basket and pre-treatment with 1 and 2% solution dip of Ca $(NO_3)_2$ and $CaCl_2$ for 10 minutes. Physiological loss in weight (PLW) was maximum in control while it was very less in the packs cushioned with paddy straw. In untreated, the post harvest decay ranged form 10.23 to 24% while it was 7.4 to 9.86 % for the treated fruits. Decay

was mainly due to stem end rot caused by *Botrydiplodia theobromae* and sour rot caused by *Geotrichum candidum*.

Value addition in bamboo shoots through processing

An experiment was conducted to produce minimally processed bamboo shoots. *Eni* (*Dendrocalamus hamiltonii*), the most common species used as food was taken for experiment. Sheaths of bamboo shoots were removed and cut into circular shape with different sizes viz. 2, 4, 6, 8 and 10 mm. Then, the shoots were blanched in water containing 0.05 % KMS and 0.1% citric acid for 25 minutes to remove astringency. It was found that 6 mm thick bamboo shoots were tender and good in colour and other sensory characteristics. These shoots were dipped in sucrose solution of different concentrations (20, 30, 40 and 50 ^{0}Bx) with varying temperatures (30, 40, 50 and 60^0 C). The ratio of the fruits and osmotic solution was maintained at 1:4 ratios, in order to ensure proper soaking of the samples. The results indicated that water loss, solid gain and mass reduction were found to increase with increase in sucrose concentration and temperature of the solution at the end of osmosis. The optimum solid gain (8.6%), water loss (29.7%) and mass reduction (19.3%) were recorded at 40^{0}B sucrose solution with 50^{0}C temperature (Fig 3).

Fig 3. Value addition in bamboo shoots

Standardization of squash making from *Taktir*

Taktir squash was prepared with different juice percentage (20, 25 and 30 %) and TSS (35, 40 and 45 ^{0}B). The acidity was kept constant. It was observed that the squash prepared with 20 % juice and 40^{o}B yielded good quality, delicious squash to other treatments. The sensory study revealed the better colour, flavour and over all acceptability to the same treatment. Storage studies clearly indicated that anthocyanin get degraded with the increase in storage period. RS, TS and acidity get increased with the storage period while pH and Vit C get decreased.

Standardization of technology for preparation of passion fruit nectar

Passion fruit is not likened by many people due to its dull appearance and sordid taste. Efforts were made to popularize the passion fruit based fruit drink in Arunachal Pradesh. Nectar was prepared with different juice percentage (12.5, 15 and 17.5%) and TSS (17.5, 20, 22.5^{o}B). Acidity was kept constant as per FPO specification. It was noticed that nectar prepared with 15 % juice percentage and TSS (22.5^{o}B) recorded superior quality nectar than other treatments. Sensory parameters like colour, flavour, body and over all acceptability were recorded best with the same treatment.

Standardization of drying and dehydration techniques for mushroom

Mushroom was dehydrated with different drying conditions namely sun drying, cabinet drying (CD) and microwave drying (MWD). The dehydration was faster in micro wave dried mushroom while it took longer time under sun drying (300 min). The drying ratio and rehydration was also more when the mushroom was dried under MWD followed by CD. Blanching the mushroom for 5 min prior to drying gave better result irrespective of drying condition.

Preparation of high moisture fruit product (HMP) from guava

Two different sucrose concentrations viz. 20 and 30% were used to standardize the HMP produces from guava. Blanching time, acidity level and preservative concentration were also standardized. It was observed that sucrose concentration of 20% yielded best HMP produce. Prior to that blanching the guava slices for five minutes in water containing 0.05% citric acid is pre-requisite

Standardization of drying and dehydration techniques for ginger

An experiment was designed with ginger to study the kinetics of drying with different driers. Blanched

ginger were dried under three different dying conditions viz. cabinet drier (CD), microwave drying (MWD) and conventional sun drier (SD) to evaluate the best drying condition for the blanched ginger. It was found that 4mm thickness when blanched for 6 minutes and dried in microwave was superior to other modes of drying in water removal and moisture ratio of products. Further, it was found through regression analysis that drying ratio and rehydration ratio was also superior in microwave drying followed by cabinet drying. In addition, descriptive analysis on sensory score was also found best with same drying condition.

Preparation of gingerale

Ginger based sport drink was prepared by using different combinations of ginger and lime. It was found that 1:2 or 3 ratio of ginger and lime recorded good sensory score than other combinations. 2/3rd amount of sugar was also added to the produce. The initial TSS was 31.8^{o}B, pH (2.9) and acidity was 0.51%.

Effect of hot water and waxing in *Khasi* mandarin

Experiment was conducted with nine different treatments consisting wax, 2, 4 D and hot water to study the effect of treatments on storage of *Khasi* mandarin. It was observed that waxing recorded profound effect on extending the shelf life of the produce. Mandarin maintained its freshness up to 30 days by using the wax as the treatment. Combination of waxing and growth regulator yielded better result than individual treatments. Not much variation in TSS was recorded during storage. However highest PLW was recorded with control (21%) followed by ambient water treated produces (18%).

Training and demonstrations

To disseminate the developed technologies, altogether 16 trainings and 7 demonstrations were conducted. Trainings were covered various topics like improved production technology for kiwi fruit, orange, pineapple and banana; rejuvenation of old senile orchard of *khasi* mandarin; off season production of vegetables; post harvest processing and value addition of different horticultural products including mushroom. Demonstrations were conducted on mulching of *Khasi* mandarin; FLD on cabbage, banana and pineapple. Trainings were sponsored by TM, NABARD and ITBP while the demonstrations were conducted from the financial assistance of Technology Mission (MM I).

AGROFORESTRY

Evaluation of multipurpose trees

During 1997-2001, 53 MPT species were planted, out of which 49 species are established. Among 16 tree species established in 1997, *Pinus kesia* attained maximum basal girth (115.3 cm) followed by *Michelia obtusifolia* (111.3 cm) and *Cuppressus torulosa* (97.6 cm). Canopy spread was recorded highest (7.98m x 8.04m) in *Pinus kesia* followed by *Cuppressus torulosa* (6.60m x 6.61m) and *Terminalia myriocarpa* (6.27m x 6.61m) after twelve years of planting. Highest plant height was recorded in *Michelia obtusifolia* (16.80m) followed by *Castonopsis indica* (16.54m) and *Anthocephalus cadamba* (16.40m). Chlorophyll content was found maximum in *Ixonanthus khasiana* (49.11 SPAD) followed by *Mesua ferrea* (46.7 SPAD) and *Livistonia jenkinsiana* (45.7 SPAD). Highest light intensity in inter-rows was recorded highest in *Terminalia myriocarpa* (671.7 lux) followed by *Gmelina arborea* (556.6 lux) and *Anthocephalus cadamba* (392.4 lux) and lowest in *Mesua ferrea* (7.1 lux).

Among the 20 tree species planted in 1998, *Acacia mangium* attained maximum height (24.10 m) followed by *Pinus wallichiana* (16.48m) and Penlow (16.00 m) and lowest in *Morus alba* (2.11 m). Basal girth was recorded highest in *Acacia mangium* (128.2 cm) followed by *Pinus wallichiana* (102.3 cm) and *Caryota urens* (87.2 cm).The canopy spread was found highest in *Acacia mangium* (9.88m x 8.80m) followed by *Pinus wallichiana* (8.38m x 8.40m) and *Penlow* (5.72m x 5.91m) and lowest in *Morus alba* (1.79m x 1.95m). Chlorophyll content was recorded highest in *Symmingtonia populnea* (67.6 SPAD) followed by *Cunninghamia lanceolata* (61.7 SPAD) and *Caryota urens* (60.3 SPAD) and lowest in *Pinus wallichiana* (1.7 SPAD). Highest interspacing light intensity was recorded in *Gravelia robusta* (872.3

lux) followed by *Alnus nepalensis* (610.3 lux) and *Lagerstoemia speciosa* (549.3 lux) and lowest in *Cunninghamia lanceolata* (9.0 lux) followed by *Symmingtonia populnea* (24.6 lux) and *Cephalo taxus* (27.6 lux).

Among six species established in 1999, *Manglietia insignis* attained highest plant height (14.27 m) followed by *Parkia roxburghii* (13.40 m) and *Aleurites montana* (11.77m) and lowest in *Bauhinia purpurea* (5.03 m). The basal girth was found highest in *Manglietia insignis* (84.2 cm) followed by *Aleurites montana* (76.0 cm) and *Engelhardtia spicata* (74.7 cm) and lowest in *Bauhinia purpurea* (25.7). *Aleurites montana* recorded the highest canopy spread (6.26m x 5.95m) followed by *Manglietia insignis* (5.41m x 5.42m) and *Engelhardtia spicata* (5.14m x 5.10m) and lowest in *Bauhinia purpurea* (2.84m x 2.80m). The chlorophyll content was recorded highest in *Manglietia insignis* (45.2 SPAD) followed by *Engelhardtia spicata* (40.2 SPAD) and *Parkia roxburghii* (28.6 SPAD) and lowest in *Aleurites montana* (23.6 SPAD). *Aleurites montana* showed the highest inter spacing light intensity (875.3 lux) followed by *Emblica officinalis* (308.6 lux) and *Bauhinia purpurea* (269.0 lux).

Among five species planted in 2000, maximum plant height was recorded in *Eleocarpus sphaericus* (19.56m) followed by Kobolakso (8.66m) and *Sapindus mukorossi* (7.05m) and lowest in *Aquillaria agallocha* (4.72m). The basal girth was found highest in *Eleocarpus sphaericus* (96.1 cm) followed by Kobolakso (44.2 cm) and *Aquillaria agallocha* (32.7 cm). *Eleocarpus sphaericus* also recorded the highest canopy spread (7.76m x 8.43m) followed by Kobolakso (4.50m x 4.08m) and *Sapindus mukorossi* (2.19m x 2.31m). The chlorophyll content was found highest in *Eleocarpus sphaericus* (41.8 SPAD) followed by *Chukrasia tabularis* (39.0 SPAD) and *Sapindus mukorossi* (35.3 SPAD). The inter row light intensity was recorded highest under Kobolakso (398.0 lux) followed by *Chukrasia tabularis* (336.3 lux) and *Elaeocarpus spharicus* (234.6 lux).

Out of four species planted in 2001, Hiko recorded the highest plant height (7.90m) followed by *Litsea lacta* (7.50m). The basal girth was found highest in *Litsea lacta* (43.0cm) followed by Hiko (45.2cm). The canopy spread was recorded highest (4.46m x 4.44m) in *Lithocarpus sperma* followed by Hiko (4.41m x 4.16m). The chlorophyll content was found highest in Hiko (42.3 SPAD) followed by *Lithocarpus sperma* (42.6 SPAD). The inter-spacing light intensity was recorded highest in *Litsea lacta* (136.6 lux) followed by Hiko (71.3 lux).

Performance of different intercrops in combination with different MPTs

Among 31 combinations of 51 species of MPT and 5 species of cane, *Anthocephalus cadamba* + *Ada* was recorded the best in terms of basal girth (32.0 cm) followed by *Alnus nepalensis* + *Takek* (31.2) and *Pinus khasiana* + *Takek* (27.2).

The chlorophyll content was found highest in *Alnus nepalensis*+*Takek* (67.3 SPAD) followed by *Pinus khasiana*+*Takek* (53.6 SPAD) and *Acacia mangium*+*Taher* (53.0 SPAD). The plant height of canes was found highest under *Duabanga grandiflora* (2.81 m) followed by *Terminalia myriocarpa* (2.37 m) and *Castanopsis indica* (1.93 m).

Among 29 combinations of MPT species and Guinea grass, the combination *Aquillaria agallocha* + Guinea recorded the highest guinea grass yield (22.6 kg / row) followed by *Terminalia myriocarpa* + Guinea (16.3 kg / row) and Kobolaxo + Guinea (15.6 kg / row). In all combinations of MPTs and other crops, the length of row was 30 meters.

Among 22 combinations of MPT species and Broom grass, the combination *Gravelia robusta* + Broom grasss recorded the highest yield (20.3 kg / row) followed by *Bombax ceiba* + Broom (13.3 kg / row) and *Lagerstroemia speciosa* + Guinea (12.6 kg / row). The intercrops of turmeric and ginger were also grown in combination with the 25 and 12 species of MPTs respectively.

Effect of tree densities on the growth performance of Ghamari (*Gmelina arborea)*

The spacing trial was established in 1999. In 11th year of establishment, trees obtained highest (15.86 m) plant height in the spacing 2m x 3m followed by 15.45m in spacing 4m x 3m. The basal girth was recorded highest (101.3 cm) in the spacing 6m x 3m followed by 93.6 cm in 4m x 4m. The girth at breast height was found highest (72.6 cm) in the spacing 4m x 4m followed by 67.8 cm in 6m x 3m spacing.

Spacing trial of Bola *(Morus laevigata)*

The trial was established in 1998 and after 12 years, maximum plant height (8.04 m) was attained in the spacing 3m x3m followed by 7.42 m in 4m x 3m spacing. The average basal girth was recorded highest (27.6 cm) in the spacing 5m x 3m followed by 24.7 cm in 3m x 3m. The average girth at breast height was also found highest (19.6 cm) in the spacing 5m x 3m followed by 17.6 cm in 3m x 3m spacing.

Spacing trial of bamboo species

Out of 13 species of bamboo grown under three spacings maximum clump circumference was recorded in *Bambusa cacharensis* (14.2 m) at 5m x 5m spacing followed by the same species (11.4 m) planted at spacing 6m x 6m. But in spacing 7m x7m, *Bambusa nutans* recorded the highest clump circumference (9.1 m). Highest number of culms per clump was recorded in *Bambusa pallida* (60) at 7m x 7m spacing followed by *Dendrocalamus sahnii* (52) at 6m x 6m spacing and *Dendrocalamus hamiltonii* (48) at 5m x 5m spacing.

MANIPUR CENTRE

Weather Report

The highest maximum monthly mean temperature (29.9 °C) was during May- June and lowest minimum (4.3°C) was in January. The highest relative humidity (91.8%) was recorded in September and lowest (72.0%) in February. The highest wind speed (5.2 km/hr) was recorded during April- May and lowest (1.5 km/hr) was in December. The highest total rainfall (303.5mm) was recorded in August and nil in December. Data are presented in the box below.

CROP IMPROVEMENT

Rice

RCM-21 (IET 20193) identified and recommended for valley and terraced areas of Meghalaya and Manipur

RCM-21(IET 20193), a derivative of Prasad X IR 24 was developed under low land transplanted conditions at ICAR Manipur Centre, Lamphelpat, Imphal, was identified by Variety Identification Committee, held from 3-6th April, 2010 at Anand Agriculture University, Anand (Gujrat). It has desirable characters such as long slender grain, soft cooking quality, high yield gain and resistance to leaf blast etc. It matures 130-135 days and showed moderate resistance to Brown Plant Hopper. The mean yield of RCM-21 (Fig 1) was recorded 5.68 t/ha. This entry showed higher yield potential than Vivekdhan 62, HPR 2143 and RC Maniphou 10. It is recommended for valley and terraced areas of Meghalaya and Manipur upto an altitude of 1000 MSL. The description of the developed variety is given in Table 1.

Fig. 1. New high yielding rice variety RCM-21 developed by ICAR, Manipur Centre

Agro-Meteorological data of Manipur Centre during 2009- 2010

Month	Temperature (°C)		Relative humidity (%)		Wind speed (km/hr)	Total rainfall (mm)
	Max.	Min.	Max.	Min.		
Apr	28.2	15.2	85.6	79.4	5.2	78.8
May	29.9	19.3	86.5	78.3	5.2	156.4
Jun	29.9	21.3	89.6	84.3	4.5	69.3
Jul	29.8	22.6	88.7	84.4	3.6	181.1
Aug	28.7	22.1	91.3	82.3	2.8	303.5
Sept	29.3	21.5	91.8	81.8	3.0	131.2
Oct	28.6	18.6	90.0	82.7	1.9	166.0
Nov	25.4	11.7	86.7	80.9	2.3	15.6
Dec	22.2	5.6	82.2	74.2	1.5	0.0
Jan	23.3	4.3	78.2	77.9	1.6	6.90
Feb	23.7	6.5	73.0	72.0	4.3	0.30
Mar	28.7	12.7	78.2	73.5	5.7	128.10

Source: Experimental Agro-Met Advisory Service, ICAR Research Complex for NEH Region, Manipur Centre

Table 1. Description of the variety RCM-21

Plant height	:	100-105 cm	1000 grain weight	:	27 g
Plant type	:	Semi-dwarf	Kernel length	:	6.84 mm
Effective tillers/plant	:	7-8	Kernel breadth	:	2.15 mm
No. of panicle/sq.m.	:	240-250	L/B ratio	:	3.18
Day to 50% flowering	:	100 days	Grain type	:	Long slender
Seed to seed duration	:	130-135 days	Kernel appearance	:	Very occasionally chalkiness
Panicle type	:	Compact	Milling recovery	:	73.1%
Panicle exsertion	:	Well Exserted	Head rice recovery (HRR)	:	59.0%
Awning	:	Absent	Alkali spreading value (ASV)	:	7.0
Apiculus colour	:	Purple	Amylose content (AC)	:	24.39%
Lemma Palea colour	:	Straw	Gel Consistency	:	45.0 mm

Other promising accessions

RCM-23 (IET23810) was developed from the cross between Leimaphou and Akhanphou during the *Kharif* 2000. It is resistant to neck blast. Presently, it has been communicated for registration at NBPGR, New Delhi. This entry may be used as a donor parent for neck blast resistance. Six new cultures namely, RCM-26, RCM-28, RCM-M-58, RCM-11-1, RCM-27 and RCM-29, developed at ICAR Manipur Centre were nominated for IVT-IM and IVT-IME of AICRIP for their all India testing for yield and its consistency and reaction to diseases and insect pests.

Breeding for high yielding, disease resistance and quality rice for main *Kharif*

Fourteen advanced lines of rice along with 3 popular checks were evaluated in a replicated advanced yield trial (AYT) for their comparative performance under lowland transplanted conditions of Manipur valley. The entry, namely, MC-34-7-5-2-75-33-19, performed exceptionally well and recorded 8.03 t/ha yield. The entry was found to be resistant to biotic stresses and out yielded all the three checks. On the basis of yield performance, this culture has been nominated in IVT (IM) for all India testing under AICRIP.

A preliminary yield trial involving 37 advanced lines of medium duration rice along with two checks was conducted in a replicated advanced trial for their comparative performance under low land transplanted conditions. Among them five outstanding lines namely, MC-34-4-24-26-27, MC-34-9-7-7-77-96-62, MC-34-7-7-17-94-60, MC-34-5-7-1-15-91-7 and MC-34-5-14-2-5-16-38 a were selected on the basis of yield performance 9.57 t/ha, 9.29 t/ha, 9.12 t/ha, 9.21 t/ha and 9.07t/ha respectively and also tested reaction to disease and insect pests.

Breeding for high yielding, disease resistance and quality rice for paddy cum fish culture in main *Kharif*

A station trial was conducted for evaluating the fifty advance lines of rice along with two checks, majority of them were tall types, for the purpose of paddy cum fish culture. All the lines were tested in replicated station trials under low land rainfed transplanted conditions. On the basis of yield performance and reaction to disease and insect-pests, 25 advance lines were selected for testing in next year under transplanted conditions.

Breeding for short duration rice genotypes suitable for pre-*Kharif* season

A set of nine short duration cultures including two checks were sown in replicated station trial during *Kharif* 2009. Out of these, two cultures namely, MC-34-1-31-19-4-8 and MC-34-1-10-35-3 (B) flowered 62 and 61 days respectively and matured in 95 and 91 days. The mean yields were recorded 3.7 t/ha and 4.8 t/ha respectively. These cultures may be useful for pre-*Kharif* season and double cropping.

Selection of promising lines from segregating and subsequent population

A large number of F_2 populations were evaluated from the crosses namely IR-64/SARS-9, IR-64/Phungphamah, IR-64/SARS-1, IR-64/Phougak,

KD-2-6-3/Yungra Makrei, KD-2-6-3/Wang shim Makel and KD-2-6-3/Phougak with the objectives of high yielding, disease and insect resistance, tolerance to abiotic stress and quality characters. About 392 lines have been selected from F_2 segregating population for desirable characters under low land transplanting condition. A huge population of F4 generation from four crosses viz. RCM-9 x Manuikharamui, RCM-10 x Akhanphou, Taothobi x RCM-10 and Akhanphou x RCM-10 was raised in lowland rainfed area and evaluation was done for high yield, resistance to disease and insect-pests and quality parameters. Selection was done in consultation with farmers representing different areas and ecologies of Manipur. Nearly five hundred outstanding families were selected for yield and yield contributing characters. All these lines will be evaluated for yield assessment and reaction to diseases and insect pests during *Kharif*-2010.

Evaluation of rice germplasm for agro-morphological characters

One hundred rice germplasm lines mostly indigenous collected from different parts of Manipur and Nagaland were evaluated for agro-morphological characters (Table 2) at ICAR Manipur Centre, Lamphelpat, Imphal.

Research Complex Regional Trial (RCRT) on upland rice (Directed Seeded)

Twelve entries were evaluated in replicated yield trial for their comparative performance under upland condition at Langol farm of ICAR Research Complex for NEH Region, Manipur Centre during *Kharif* 2009. Five entries namely, RCPL-1-128, RCPL-1-97, RCPL-1-80, RCPL-1-111 and RCPL-1-96 were outstanding over three checks and gave 6.70, 5.70, 5.60, 5.58 and 5.38 t/ha yield, respectively.

RCRT on lowland rice (Transplanted)

In this experiment, 14 entries along with one local check were evaluated in three replications for yield and its attributing traits under low land transplanting conditions. Out of these, six entries namely RCPL-1-307 (7.19t/ha), RCPL-1-300 (7.10 t/ha), RCPL-1-304 (6.71 t/ha), RCPL-1-302 (6.64 t/ha), IR-64 (6.23 t/ha) and RCPL-1-160 (6.21 t/ha) out yielded over the check. Flowering duration was from 88-110 days.

All India Coordinated Trials

Five trials of AICRIP namely, IVT-IME, (64 entries), IVT-IM (64 entries), AVT-2 M (H) (8 entries), AVT-1-M (H) (10 entries) and IVT- M (H) (19 entries) were tested for their comparative performance under low land transplanted conditions in Manipur valley during *Kharif* 2009. Out of sixty four entries, only six entries exhibited better performance over the best check, whereas in IET-(IVT-IM), 15 entries performed well and recorded significantly higher yield over the three checks. In AVT 2- M (H), eight entries were tested and out of them, four entries were superior over all the checks.

Table 2. Agro- morphological characteristization of rice germplasm

Name of character		Number of lines	Name of character		Number of lines
Grain type			**Flag leaf**		
Bold grain	:	13	Recover	:	24
Medium bold grain	:	21	Horizontal	:	17
Bold and elongated	:	1	Erect	:	29
Short bold	:	5			
Long slender	:	1	**Panicle axis**		
Long bold	:	6	Droopy	:	47
			Straight	:	1
Plant type					
Tall	:	9	**Panicle type**		
Dwarf	:	2	Intermediate	:	3
Semi-dwarf	:	1	Compact	:	42
Medium tall	:	54	Open	:	2
			Spreading	:	1

INGER Nurseries

Four INGER nurseries namely, IURON, IRCTN, INEVDUST and AERON were sown. Ninety nine entries including check were tested in IURON for yield and its attributing characters. Out of these, seven entries showed better performance over the check in upland conditions. These entries will be tested again in *Kharif* 2010 for yield attributing traits. IRCTN trial consists of 53 genotypes along with local check, was evaluated in rainfed low land transplant condition. Some genotypes did not germinat while some others showed susceptibility to cold. Nine genotypes exhibited better performance over check, when sowing was done in last week of August. An experiment was conducted on INEVDUST for DUS characterization of 77 genotypes at Langol farm of ICAR. Data were collected on eighteen DUS traits.

Pulse Improvement Programme

Evaluation and advancement of segregating generation of interspecific crosses in pigeon pea

The interspecific crosses comprised four cultivars of pigeon pea i.e. UPAS-120, ICPL-98015, ICPL-88034 and ICPL-99004 and one of its wild relatives i.e., *Cajanus scarabaeoides*. The cultivars of pigeon pea in interspecific hybridization were used as female parent, whereas *C. scarabaeoides* as male parent. The crosses were made with the objectives of creation of genetic variability and transfer of insect-pest resistant trait especially for pod boring weevil.

In this experiment, F_1, F_2, BC1 and their parents were grown in compact family block design and selection were made for further evaluation. The data on morphological traits for F_1, F_2, BC_1 and their parents were recorded for inheritance study. The results showed that hairs on pod were present in all F_1's of four crosses whereas it was occasionally absent in F_2 and BC_1 progenies in all crosses. This character came from male parent. However, growth habit of stem was spreading type (intermediate) in all F_1, while female parent was erect type and male as climber type. Seed size was noticed intermediate to both the parents. Male parent had striphoile on the seed which was transferred to F_1 and exhibited as dominant characters.

Evaluation of pigeon pea varieties under hill conditions

Twenty one varieties of pigeon pea were evaluated for yield and its contributing traits. On the basis of average of two years data, analysis was done on main quantitative characters. The highest plant height was recorded for the variety ICPL 88034 (238.73 cm), followed by GT-101 (238.4 cm) and CORG 2001-05 (236.5 cm). No. of primary branches/ plant was maximum for the variety ICPL 99004. However, H94-6 and ICPL85010 varieties exhibited the shortest duration for days to 50% flowering (74 days). The variety CORG 2001-05 showed the highest yield (2.01 t/ha) followed by Pusa 2003-1 (1.99 t/ha) and UPAS 120 (1.93 t/ha)

Evaluation and maintenance of germplasm lines

Eighty germplasm lines of rice bean and 50 germplasm lines of indigenous maize were evaluated and maintained for use in future breeding programme.

HORTICULTURE

Improvement programme on tomato

With the objective to develop high yielding tomato variety for Manipur, an experiment was laid out in RBD with 9 advance breeding lines. Among the selections, RCMT 4B exhibited uniform colour development and early ripening character while RCT-9 showed resistance against water logging and bacterial wilt. In terms of yield, RCT 3 (Fig 2) was found best (45.50 t/ha), followed by RCT 1 (40.75 t/ha), All these selections were more or less free from wilt and cracking. The release proposal for Selection 9A has already been sent to State Variety Release Committee.

Improvement programme on brinjal

Ten promising genotypes of brinjal were evaluated to find out suitable bacterial wilt resistant variety for Manipur, resistant to bacterial wilt. The

Fig. 2 High yielding tomato selection RCT-3

experiment was laid out in RBD with 10 advance breeding lines along with released variety Arka Keshav as control. Among the 10 genotypes, highest yield (31.00 t/ha) was recorded with RCMB 10 (Fig 3), as compared to 24.75 t/ha in Arka Keshav, though RCMB 10 was moderately resistant to bacterial wilt. Whereas, RCMB 5, RCMB 6 and RCMB 9 were found free from bacterial wilt, but yield was low. These lines can be effectively used as donor parent.

Fig. 3. RCMB 10

Improvement programme on colocasia

The experiment was laid out in RBD with 4 clonal selections (RCMC 1 to 4) of F_6 generation with five replications. Released variety Muktakeshi was taken as control. The results revealed that maximum yield (30.91 t/ha) was associated with RCMC 2, followed by RCMC 1 (27.30 t/ha) as compared to control (17.10 t/ha). The clones showed a steady performance in last three cropping seasons and RCMC-1 is now being evaluated in farmers' field.

Improvement programme on turmeric

Twenty advance breeding lines of F_6 generations were evaluated. Among different accessions, in terms of yield, RCMT-9 performed best (32.86 t/ha), followed by RCMT-11 (31.95 t/ha). The curcumin content of RCMT-9 and RCMT-11 was 6.5% and 6.62% respectively. Highest curcumin percentage (8.6%) was recorded with RCMT-7 (Fig. 4) with a yield potential of 28.7 t/ha. Curcumin content more than 7.0% was found in RCMT-23 (7.45%), RCMT-13 (7.35%) and RCMT-12 (7.1%).

Fig 4. Turmeric selection RCMT-7

Evaluation of Indigenous turmeric germplasm

Four indigenous turmeric germplasm (Fig. 5) were collected from Tamenglong district of Manipur which are extensively used as medicine by the local people. The germplasm are unique in terms of their flesh colour (white, grey, deep blue and light blue). The germplasm were given accession number namely RCMIT-1 (Dark blue), RCMIT-2 (Light blue), RCMIT-3 (Grey) and RCMIT-5 (White) and evaluated under foothill condition at Langol farm. In terms of yield, RCMIT-2 was found best (29.90 t/ha), followed by RCMIT-4 (25.50 t/ha), RCMIT-3 (23.40 t/ha) and RCMIT-1 (23.25 t/ha). Qualitative estimation for antioxidant properties is under progress.

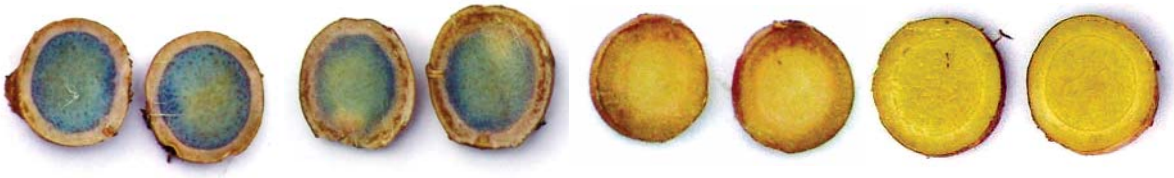


Fig. 5. RCMIT-1 RCMIT-2 RCMIT-3 RCMIT-4

Evaluation of indigenous ginger germplasm

Seventeen indigenous germplasm of ginger were collected from different parts of Manipur and evaluated under foothill condition at Langol Farm. Maximum yield (14.94 t/ha) was recorded with RCMG-3, followed by RCMG-2 (12.96 t/ha). Lowest yield was found in RCMG-11 (3.60 t/ha). The experimental result revealed that, there is a need as well as vast scope for improvement of local ginger germplasm in term of yield.

Collection, evaluation, characterization and documentation of local French bean, *Dolichos* bean and cowpea germplasm of NEH region using morphological and protein marker.

Twenty local germplasm of French bean, 12 local germplasm of *Dolichos* bean and 15 local germplasm of cowpea were collected from different parts of Manipur. The protocol for extraction of protein from mature seeds was standardized. Electrophoresis for SDS-PAGE protein profiling was carried out in separating gel of 12%, 12.5%, 13% and 14% concentration. Maximum variation was recorded in 13% gel concentration.

Effect of organic manures and inorganic nitrogen on King chilli

King chilli is one of the most important indigenous spice crops in Manipur. But very little work has been done on standardization of agro-techniques for this popular crop. Therefore, an experiment was conducted to study the effect of organic and inorganic sources of nitrogen on King chilli. Nitrogen @ 100 kg/ha was applied through 3 levels of organic manures i.e. FYM and vermicompost (25% N, 50% N and 75% N) in combination with 3 levels (75% N, 50% N and 25% N) of inorganic source of nitrogen (urea). The result revealed that application of 25% N through vermicompost along with 75% N through urea was found to be the best in terms of maximizing the yield of King chilli (1.50 kg/plant) under foothill conditions of Manipur.

Standardization of irrigation schedule through bamboo drip in passion fruit

The experiment was conducted to standardize the water requirement and irrigation schedule for passion fruit to provide life saving irrigation through bamboo drip. The experimental result revealed that, application of 3 lit of water at 2 days interval is best in terms of yield (21.82 t/ha), followed by watering at 3 days interval (20.82 t/ha).

Standardization of mushroom spawns and mushroom production technologies with locally available raw materials

Paddy straw, maize stem and banana pseudostem were tested for production of mushroom spawn (*Pleurotus* sp.). The experimental results revealed that maize stem was equally good as paddy straw for spawn production. As maize is an important crop in hill region, chopped maize stem has a good prospect for production of mushroom spawn. For mushroom production, paddy straw followed by banana pseudostem was found to be the best.

Standardization of technology for off season production of vegetables

The experiment was undertaken to standardize a crop cycle for year round production of vegetables under low cost polyhouse condition (Fig 6). The results revealed that crop cycle involving King chilli (Oct-Apr) → cucurbits + okra (May-Sep) → capsicum + beans (Oct-Jan) → lettuce + chilli (Feb-May) → cowpea + spinach + tomato (Jun-Sep) was the best combination for off-season production.

Fig 6. Performance of capsicum var. Thai Wonder under low cost polyhouse

Effect of vermicompost on growth and yield of broccoli

In the first experiment, there were 6 treatments, where 100%, 80%, 60%, 40% and 20% of recommended dose of nitrogen were applied in form of vermicompost and remaining part in form of urea. 100% N urea served as as control. The result revealed that application of 20% N through vermicompost and 80% N through urea was best in terms of maximum yield (20.23 t/ha) and saved 20% of inorganic fertilizer.

The second experiment was conducted to select the most suitable combination of vermicompost and biofertilizer(s) for broccoli. In this experiment *Azotobacter*, *Azospirillum* and PSB were applied singly or in combination with vermicompost. The result showed that application of vermicompost @ 8 t/ha along in combination with *Azospirillum* and PSB was most suitable for broccoli and recorded 18.68 t yield /ha.

Standardization of paddy based vegetable cropping system in Manipur valley

The experiment was carried out to select draught resistant tomato lines for fallow land. Tomato Sel. 9A was found suitable in terms of projected yield (43 t/ha), followed by Sel. 11 (37.5 t/ha). Both the lines are also resistant to cracking and bacterial wilt.

POST HARVEST TECHNOLOGY AND VALUE ADDITION

Standardization of post harvest technology in passion fruit

The experiment was undertaken to develop commercially viable value added product of passion fruit through spray drying. Fruits at different ripening stage (1/3rd, ½, 3/4th, full ripe and over ripe) were taken for qualitative estimation. Maximum juice content (58 ml) was recorded in fruits at 1/3rd ripening stage, whereas minimum juice content (48 ml) was found in overripe fruits. Based on juice content, fruits at 1/3rd ripening stage were taken for spray drying. To maximize the powder yield (Fig 7), commercial starch (Maltodextrin) at different concentration (15, 20, 25, 30, 35 and 40% of fruit juice) was mixed with fruit juice. Maximum powder yield (40.12 g/100 ml fruit juice) was obtained with 40% Maltodextrin. The physical conditions of the spray drier like inlet and outlet temperature, pressure, flow rate etc. were standardized for passion fruit juice.

Fig 7. Spray dried powder of passion fruit

NATIONAL NETWORK ON INTEGRATED DEVELOPMENT OF JATROPHA

Survey and collection of Jatropha germplasm in Manipur

In addition to previously collected 16 local genotypes other two local genotypes (MNJ 017 and MNJ 018) were collected from Chandel and Imphal East respectively.

Progeny trial : In progeny trial, the percent increase in plant height was recorded maximum (83.74%) in TFRI-02. JIP-17 performed best in terms of percent increase in collar diameter (330.30%); maximum increase in number of branches per plant (77.49%) was high in TFRI-03. Maximum Seed yield (1500 g/plant) was recorded in accession TFRI-04. Highest fruit yield (1500 g/plant) was in JIP-15.

Local trial: In local trial, the percent increase in plant height was maximum (102.63%) in MNJ-04; whereas, MNJ-05 performed best both in terms of percent increase in collar diameter (81.66%) and increase in number of branches per plant (90.09%).

Zonal trial: In zonal trial, the maximum percent increase in collar diameter (23.58%) and number of branches per plant (289.70%) were observed in JIP-13; whereas maximum percent increase in plant height (54.20%) was in PJ-01. Highest fruit and seed yield (890 and 650 g/plant respectively) were recorded in JIP-15

Multilocational trial: In multilocational trial, the percent increase in plant height (109.14%) was

found in HAUJ-39; whereas percent increase in collar diameter (113.78%) and number of branches per plant (444.00%) was found maximum in MPJ-55 respectively.

National network trial: In National Network Trial, maximum increase in plant height (108.81%), collar diameter (52.75%) and number of branches per plant (352.76%) were recorded with TFRI-03, PJ-01 and TFRI-01 respectively.

National trial III: In national trial III, accession no. RJ-92 performed best in terms of maximum percent increase in plant height (150.52%) as well as collar diameter (146.74%); whereas number of branches per plant (5457%) was found best in accession TR-4.

Spacing trial : In spacing trial, the experimental results clearly revealed that tallest plant (356.25cm), maximum collar diameter (130.25mm) and maximum number of branches (90.12) were associated with wider spacing (3m x 4m); the percent increase in plant height (22.58%) was found in spacing (3m x 3m); whereas percent collar diameter (106.72%) and percent increase in number of branches (65.42%) were found in the wider spacing (3m x 4m); whereas, highest fruit yield (2050.00 g/plant) and seed yield (1500.00) were associated with wider spacing (3m x 4m).

Agri-silvicultural trial: Under agri-silvicultural trial, it was observed that sweet potato (var. Gauri), French bean (var. Anupam), broad bean (local), groundnut (var. ICGS 76) and soybean are the most suitable crops for intercropping in Jatropha plantation under hill slope of Manipur.

SEED TECHNOLOGY

Feasibility study on scientific production and storage of farmers' saved seed in major crops

Quality levels of the farmers' saved seeds were much superior in all aspects over the traditionally (T) produced ones. In rice varieties, RC Maniphou-7 and RC Maniphou-10, the off types present were as low as 1.13% and 1.30% respectively under *T* as compared to 13.54% under farmers' conditions. The yield advantage due to seed quality was as high as 18.50% over those using locally saved seeds (Table 3).

Table 3. Quality of farmers own produced rice seed under supervision

Standards under Indian minimum standard	Seed produced under supervision	Check
Pure seed (98%)	98.76%	87.33%
Inert matter (2.5%)	1.65%	11.67%
Weed Seed (10/kg)	2.85	35.20
Germination (80%)	85.25%	75.60%
Moisture content (%)	10.37%	13.33%

This clearly indicated the possibility of producing farmers own farmers' saved quality seeds. In maize, the variety Pusa Composite-3 produced with time isolation by *rabi* raising in Kakching (Thoubal District) and Imphal West areas was maintained for five generations and farmers could get better quality saved seeds through selection. In rapeseed too, by early sowing during Sep-Oct the cross pollination was avoided and purity level was within the permissible limit under Indian Minimum Seed Certification Standards. In rapeseed M 27, the off-types present was as low as 4.50% under scientific supervision as compared to 27.33% under traditional system of own seeds saving.

The seeds stored inside RC Seed bin (Fig 8) using charcoal as desiccant (Fig 9) was found to maintain the seed quality in respect of physiological and health aspects for more than two sowing seasons as compared to the ambient open storage in all these crops. Thus small farmers could use good quality seeds from their own crop fields for their own use just with some extra efforts and care and participatory approach.

Fig 8. RC seed bin

Fig 9.Tying of 0.7 mm polythene bag over seed and charcoal bags for moisture vapour proofing in RC seed bin

Maintenance breeding of locally released/ recommended varieties of important crops

Rice varieties being released from the centre are being maintained through panicle row selection and basic seeds are being produced every year. Seeds were supplied to the framers either directly under FLD programmes or through state Department. The varieties are for pre *Kharif*, RC Maniphou 4 and RC Maniphou 5. The main *Kharif* varieties are RC Maniphou 6, RC Maniphou 7 and RC Maniphou 10. In maize composite variety Pusa Composite 3 has been maintained since 2005 with time isolation by sowing during *rabi*. Rapeseed variety M 27 was maintained for 5 years with 96.54% purity level.

During the year, 2530kg basic seed of RC Maniphou 4 and 1980 kg of RC Maniphou 5 were produced as pre *Kharif* varieties. 4050kg of Basic seeds of RC Maniphou 7 (Fig 10), 1300 kg of RC Maniphou 10 were also produced. 130kg seed of RC Maniphou 6 is under nucleus stock purification for multiplication through panicle rows. In maize, Pusa Composite 3 (Fig 11) was maintained with time isolation by *Rabi* planting (Dec-Jan) in the valley area. 225 kg of basic seeds was produced. In rapeseed M27 too, pure seeds was maintained by early sowing and 130 kg of breeder quality seed was produced. In groundnut, varieties ICGS 76 and JL 24, TAG 24 while in soybean, variety JS 335 were maintained (Table 4).

Fig 10. Maintenance of rice variety RC Maniphou 7 through panicle row selection

Fig 11. Maintenance of maize var. Pusa Composite 3 with time isolation

Development of seed production packages in important crops

As seed industry is almost absent in the region, an effort was on to develop suitable seed production practices under the locally prevailing situations. The major problem in seed production is small size land holdings. Thus, specialized techniques suitable to small and poor farmers need to be developed. For rice fields, 2 to 3 years were needed to clear obnoxious weeds (Fig 12) which are abundantly found in the wetland rice fields. It could be improved through vigorous roguing. For pre *Kharif* rice varieties, summer planting was found almost at par with pre *Kharif* sowing due to the cold temperature at early stage. Seed replacement after 2-3 years was found better for own save seeds use cycle.

Table 4. Basic seed production during 2009-2010 at Manipur Centre

Crop	Variety	Basic seed production (kg)	Crop	Variety	Basic seed production (kg)
Rice	RC Maniphou 4	2530	Rapeseed	M 27 (Breeder seed)	13
	RC Maniphou 5	1980		M 27	610
	RC Maniphou 6	130	Groundnut	ICGS 76	180
	RC Maniphou 7	4050		ICGV 86590	157
	RC Maniphou 10	1300		JL 24	19
Maize	Pusa Composite 3	50		TG 37-A	23
	Sweet corn	5	Soybean	JS 335	200

Fig 12. Obnoxious weed present in rice seed production field as genetic contaminants

Fig 13. Effect of planting time on seed set in two rice varieties RC Maniphou 7 and RC Maniphou 10

For cross pollinated crops like maize, time isolation by *rabi* planting (Dec-Jan) was found suitable both for pollination and post harvest operations. Early planting by Aug to Oct depending on soil moisture was suitable for rapeseed, M 27 seed production. RC Maniphou 7 (Fig 13) was suitable for late planting and RC Maniphou 10 could not set seed under very late conditions.

Development of seed storage practice

The humid and fluctuating weather pose difficulty in safe storage of seeds in the region. In an effort to develop sustainable low cost medium seed storage technology for different crops, studies were conducted in rice, maize, soybean, rapeseed and peas to assess the effect of botanicals in seed storage. There was reduction in storage pests with application of locally available botanicals viz., *Artemisia parviflora, Goniothalamus sesquidedalis, Plectranthus ternifolius, Vitex negundo* (Table5). These botanicals, when applied to the storage pests exhibited knock down effects showing repellent action but no lethality of the insects were noticed. But these did not have long residual effect. However, storage under desiccated conditions with charcoal could reduce the moisture and thereby the infestation of macro and micro organisms too.

Table 5.Effect of plant powders on germination percentage of seeds after storage

Botanicals	Rice (var.RC Maniphou 7)				Maize (var.Pusa Composite 3)			
	Storage period (months)							
	4	8	12	20	4	8	12	20
Artemesia parviflora	91.88%	90.88%	85.21%	65.25%	89.71%	89.34%	65.22%	23.45%
Goniothalamus sesquipedalis	94.35%	91.40%	84.25%	67.34%	91.50%	92.25%	67.33%	26.65%
Plectranthus ternifolius	92.65%	91.25%	83.26%	64.33%	90.33%	89.55%	55.88%	32.66%
Vitex negundo	90.34%	91.24%	87.24%	65.16%	91.45%	92.64%	66.78%	22.34%
Botanicals	**Soybean (var.JS335)**				**Rapeseed (var.M27)**			
	Storage period (months)							
	4	8	12	20	4	8	12	20
Artemesia parviflora	87.43%	88.65%	67.34%	31.44%	86.66%	88.50%	80.44%	76.50%
Goniothalamus sesquipedalis	88.12%	88.54%	66.95%	22.87%	87.45%	86.45%	82.33%	78.25%
Plectranthus ternifolius	85.60%	84.55%	65.34%	24.02%	87.33%	85.46%	81.24%	77.85%
Vitex negundo	83.68%	82.45%	66.33%	30.65%	86.35%	86.35%	83.41%	72.33%

Establishment of model nurseries of medicinal plants at Imphal West, Churchandpur and Ukhrul district under NMMP

Under the sponsorship of National Mission on Medicinal Plants (NMMP), three Model Nurseries were to be established at Imphal West, Churachandpur and Ukhrul district. Out of these, a main mother Medicinal Plant Garden has been established (Fig 14). At the Main Model Nursery at Imphal, 3300 *Acorus calamus* was planted. *Stevia rebaudiana* (2800 plants) were transplanted from seedling and propagated through stem-cutting. 100gm seed was also harvested. There are 40 grafted and 24 seedlings of *Emblica officinalis* in the propagation house and 350g of seeds was procured from outside the state. Four hundred stem-cuttings of *Rauwolfia serpentina* procured from outside were planted as mother plant for further multiplication through stem-cutting. *Piper longum* (280nos.) stem-cutting plants were planted. Medicinal plants, viz., *Ginseng, Paris polyphylla, Taxus bacatta, Smilax lanceifolia* and *Swertia chirata* were planted (Fig 15).

Fig 14. A View of model nursery of medicinal and aromatic plants at ICAR, Manipur Centre

Fig 15. Planting material of medicinal and aromatic plants at hardening stage

CROP PRODUCTION

Collaborative trial on bold seeded groundnut (A Series and B Series)

Under this trial, 12 bold seeded groundnut varieties (A series) were tested under foothill condition of Manipur. NRGS-CS-268 was found to be the best yielder 3.69 t/ha) followed by JH-24 (2.970t/ha) and G-42 (2.65 t/ha). Lowest yield was observed with GG-20 (1.02t/ha). In another experiment, 13 bold seeded groundnut varieties (B series) were evaluated at Langol farm (Approx. 800 m above MSL) to study the yield performance. Among the different varieties, maximum yield was recorded with GG-8 (3.73t/ha), followed by TG-37-A (3.59t/ha) as compared to lowest yield (1.15t/ha) in GG-16.

Collaborative trial on boron nutrition on groundnut

The efficacy of different commercial formulations of boron on growth and yield of groundnut was studied (Table 6). The results revealed that the soil application of Agricol @ 50 kg/ha was best in terms of obtaining maximum yield (4.93 t/ha), followed by soil application of Borosol @ 25kg/ha (4.38 t/ha).

PLANT PROTECTION

Survey and management of important diseases of passion fruit

Survey of passion fruit growing areas was completed and the recorded pathogens were identified; *Verticillium alboatrum, Fusarium oxysporum, F. solani, F. redolense, Periconia lateralis, Phomopsis tersa. Arthrinum pheospermum, Epicoccum purpurascence, Botryodiplodia theobrome*. In vitro evaluation of five fungicides viz. Bavistin (carbendazim 50WP), Antracol (propineb 75 WP), Sectin (fenamidone 10% + mancozeb 50%WG), Monceren 250SC (pencycuron 22.9SC) and Folicur250 SC (tebuconazole 25.9 EC) was done against *Fusarium solani*, *Phomopsis tersa* and *Glomerella cingulata*. Folicur and Monceren gave 100% control of *Fusarium solani, Phomopsis tersa* and

Table 6 Performance of different sources of boron on groundnut

Treatment	Dose (kg/ ha)	Mode of application	Plant height (cm)	No. of branches	No. of pods per plants	Yield (t/ha)
Borax	44	Soil Application	50.78	11.11	6.22	3.83
Agricol	50	Soil Application	50.22	11.45	8.11	4.93
Chemibor 11S	25	Soil Application	52.00	10.44	5.89	3.99
Chemibor 20	15	Foliar Spray	58.00	12.33	7.93	3.35
Solubor	25	Soil Application	53.89	17.67	9.30	3.57
Solubor	13	Foliar Spray	57.33	10.67	8.11	3.70
Borosol	25	Soil Application	54.56	10.67	8.37	4.38
Borsol	13	Foliar Spray	54345	11.56	9.15	4.22
Maxibore	25	Soil Application	60.78	10.33	7.59	3.94
Control	—	—	53.33	12.22	10.26	3.85

Glomerella cingulata followed by Bavistin as compared to control.

Studies on diseases of jatropha in Manipur

Survey of jatropha (*Jatropha curcas*) plantations for various diseases was completed and the pathogens were identified (Table 7). During the year following fungi were isolated and identified; *Phoma sorghina, Pestalotiopsis guepinii, Periconia byssoides, Phoma exigua, Fusarium equesetti, Botriodiplodia theobrome, Neocosmospora vasinfecta, Phomopsis tersa*. In vitro evaluation of five fungicides viz. Bavistin (carbendazim 50WP), Antracol (propineb 75 WP), Sectin (fenamidone 10%+mancozeb 50%WG), Monceren 250SC (pencycuron 22.9SC) and Folicur 250 SC (tebuconazole 25.9 EC) was done against *Colletotrichum gloeosporioides* and *Glomerella cingulata*. Monceren was 100% effective against *C. gloeosporioides* followed by Bavistin. Folicur and Monceren gave 100% control of *G. cingulata* as compared to control. Antracol and Sectin were not effective against *G. cingulata*.

Evaluation of rice germplasm against fungal diseases

Two hundred and eighty eight lines / varieties were evaluated under field conditions under the

Table 7. Incidence of diseases in Jatropha collections

Accession no.	Place of collection	% Disease infected plants		
		Mosaic	Powdery mildew	Powdery mildew + Mosaic
MNJ-001	Chandel	90.00	0	20.00
MNJ-002	Khumbong, Imphal West	85.71	0	14.28
MNJ-003	Changangei, Imphal West	25.00	12.50	50.00
MNJ-004	Sabal Leikai, Nambol, Bishnupur	50.00	0	25.00
MNJ-005	Phoijingtongba Kabui village, Bishnupur	83.33	0	0
MNJ-006	Pangei, Imphal West	75.00	12.50	12.50
JIP-02	SKUAST, Jammu	16.66	16.66	0
JIP-13	SKUAST, Jammu	0	0	0
JIP-15	SKUAST, Jammu	0	20.00	0
JIP-17	SKUAST, Jammu	40.00	20.00	20.00
TFRI-01	TFRI, Jabalpur	16.66	0	0
TFRI-02	TFRI, Jabalpur	0	20.00	0
TFRI-03	TFRI, Jabalpur	50.00	0	12.50
TFRI-04	TFRI, Jabalpur	75.00	0	0
PJ-01	GBPUAT, Pantnagar	50.00	0	0
PJ-02	GBPUAT, Pantnagar	57.14	0	0

project "Rice improvement through participatory plant breeding" for their reaction against blast, sheath blight and brown spot diseases. For neck blast the disease score varied from 1 in KD-5-3-1-4, Ngonolhasia, Thekrulha , Bauwhite(AP), Kwangohai, China 1, Tamphaphou, Drumphou upok, Kumpamah, Makharol, Langphou angoubei, Akutphou, Kenhon, Chakhou amoubi, Ching chakhao, Manui nira, Mayamasitang , Yangoepya, Kazizhum, Ymkgisdi, Ratkhara, KD/phougak, Runya, Drum phou, Athormah to 7 in Changfai, Lmsajang, and Prakash. The incidence varied from 5 in Phourel to 60.25 in Leimaphou (KD 263). All other lines were free from neck blast. The highest disease score of 7 against leaf blast was recorded in Kene. The score of 2 was recored in Khatajang, WR-1-9-1-9, China chakhao, Kunpamah, RCM10, and Gumdhan.

In case of brown spot disease, lowest disease score of 1 was recorded in Apagaizuche, sangbaimah, Mephongissok, Mayajang, China 1, Tsushruri, Kwangohai, M-26-6-2-3-1, basmati 370, Saras 9, Mioun-AP, Wesheioru, Thumpak-TSS, Phougak, Roto-tasia, SS-saras 9, Maya special 2, Khatishizunk, Teruntssok, Sariemasojang, Ngoloharia, Moroephyo, Kumunub-Thei, Talui, Lesemjang, Rachatmakra, Phoutumah, Yanjoepya, Mutshku, Moyajangtemesong, KD phou, Daksemla, Naga-S1, Kezizhum, Seicalha, Alucaisho, Ratkhara, KD/phoigak, Tslumasotame, Tsuduri, Wokha, Athormah, Zunhidoto, Tssoknyiku, Nagarhmah, Maisagang to 6 in SS-Sara9.

In case of sheath blight, the disease score varied from 7 in KD263, Lungnilaphou, Wazhuhophek, KD phou to 1 in Thekrulha and Kezishum.

In case of sheath rot, the highest score of 5 was recorded in Chakhao angou, WR-1-9-1-1, Moibo-tsok, Chingpumah and Mahakalwa to 1 in Dukencyh, Ngoazu, Otsokhria, Phagmo, Koyajang, Phungmah, Chakhao, Kumnukuzum, China 1, Saras 2, basmati 370, Tengubedphek, Metiak, Kenyo, Phumphamuh, Langhouupokpi, Amukungmei, Taloimah, Chakhaolamhmae, Tshngmekijang, Chingphaorel amubi, Bisaho, Chingphourel, Wezhuho, Thumpak-TSSOK, Saras 2, Chingphou, Khatishi-zunk, Kisheghi, Teru TSSOK, Ngolohasia, Talui, Mayamasitang, Phoutumah, Chongphouawangdi, Machangkajik, Moikhongnembi, Moyajongtemesong, KD phou, Daksemla, Kiphekmukhi, SS-Saras 9, Tsunghi, Seicalha, Jaksa, W/R/RCM20, Chakaho Kumbi, Mutsaku, Uteiuimh, Zunhidoto, Bali (red), Talinamh, and Tsuknyiko 263, Lungnilaphou, and Wazhuhophek, to 1 in Kezishum, Thekrulha .

Monitoring of field virulence in *Pyricularia oryzae*

A trial was laid out to monitor the virulence pattern in the population of blast pathogen. The nursery included 25 cultivars consisting of international differentials, RILs, donors and commercial cultivars. The observations were recorded on 0-9 scale of SES on different differentials. Data are given in Table 8.

Table 8. Virulence pattern of *Pyricularia oryzae* on differentials

Differential entries		Leaf blast	
No.	**Name**	**Lesion type**	**Mean score**
BL. 1	C 101 LAC	D	3.33
BL. 2	C 101 A51	D	4.00
BL. 3	C 104 PKT	E(D)	7.33
BL. 4	C 105 TTP-4-L 23	A	0.00
BL. 5	RIL 10	E(D)	7.67
BL. 6	RIL 29	D	3.33
BL. 7	*O. minuta*	C	2.33
BL. 8	BL 122	C	2.67
BL. 9	BL 245	A	0.00
BL. 10	A 57	E(C)	4.67
	RCM10 (Resistant check)	A	0.00
BL. 11	C 101 PKT	A	0.00
BL. 12	Raminad Str. 3	A	0.00
BL. 13	Zenith	E(D)	7.00
BL. 14	NP 125	E(D)	5.00
BL. 15	Usen	D	4.33
BL. 16	Dular	A	0.00
BL. 17	Kanto 51	A	0.00
BL. 18	Shi-tia-tsao	A	0.00
BL. 19	Calaro	A	0.00
BL. 20	Tadukan	A	0.00
	KD 263 (Susceptible check)	C	2.33
BL. 21	IR 64	A	0.00
BL. 22	Tetep	A	0.00
BL. 23	HR 12	E(D)	4.67
BL. 24	Rasi	D	3.33
BL. 25	Co 39	D	2.33

Cluster analysis of *P. oryzae* reactions on the selected genotypes revealed that the racial spectrum at Imphal, Upper Shilling, Barapani Coimbatore,

Mugud, Rajendranagar, Karjat, Pattambi, Nellore, Nawagam, Titabar, DRR, Hazaribagh, Jadalpur and Raipur were similar.

Screening for rice diseases (NSN-H)

Eighty six entries sent (NSN-H) by DRR Hyderabad were screened for multiple diseases. The disease score for neck blast varied from 1 in SJR 51-1-2-1, Vl 31451, RCPL 1-1/6, VL 7852, VL 30560, VL 7620, SKAU292 to 9 in SKAU, HPR, Vivekdhan 62. The lowest disease score of 1 was recorded in UPRI2006-1. The highest disease score of 9 was recorded in RCM12, RCM 24, RCM 25, HPR2543, HPR 2589, HPR 2625{D(24)}, VL31452, UPR3276-6-1-1, UPR32281-3-1-1, VL 31451, RCPL1-115, RCPL1-116, UPR3297-9-1-1, KD263, VL31329, VL31331, Vl31335, UPR2919-14-1-1, UPR2992-17-3-1, VL30917, VL30919, HPR2512, RCM21, VL30920, Vl31339, Vl31334, HPR2143, RP2421, Rasi, IR64, Vikramarya, IR50, Ajaya, TN1. The disease for brown spot varied from 2 in Vivekdhan 62 to 8 in VL7820. The lowest disease score for sheath rot was 3 in UPR3276-6 - 1-1, UPR3297-9-1-1 and it was 7 in Vivekdhan 154.

FISHERY

Standardization of seed production and culture techniques of some potential indigenous fish species of northeast hills for aquaculture

Bagana dero (Khabak), *Clarias magur* (Ngakra) and *Channa gachua* (Meitei ngamu) collected from different water areas of Manipur. Studies on food and feeding habits, length and weight relationship, sexual dimorphism, reproductive cycle and reproductive strategies were initiated in *Bangana dero* (Fig 16), locally known as khabak (Manipuri), Khital (Tangkhul), Ngatai (Myanamar). It is a medium carp with maximum standard length of 40cm. It highly relishes eating fish. This fish species known to occur plenty in lakes and river of the state. However, the fish is now confined to clear streams and river of foothills of Manipur.

Thirty five advanced fries of this species having a total length of 6.5±2.1 cm and body weight of 2.70±4.5g were collected from the rivers in Tamenglong district of Manipur in the month of October and November 2009. The fishes were reared in earthern ponds. The fishes were fed with a formulated feed containing 30% crude protein at the rate of 5% body weight per day. Matured fishes show sexual dimorphism. The male has a slender body its pectoral fin has rough dorsal surface and the same is longer than female and its abdomen does not bulge out as in females.

Further on applying gentle pressure, milt oozes out through the genital aperture. In female, the pectoral fin is smooth, has a reddish, soft swollen and bulging belly. On applying gentle pressure on its belly eggs ooze out. Studies on spawning behaviour and induced breeding are under progess.

Description of the ovaries

Ovary of *B. dero* was bilobbed with a short oviduct. The two lobes of each ovary were more or less of same size. The shape and size of the ovary were found to depend on the stages of sexual maturity of the female. In the immature and resting stage, ovaries were stripe like and white in colour, but in mature stage it became larger in size and yellowish in colour. The ripe ovaries were found to extend up to the end of the urinogenital pore. The size of the matured ovum ranged from 0.68 to 0.78 mm with an average of 0.70 ± 0.68 mm in ripe stage and obtained around 600-800 ova.

Fig 16. *Bangana dero*

Standardization of breeding and culture techniques for potential indigenous ornamental fishes of northeast region for commercialization

Regular surveys were conducted in different water areas of Manipur Different fish samples were collected by using different fishing techniques and tools as per fish collection methods and standard

(1993). Live specimen were transported, acclimatized and maintained in the laboratory for further studies. Identification of the fish species was done with reference to Day (1988), Talwar and Jingaran (1991), Jayaram (1999), Vishwanath (2002). A total of 57 indigenous ornamental fish species including 12 endemic belong to 35 genera under 17 families were collected from different water areas of Manipur. Studies on bio-ecology and breeding behaviour of selected fish species viz., *Devario acuticephala, Acanthocobitis zonaltrenus, Mystus* spp and selected *Puntius* spp. were initiated.

SOCIAL SCIENCE

Estimating marketing efficiency of horticultural commodities under different supply chains in India

Tomato marketing in Manipur

The examination of per hectare disposal pattern of tomato showed that the farmers marketed almost all the produce (94.81 percent) from the farm. Total marketed surplus was 316.91 quintal per hectare. The total cost of production varies from Rs. 70327.71 on large farms to Rs. 73165.61 on small farms. There existed a negative relationship between the tomato production and farm size. The benefit cost ratio was higher on small farms (5.77) as compared to large farm (5.75) and medium farms (5.73).

Three types of marketing channels were observed (Table 9). It was observed that the maximum quantity of tomato was passed through channel 1 (62.20 percent), followed by channel 2 (28.74 percent) and the lowest quantity of tomato was sold through channel 3 (9.07 percent). Study on marketing costs and marketing margins per quintal of tomato for channel 1 revealed that the farmer's share in the consumer's rupee has been found to be 82.75 percent. Marketing costs and marketing margins per quintal of tomato for channel 2 in Manipur showed that farmer's share in the consumer's rupee has been found to be 51.90 percent. However, in the case of channel 3 the farmer's share in the consumer's rupee has been found to be 42.81 percent. Total marketing expenses incurred by farmer is worked out to be Rs.70.98 per quintal of which losses consumed highest share, *i.e.*, about 95 percent of the cost incurred by producer. It is observed tomato producer fetches Rs.1321.76 per quintal as his net margin. Channel-wise marketing cost and marketing margin of tomato showed (Tables 10 and 11) that marketing cost and marketing margin vary considerably from channel to channel and were related directly to the length of the channel, *i.e.*, longer the channel, more were the marketing cost and marketing margin. Similarly, the price paid by the consumer increased with the increase in the length of the marketing channel or with the increased in the numbers of intermediaries involved between the producer and the ultimate consumers.

Table 9. Marketing channel of tomato

Particulars	Supply chain
Channel 1	Producer - Retailer - Consumer
Channel 2	Producer - Wholesaler -Retailer - Consumer
Channel 3	Producer - Village trader - Wholesaler - Retailer - Consumer

The price spread in Channel 1 was found to be lowest (Rs.379.92 per quintal) and highest in Channel 3 (Rs.1766.07 per quintal). Thus it can be concluded that as the length of channel increases the price spread also increases and vice-versa. The marketing efficiency was found to be highest in Channel 1 (11.51); followed by Channel 3 (7.06) and lowest in Channel 2 (6.55).

The constraints being faced by farmers in the marketing of tomato were ranked and prioritized by using Garrett's ranking method. Perishable nature of the product was ranked as the first major constraints (with a mean score of 76.54) faced by the tomato farmers in the marketing of the product. Next second rank with the score value of 73.04 was given to the problem of transportation. Third rank with the score value of 72.42 was given to presence of exploitative middlemen. Low price, bands, blockade, strikes, curfew, lack of market information, lack of knowledge of proper grading and packaging, inadequate facilities in market, lack

Table 10. Marketing cost and marketing margin of tomato (Rs./q)

Item	Channel 1		Channel 2		Channel 3	
	Cost	% Consumer price	Cost	% Consumer Price	Cost	% Consumer price
Farm gate price	1822.83	82.75	1436.04	51.90	1321.76	42.81
Marketing cost						
Producer	122.41	5.56	131.09	4.74	70.98	2.30
Assembler/Trader	-	-	-	-	93.06	3.01
Wholesaler	-	-	196.03	7.08	190.70	6.18
Retailer	69.04	3.13	95.44	3.45	82.36	2.67
Total Marketing Cost	191.45	8.69	422.56	15.27	437.10	14.16
Marketing margin						
Assembler/Trader	-	-	-	-	414.19	13.41
Wholesaler	-	-	386.47	13.97	370.15	11.99
Retailer	188.47	8.56	522.09	18.87	544.62	17.64
Total marketing margin	188.47	8.56	908.56	32.83	1328.97	43.04
Consumer price	2202.75	100	2767.16	100	3087.83	100

Table 11. Measurement of marketing efficiency of tomato

Particulars	Unit	Channel 1	Channel 2	Channel 3
Retailer's sale price (RP)	Rs./q	2202.75	2767.16	3087.83
Total marketing cost (MC)	Rs./q	191.45	422.56	437.10
Total margins of intermediaries (MM)	Rs./q	188.47	908.56	1328.97
Price received by farmers (FP)	Rs./q	1822.83	1436.04	1321.76
Value added by the marketing system (1-4)	Rs./q	379.92	1331.12	1766.07
Convention method (E) (5/2)	Ratio	1.98	3.15	4.04
Shephered's method (ME) (1/2)	Ratio	11.51	6.55	7.06
Acharya's method (MME) [4/(2+3)]	Ratio	4.80	1.08	0.75

of storage facilities, non-availability of market credit, faulty weighment and no facilities for personal stay at market were allotted fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh and twelfth ranks respectively.

Socio-economic analysis of agricultural systems in the hill side areas of Churchandpur, Tamenglong and Chandel districts, Manipur

Adoption of shifting cultivation in Churchandpur district, Manipur

The Churchandpur district of Manipur is one of the worst shifting cultivation affected districts of Manipur (Basic Statistics of Manipur, 2007). About 57 per cent of the total households were engaged only in *jhum* agriculture while 15 per cent were practising both *jhum* and terrace cultivation. Thus, in total over 70 per cent of the households were entirely or partially depended on *jhum* agriculture. In terms of area, the proportion of net cultivated area under *jhum* cultivation was 61 per cent (55 per cent solely *jhum*ing and 6 per cent *jhum*ing plus terrace). This clearly indicated that *jhum* cultivation is the predominant feature of the area, occupying over three-fifth of the net cultivated area on which over two-third of the households were directly or indirectly dependent for their livelihood. The average size of farm holdings and per capita availability of land under solely jhuming was also found to be very low (1.07 ha and 0.15 ha). Over 87 per cent of the areas under jhum cultivation fall under the low *jhum* cycle of 5-7 years (Table 12). The low *jhum* cycle and per capita availability of *jhum* land is mainly due to larger family size and existence of limited *jhum* lands for cultivation. This

trend may lead to further deterioration in the sustainability of hill agriculture in the long run by means of more deforestation and declining land productivity (Table 12).

Determinants of adoption of shifting cultivation

The study indicated that among the various factors responsible for adoption of *jhum* cultivation, lack of viable employment and income earning alternatives was found to be the most important factor expressed by cent per cent (100 per cent) *jhumias* under study. The jhumias neither had their own enterprises nor other employment avenues where they could work on day to day basis. Moreover, the state as a whole is lagging behind in industrial establishments and undertakings, thus providing limited off-farm employment opportunities. It is worthwhile to mention that some of the *jhumias* had abandoned *jhuming* and were working as labourers in the GREF (General Reserve Engineering Force) road construction programme in some villages of the study area, implying that employment generation programmes have significant importance in the area. The lack of infrastructure, particularly irrigation, road, communication, market and rural electrification was another crucial factor for continuation of *jhum* occupation. Inadequate government support and lack of suitable lands for settled cultivation were also found to be major problems. Lack of irrigation facilities constrains the conversion of *jhum* land into terrace field. Although horticultural crops had high potential in the area, it remained as a dream for the *jhumias* due to lack of market infrastructure, road, and communication network, etc. Lack of prevailing market information in the town market was also responsible for low price of their produce which was almost controlled by the itinerant traders. Settled cultivation required higher initial investment both in terms of money for purchasing land from the chief, hiring of labour and other inputs. On the other hand, most of the *jhum*ias were in the grip of poverty. Thus, inadequacy of capital to invest in land improvement and generate other infrastructure on farm came out to be the fifth most important factor. Lack of institutional support and credit in the study area rather worsened the conditions of the *jhum*ias. There is no institution or agency involved in conducting research in finding out viable alternatives to *jhum*ing or improvement of the present system through crop and livestock development, soil conservation, horticultural development, and agroforestry, etc. The agricultural research in the region had given more attention to valley based system of cultivation, keeping *jhum* cultivation in the embryonic stage of agricultural development. Similarly, most of the training and extension programmes were oriented towards valley based agriculture and thus, did not cater to the needs of the *jhum*ias. Absence of individual ownership right of land got a quantitative score of 292 indicating the important of its influence in continuing shifting cultivation. Due to lack of ownership rights the *jhumias* rendered less effort for land development activities. The financing institutions also did not lend agricultural credit to *jhumias* as they were unable to mortgage the land owned by the village chief. Socio-cultural factors of the farmers got the least score of 85.

Table 12. Distribution of farm households and net cultivated area under different types of cultivation

Types of cultivation	No. of farm household	Net cultivated area (ha)	Cultivated area per household (ha)	Family member per household (no.)	Land per capita (ha)
Solely *jhum*ing	85 (57)	91.26 (55)	1.07	7.07	0.15
Jhuming + Terrace	23 (15)	31.67 (19)	1.38	7.80	0.18
Solely terrace	22 (15)	20.12 (12)	0.91	7.51	0.15
Solely valley	20 (13)	23.50 (14)	1.18	6.30	0.19
Total/average	150	166.55	1.14	7.17	0.16

Figures in parentheses indicate percentage to total

Economic analysis of adoption of quality seed in Manipur

In this study, a multiple response of supportive and hindering factors in the use of quality seed was observed (Table 13).

Among the supportive factors, awareness has maximum impact in the acceptance of quality seed in all the four selected crops, while new variety has the least important in the adoption of quality seed. In rapeseed and mustard, potato, and tomato, the availability of seed is the second most important supportive factor. Publicity, yield difference and demonstration effect are also important supportive factors for the adoption. In the case of potato and tomato, yield difference is the second most important supportive factor followed by publicity. Purity also has good response in the acceptance of quality seed. Lack of awareness was found to be the most hindering factor in paddy while in the case of rapeseed and mustard non-availability of desired variety seed to be important. In case of potato, untimely supply was the most hindering factor for the acceptance of quality seed followed by non availability of desired variety seed. Higher prices and lack of fund are also important hindering factors which negatively influenced the acceptance of quality seed in potato and tomato. Fear of adulteration in quality seed is another important criterion to neglect the quality seed in rapeseed and mustard and tomato. A higher price is the least hindering factor in paddy, and rapeseed and mustard while lack of awareness is the least hindering factor for potato and tomato (Table 14).

FLD on high quality protein maize variety HQPM 1

Front line demonstrations of high quality protein single cross hybrid maize HQPM 1 was conducted in four districts of Manipur. The total area covered was 10 ha with a yield ranging from 2.70t/ha to 5.20t/ha. The yield advantage was upto 26.54% over the traditional varieties/seeds.

Fig 17. Hybrid maize HQPM 1

Table 13. Level of adoption of quality seed in Manipur

Particulars	Paddy	Rapeseed and Mustard	Potato	Tomato
Total number of farmers surveyed	160	40	30	70
Acreage covered under the crop in the survey (ha)	192	52	17	41
Acreage under certified seed in the survey (ha)	7.68	48.95	12.62	39.34
Per cent area under certified seed	4.00	94.14	70.95	95.94
Number of farmers who used the certified seed	7	38	23	68
Percentage of farmers who used the certified seed	4.38	95.00	76.67	97.14

Table 14.Transfer of technology under National Agricultural Innovation Project (NAIP)

Programme	No. of farmers	Area covered (ha)
Adoption of Rice seed production (RCM 5 and RCM 10)	21	5
Adoption of Hybrid maize production (HQPM-1)	18	1.5
Adoption of black gram cultivation (T-9)	35	5
Adoption of soya bean cultivation (JS 335)	21	2.5
Adoption of groundnut cultivation (ICGS 76)	32	2.5
Adoption of zero tillage in rapeseed-mustard cultivation (M 27)	40	12.5
Farmers' training programme	20	340 persons

MIZORAM CENTRE

Weather Report

The meteorological data were recorded at ICAR, Mizoram Centre. The maximum monthly average temperature (29.4ºC) was recorded in April, 2009 and the minimum average temperature (14.7ºC) in January, 2010. The mean monthly minimum relative humidity (37.1%) was recorded in February, 2010 and the mean monthly maximum relative humidity (90.8 %) was recorded in August, 2009. The annual rainfall was 2257 mm during the year 2009-10. Total numbers of rainy days were 112. During Dec-Jan., 2010, no rainfall had occurred, making the climate dry and 78.9 % of total rain occurred during April to October, 2009 (Fig 1).

Agro-met advisory bulletins were prepared twice weekly based upon the forecasTING issued by Indian Meteorological Department (Pune).

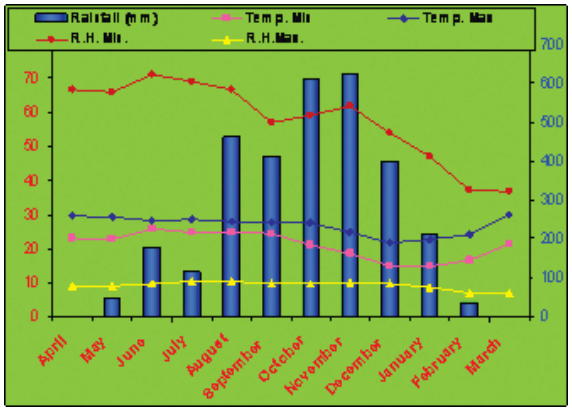


Fig 1. Graphical representation of the weather data for the period 2009-2010

AGRONOMY

Development of package of practices for cereal crops under agro-climatic conditions of Mizoram

Rice

Performance of different varieties under RCRT- upland rice trial during *kharif*

Eleven upland rice varieties were evaluated for their yield potential. The experiment was laid out in randomized block design (RBD) with three replications. The row to row spacing was 20 cm and plant to plant was 10 cm. A fertilizer dose of 80:50:40 NPK kg/ha was given by three split doses of nitrogen and full dose of phosphorus and potash was applied uniformly in the rows before sowing. The data presented in Table 1 revealed that variety RCPL1-101 recorded maximum plant height while minimum plant height was recorded with Bhalum-1. The maximum number of tillers/ hill (12.8) was recorded with variety RCPL 1-115 and the minimum number of tillers/hill was recorded with Bhalum-1. The longest panicle length was recorded in RCPL1-28 (23.3 cm) while shortest was recorded with RCPL1-80 (19.9 cm). The heaviest 1000 grain weight of 29.1 g was recorded with RCPL1-128 and lightest of 22.4 g was recorded with Sukardhan. The variety RCPL1-101 took 100 days to achieve 50% flower while shortest duration of 77 days was taken by Bhalum-1. The maximum grain yield (2.33 t/ha) and straw yield (4.66 t/ha) were recorded with RCPL1-101 which were at par with RCPL1-96, RCPL1-128 and RCPL1-97, and significantly higher than other varieties. The lowest grain yield of 1.35 t/ha and straw yield of 2.70 t/ha were recorded with RCPL1-91, respectively.

Performance of different varieties under RCRT- upland rice trail during *kharif* 2009

Eight upland rice varieties were evaluated for production potential. The experiment was laid out in CBD with three replications. The row to row spacing was 20 cm and plant to plant was 10 cm. A uniform fertilizer dose of 80:50:40 kg N, P_2O_5 and K_2O / ha was applied. The data (Table 2) revealed that the maximum height (108.1 cm) and number of grains/panicle were recorded with variety RCPL 1-103, which were significantly higher than all other varieties. Significantly, heaviest 1000 grain weight was observed with RCPL 1-117. The maximum number of productive tillers/hill (11.1) and grain yield were recorded with variety RCPL-1-103 which was significantly superior over RCPL 1-114, RCPL 1-117 and Sukardhan and at par with other varieties.

Performance of different low land rice varieties under RCRT trial

Thirteen varieties of rice were evaluated for their production potential. The data presented (Table 3) revealed that the maximum plant height 93.4 cm was recorded with variety RCPL1-72. The

Table 1. Performance of different upland rice varieties under RCRT - trial during *kharif*

Treatment	Height (cm)	No of tiller/ hill	Panicle length (cm)	No of filled grains/ panicle	Days to 50% flowering	1000 grain wt. (g)	Straw yield (t/ha)	Grain yield (t/ha)
Bhalum 1	63.0	11.4	20.8	93.7	77.0	28.3	31.6	1.58
Sukar dhan	76.0	10.7	22.4	87.0	81.0	22.4	29.1	1.46
RCPL1-78	76.4	10.1	20.4	109.4	97.0	24.7	30.8	1.54
RCPL1-96	90.8	10.0	20.0	108.4	99.0	28.7	45.1	2.25
RCPL1-101	97.3	8.5	21.3	141.3	100.0	26.3	46.6	2.33
RCPL1-80	91.8	11.4	19.9	120.5	96.0	26.1	35.7	1.79
RCPL1-91	78.1	10.1	20.8	96.8	88.0	25.0	27.0	1.35
RCPL1-93	76.1	10.0	22.3	130.3	85.0	28.1	35.5	1.77
RCPL1-111	68.7	8.5	20.1	99.9	96.0	28.1	31.0	1.55
RCPL1-128	73.8	10.1	23.3	177.8	98.0	29.1	41.8	2.09
RCPL1-97	94.7	11.0	20.7	142.4	98.0	26.3	39.2	1.96
SEm ±5	6.0	1.0	0.9	16.2		0.2	3.31	1.79
CD (*P*= 0.05)	17.7	2.9	2.5	47.9		0.5	9.76	5.29

Table 2. Performance of different upland rice varieties under RCRT- trial during *kharif* 2009

Treatment	Height (cm)	50% flowering	No of panicle / hill	No grains per panicle	1000 grain wt	Yield (t/ha)
RCPL 1-103	108.1	79	11.1	149	25.0	1.68
RCPL 1-46	71.8	92	11.1	105	27.5	1.38
RCPL 1-113	48.6	103	10.0	110	26.0	1.28
RCPL 1-114	72.1	96	9.1	94	30.4	1.40
RCPL 1-117	61.1	97	9.4	99	39.2	1.64
BHALUM 1	63.8	78	10.8	109	27.5	1.31
BHALUM 2	66.5	77	11.0	98	30.5	1.62
Sukar Dhan	67.0	81	7.6	80	26.9	1.33
SEm ±5	3.6		0.5	11	1.1	1.1
C.D. (*P*= 0.05)	10.8		1.7	33	3.4	3.3

maximum number of productive tillers/hill (12.7) was recorded with variety RCPL-303 which was significantly superior to IR 64, only. The highest number grains/panicle (168) was recorded with variety RCPL-307 and significantly, superior over RCPL1-303, RCPL1-160, IR 64 and RCPL1-302. The highest grain yield was record in UPL1-5 (4.78 t/ha) which is significantly superior to RCPL1-307, RCPL1-305, RCPL1-308 and RCPL1-304.

Varietal evaluation of RCRT trial of lowland

Seven varieties of rice were evaluated for their production potential. The data (Table 4) revealed that that the maximum plant height (98 cm) was recorded with variety RCPL-1-123, which was significantly superior over rest of the varieties. The varieties RCPL-1-124 and RCPL-1-125 came to 50% flowering earlier; while other Shasarang came to flowering late. The variety Shasarang showed

Table 3. Performance of different low land rice varieties of under RCRT trial during *kharif*

Treatment	Height (cm)	Days to 50% flowering	No grains /panicle	No of panicle / hill	1000 grain wt	Grain yield (t/ha)	Straw yield (t/ha)
RCPL1-72	93.4	99.0	126	12.1	33.0	3.78	10.7
RCPL1-160	93.3	99.0	115	12.0	33.1	4.14	12.8
RCPL1-300	90.5	96.0	140	11.4	26.1	3.44	12.9
RCPL1-301	84.9	81.0	153	11.6	26.3	4.17	9.5
RCPL1-302	73.1	96.0	101	12.7	26.7	4.50	11.1
RCPL1-303	67.8	99.0	117	11.7	28.1	4.39	9.1
RCPL1-304	77.1	96.0	152	11.2	26.4	2.91	9.6
RCPL1-305	63.7	99.0	120	11.8	28.6	3.67	9.7
RCPL1-306	70.3	103.0	156	11.8	29.0	3.81	11.6
RCPL1-307	77.2	104.0	168	12.0	27.7	3.67	11.2
RCPL1-308	73.3	94.0	129	11.5	26.5	3.62	11.9
UPL1-5	87.0	104.0	156	10.8	32.6	4.78	10.3
IR 64	54.5	94.0	112	9.2	26.0	4.36	9.2
SEm ±5	4.82		14.70	0.73	2.14	3.44	0.76
CD (*P*= 0.05)	14.06		42.90	2.14	6.25	10.06	2.21

Table 4. Performance of different low land rice varieties under RCRT trial of during *kharif*

Treatment	Height (cm)	Days to 50% flowering	Panicle length (cm)	No grains / panicle	No of panicle / hill	1000 Grain wt	Grain yield (t/ha)
RCPL1-123	98	96	19.9	68.1	7.7	26.6	1.04
RCPL1-124	69	92	23.6	72.0	8.0	27.4	1.36
RCPL1-125	95	92	22.4	79.4	8.7	26.3	2.07
RCPL1-126	95	92	26.7	37.7	10.0	29.2	1.24
Shasarang	86	98	28.2	134.7	12.3	24.9	2.05
REM 11	69	94	26.6	128.0	9.9	28.2	2.17
IR 64	55	94	21.8	112.5	9.2	26.0	2.16
SEm ±5	3.75		0.71	0.95	0.69	0.49	2.88
CD (*P*= 0.05)	11.55		2.18	2.94	2.12	1.52	8.9

significantly higher panicle length, more number of panicles/hill and highest grains/panicle. The test weight and grain yield were higher in the variety REM 11 which was at par with IR64 and significantly higher than rest of the varieties.

Performance of rice lines under IVT (Early) under irrigated condition

Thirteen entries received from DRR, Hyderabad were evaluated for yield potential under irrigated condition. The seeds were sown on 20th May 2009 and transplanted on 12th June. The maximum plant height of 92 cm was recorded with IVT 2302 (106.8 cm) which was significantly superior over rest of the varieties entrieS except IVT 2301. The entry IVT 2311 came to flowering very early than rest of the entrieS. The highest number of panicle/m^2 entrien was observed with IVT 2301 which was significantly superior over rest of the entrieS expect IVT 2302. Significantly higher grain yield was observed with IVT 2305 (4.92 t/ha) which was at par with IVT 2310, IVT 2309, IVT 2303 and IVT 2301, respectively.

Maize

Yield performance of different maize varieties/ hybrids

Eleven hybrids/varieties of maize received from VPKAS, Almora and two local landrace of Kolasib were evaluated for yield potential. The crop was

Table 5. Performance of rice lines under IVT (Early) under irrigated condition

Entry No.	IET No.	Plant ht. (cm)	Days to 50% flowering	Panicles / m²	Grain yield (t/ha)
2301	21384	97.1	76.3	396	4.00
2302	21385	106.8	78.3	363	3.48
2303	21386	84.4	77.7	264	4.19
2304	21387	78.3	46.7	297	2.52
2305	21388	56.0	72.3	264	4.92
2306	21389	69.8	74.7	264	3.33
2307	21390	87.5	48.7	231	3.58
2308	21391	83.4	73.3	297	2.51
2309	21392	83.4	75.0	264	4.40
2310	21393	87.8	74.3	307	4.58
2311	Vivekdhan 82	78.3	40.3	264	3.58
2312	RP 2421 (Check)	90.7	71.0	241	3.39
2313	Shashrang	61.1	68.0	241	3.68
SEm ±5		4.5		24.4	0.35
CD (*P*= 0.05)		13.2		70.9	1.01

sown on the 11th April 2009 with a spacing of row to row 60 cm and 25 cm plant to plant. The result (Table 6) revealed that, the maximum plant height (260 cm), cob weight (420), cob length (24 cm), cob girth (18.5 cm) and lines per cob (16.1) were recorded in local land race of Saiha white significantly higher than rest of the varieties/ hybrids observed. The grain yields was superior in the Vivek QPM -9 (7.00 t/ha) which was at par with Vivek HYB -31 (6.99 t/ha).

Groundnut

Effect of different source of boron on yield of groundnut

Performance of bold seeded groundnut variety ICGS-76 was evaluated with different boron sources. The treatments comprised of different boron sources either foliar application (three sprays at 15 days interval at 30 DAS) or as soil application or as seed dressing. The crop was sown on 11th

Table 6. Yield performance of different maize varieties/ hybrids of during *kharif*

Treatment	Height (cm)	Cob wt	Cob length	Cob girth	Lines cob	Yield (t/ha)
HIM-129	155	193	16.1	14.8	14.1	4.87
Vivek HYB-5	172	290	17.7	15.9	14.4	6.43
Vivek HYB -9	162	210	17.5	15.8	21.3	5.89
Vivek -15	158	270	17.7	15.9	14.9	5.12
Vivek -21	164	370	18.1	15.9	14.9	5.59
Vivek -23	163	307	17.8	16.7	14.2	6.36
Vivek -25	152	317	19.1	16.3	13.6	5.52
Vivek Hyb -33	167	297	17.6	16.6	17.9	4.56
FH-3356	156	300	17.2	16.8	15.1	4.87
Vivek Opm -9	191	290	18.0	16.9	15.6	7.00
Vivek Hyb -31	178	290	17.5	15.4	15.1	6.99
Kolasib Black	158	152	13.3	13.3	9.3	4.51
Saiha White	260	420	24.0	18.5	16.1	5.91
SEm ±5	7	15	0.9	0.5	1.9	0.37
CD (*P*= 0.05)	20	44	2.5	1.4	5.4	1.08

Aug 2009 at a spacing of 45cmx10 cm. The data (Table 7) revealed that maximum pod yield (0.92 t/ha) was recorded with application of Colemanite (2 kg/ha) as foliar spray and it was at par with application of borax as soil application (20kg/ha).

Effect of different Integrated Nutrient Management in groundnut during *kharif*

The variety ICGS-76 was evaluated under different source of nutrient for the sustainable production of groundnut. The variety was sown on 13th Aug 2009. The treatments comprised of different fertilizer sources either alone or in combinations. Maximum pod yield of 2.31 t/ha was obtained with P50+K50+L2.5 (t/ha) + boron + molybdate which was significantly superior to P50 + BF, P50 and control (Table 8).

Effect of different nutrition of bold seeded groundnut varieties in acidic soils during *kharif*

Performance of groundnut variety ICGS-76 and TAG 37 was evaluated under different fertility levels to determine the nutritional requirement of bold

Table 7. Effect of different source of boron on yield of groundnut during *kharif*

Treatment	Height (cm)	No. of branches /plant	No. of pods /plant	100 pod wt. (g)	100 kernel wt (g)	yield (t/ha)
Colemanite Soil application	27.9	8.1	10.8	149.6	59.2	0.72
Colemanite Seed Dressing	21.5	7.5	8.9	134.6	51.1	0.68
Colemanite Foliar Spray	27.1	8.8	11.8	152.5	60.4	0.92
Solubur-Soil application	26.5	7.3	9.6	143.2	57.7	0.57
Solubur- Foliar Spray	28.2	8.6	14.0	144.5	58.2	0.51
Borosol Soil application	25.6	6.7	10.0	150.6	59.5	0.61
Borosol Foliar Spray	22.0	7.8	10.3	127.7	52.6	0.71
Borax Soil application	24.3	8.0	10.4	134.4	53.0	0.76
Boric acid Soil application	30.7	7.5	10.1	143.9	56.6	0.64
SEm ±5	3.00	1.76	0.58	4.89	1.90	0.07
CD (*P*= 0.05)	8.98	5.26	1.73	14.65	5.70	0.20

Table 8. Effect of different Integrated Nutrient Management in groundnut during *kharif*

Treatment	Height (cm)	No. of branches /plant	No. of pods /plant	100 pod wt. (g)	100 kernel wt (g)	yield (t/ha)
Control	22.3	6.6	9.2	158.7	65.3	1.21
10t/ha FYM	24.5	8.9	11.8	154.4	62.1	2.15
P50	22.6	8.1	12.5	140.2	57.4	1.56
Ca 100	21.0	6.7	13.0	146.8	59.1	1.91
Ca 100 through local source	25.9	8.8	17.1	170.7	62.6	2.24
P50+ Ca 100	24.3	7.1	13.0	159.3	62.3	2.11
P50+ Ca 100 + boron	28.7	8.7	19.6	164.5	64.5	2.18
P50+ Ca 100 + boron + Mo	30.4	9.3	15.2	166.1	65.3	2.28
P50 + BF	23.7	8.3	11.6	174.4	67.6	2.31
Ca 100+ BF	23.5	6.7	9.9	158.6	62.9	1.27
P50+ Ca 100+ BF	24.8	7.7	10.1	148.9	60.4	2.19
P50+ Ca 100 + boron + Mo+ BF	27.9	8.5	15.1	141.2	59.6	2.31
SEm ±5	2.0	0.8	1.1	8.3	3.7	0.24
C.D. (*P*= 0.05)	5.7	2.3	3.2	23.9	10.5	0.70

(Local source as Sun grass 2kg per m^2)
Boron as 2 kg Borax /ha, BF as rhizobium, Mo as 500 g sodium molybdate

seeded groundnut during *kharif*. The treatments comprised of different fertilizer levels either alone or in combinations along with recommended fertilizer dose and a control. The crop was sown on 14th Aug 2009. The data revealed that maximum pod yield of 1.57 and 2.11 t/ha, were recorded with ICGS-76 and TAG-37, respectively, with application of P50 + K100 + lime 2.5t/ha+ FYM 10t/ha. The performance of the TAG-37 was better than ICGS 76 in response to the nutrient application.

Black gram

Performance of different varieties of black gram during pre *rabi*

Five black gram varieties were evaluated for their yield potential under pre *rabi* condition. The data (Table 9) revealed that variety RCRT BG 09-26 recorded maximum plant height while minimum plant height was recorded with RCRT BG 09-10. The maximum number of pods/plant (21.7), average pod weight (0.41) test weight (45.01) resulted in higher grain yield of 924 kg/ha in RCRT BG 09-20 which was higher than other varieties.

Greengram

Performance of different green gram varieties during pre *rabi*

Twenty one varieties of green gram were evaluated for their yield potential under pre *rabi* condition. The highest plant height was observed in the RCRT M 09-9. The highest numbers of branches were produced in the variety RCRT M 09-14(4.8) followed by RCRT M 09-16, RCRT M 09-13 and RCRT M 09-17 and were significantly superior over the rest of the variety. The variety RCRT M 09-16 produced highest number of pods/plant (39.33) which was at par with the varieties RCRT M 09-15, RCRT M 09-13 and RCRT M 09-17. Significantly higher test weight (58.13 g) was observed in the variety RCRT M 09-6. Highest grain yield of 567.6 kg/ha was recorded with variety RCRT M 09-23 which was at par with RCRT M 09-9(566.7 kgs), RCRT M 09-17(400.0 kg) and RCRT M 09-18 (353.3 kg.)

Lentil

Performance of lentil varieties under different spacing

An experiment was conducted during *rabi* 2009-10 to determine suitable planting geometry for lentil with five lentil cultivar viz. VL-103, VL-125, VL-126, VL-307 and VL-507 from VPKAS, Almora. The crop varieties were sown on 22nd Nov 2009 and harvested on 5th April 2010. The data (Table 10) revealed that maximum grain yield (436 kg/ha)

Table 10. Grain yield (kg/ha) of lentil varieties under different spacing during *rabi*

Variety	Spacing			
	30X10 cm	40X10 cm	50X10 cm	Mean
VL-307	618	448	241	436
VL-103	398	510	209	373
VL-125	95	134	117	115
VL-126	365	248	41	218
VL-507	446	151	85	227
Mean	384	298	139	

Table 9. Performance of different varieties of black gram during pre *rabi*

Treatment	Height (cm)	Branches / plant	Pods / plant	Pod wt	No of seeds / pod	1000 Grain wt	Grain Yield (kg/ha)
RCRT BG 09-5.	9.3	4.1	15.9	0.40	6.07	45.16	659
RCRT BG 09-7.	9.7	4.1	13.9	0.35	5.60	42.74	857
RCRT BG 09-10.	7.8	5.2	18.9	0.37	5.80	42.99	551
RCRT BG 09-20.	9.6	4.9	21.7	0.41	5.93	45.06	925
RCRT BG 09-26.	12.8	5.6	39.2	0.39	5.77	36.18	677

was recorded with the variety VL-307 followed by VL-103(373 kg/ha). The average spacing yield was higher with 30x10 cm (384 kg/ha) followed by 40x10 cm and 50x10 cm. In the of variety and spacing VL-307 with 30x10 cm (618 kg/ha) produced highest yield followed by VL-103(510 kg/ha), respectively

Cropping System

Performance of mustard, lentil and green pea after low land rice crop during *rabi*

After the harvesting of low land rice, three rabi crops *viz,* mustard (M-27), lentil (VL-125) and green pea (var.Arkel) were broadcast sown on first fortnight of Nov at available moisture level of the harvested field. Green pea crop stand was poor due to rat damage. The crop stand of the mustard and lentil was good with application of 25% more seed rate than normal. The harvesting of the green pea and mustard was done on 8th Feb, 27th Feb and 28 Mar 2010. Application of the vermicompost and FYM was done along with broadcasting of seed. Lentil performed better than mustard and pea. Application of vermicompost also improved lentil yield by 37% over the control (Table 11).

Table 11. Performance of mustard, lentil and green pea after low land rice crop during *rabi*

Treatments	Lentil	Pea	Mustard
Control	425	375	375
FYM	650	425	475
Vermicompost	750	475	562.5

Performance of black gram, soybean, rice-bean and green gram after maize crop during late *kharif*

After the harvesting of maize, four pre *rabi* crops i.e. black gram, soybean, ricebean and green gram were line sown. Black gram and soybean performed better than green gram and ricebean. Application of vermicompost also improved rice beans yield by 31% over control followed by soybean (30%), green gram (24 %) and black gram (18%), respectively (Table 12).

Table 12. Performance of black gram, soybean, ricebean and green gram after maize crop during late *kharif*

Treatments	Green gram	Black gram	Soybean	Ricebean
Control	563	688	613	438
FYM	663	750	668	563
Vermicompost	700	813	800	575

Performance of perennial pigeon pea

Local pigeon pea was evaluated for yield potential and its perennial nature. The local type took 188 days to flowering.The plants showed average height of 207 cm, no. of branches 10.7 no.of pods 127.3. The dry seed yield was 0.62 t/ha.

Performance of mustard under FLD

Mustard var.M-27 was sown after upland rice for its yield performance. The M-27 took 38 DAS to 50% flowering. The height was 41 cm with 2.7 numbers of branch/plant, 32 pods/plants and grain yield was 549 kg/ha.

Agricultural Entomology

Monitoring and management of pest complex of cereals, pulses and oilseeds in Mizoram

Rice

Major insect pests of rice recorded were stripped stem borer, *Chilo suppressalis* Walk, leaf folder, *Cnaphalocrocis medinalis*, white backed planthopper, *Sogatella furcifera* (Horvath), gundhi bug, *Leptocorisa orotorius* (Thunb.), thrips, *Stenchaetothrips biformis* (Bagnall), White grubs, *Holotrichia* spp., skipper, *Pelopidas mathias* F., green horned caterpillar, *Melanis leda ismene* and whorl maggot, *Hydrellia philippina* Ferino.

Seasonal abundance of major insect pests of upland rice

An experiment was conducted to study the seasonal abundance of major insect pest complex of rice in upland ecosystem during 2009-2010 (Fig. 1). Seven insect pests and one mite infested the upland rice ecosystem. Among them, small black flea beetle and stem borer were found economically

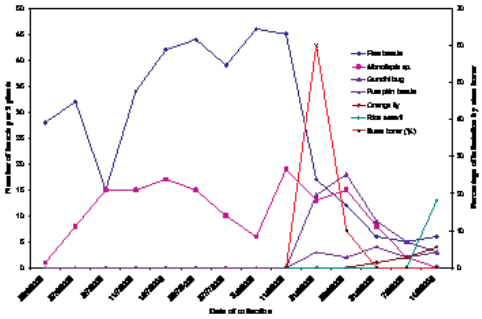


Fig 1. Seasonal abundance of major insect pests of upland rice

important and categorized as major pests. The abundance of small black flea beetle and stem borer were noticed during vegetative and reproductive stages, respectively and attained the peak level of infestation during first week of August and third week of August, respectively. The second most important insect pest was *Monolepta* sp., which was categorized as major insect pests of upland rice. It was noticed throughout the cropping period but attained the peak level of infestation during second week of August. The gundhi bug was more abundant during last week of August. The non-insect pest, red spider mite was more dominant pest and it caused severe damage to the crop and categorized as major pests of rice in Mizoram.

Seasonal incidence of major insect pests of lowland rice

The field experiment was conducted to study the seasonal incidence of major insect pest complex of rice in lowland ecosystem (Fig. 2). Small black flea beetle and leaf folder were found economically important and categorized as major pests. The occurrence of small black flea beetle and leaf folder

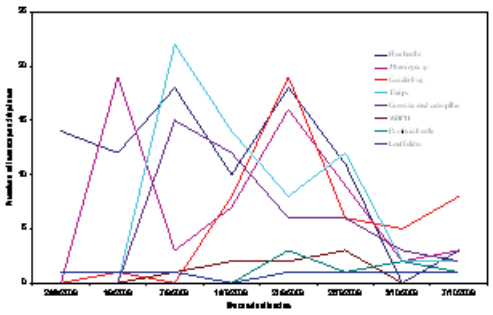


Fig 2. Seasonal incidence of major insect pests of lowland rice

attained the peak level of infestation during the month of September and October, respectively. The second most important insect pest was *Monolepta* sp., a major insect pest of lowland rice and it attained the peak level of infestation on first week of September. The gundhi bug and white backed planthopper were more abundant during third and last week of September respectively. The activity of thrips was noticed during the second week of September.

Maize

Maize stem borer, cob borer, aphids and flea beetle were the major insect pests. Maize stem borer caused windowing and dead heart symptoms. Cob borer incidence was noticed during cob formation stage and estimated yield loss up to 25 %. Aphids were also recorded causing economic damage.

Seasonal activity of major insect pests of maize (sweet corn)

Flea beetle and aphids were observed as major pests and their infestation was noticed during the month of July.

PULSES

Red gram

Pod boring weevil, pod fly and stem borer were the major insect pests of red gram. Among these, pod boring weevil was found serious pest which caused 70 to 80 per cent damage to the pods and 40-50 per cent to the grains.

Seasonal occurrence of major insect pests of red gram

Flea beetle, coreid bug and leaf footed bug were found as major pests (Fig. 3). The peak level incidence of flea beetle, coreid bug and leaf footed bug was noticed during last week of November, first week of August and second and third week of August, respectively. The second most important insect pests were mealy bug and ash weevil of red gram and they attained the peak level of infestation in the last week of November and last week of September, respectively. The jassids were more abundant during the month of November (Fig. 3).

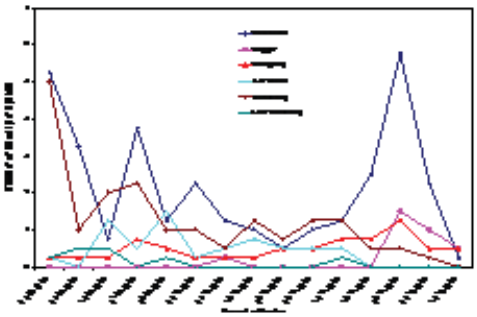


Fig 3. Seasonal incidence of major insect pests of red gram

Lentil

Leaf folder, aphids, leafhopper and pod borer recorded were the major insect pests of lentil. Leafhoppers and aphids caused yield loss up to 10-15 per cent.

Pea

Leaf miner and aphids were the major insect pests of pea. Leaf miner was noticed from vegetative stage to till maturity stage and caused economic damage to the crop.

Seasonal activity of major insect pests of pea

Aphids were recorded to be economically important pests. The activity of aphid was at peak level during second week of January. The second most important and dominant insect pest was blue butterfly of pea. It attained the peak level of infestation in the last week of January. The flea beetle was more abundant during first week of December.

Green gram/black gram

The insect pests of green gram and black gram recorded were stem fly, blister beetles, aphids, leaf folder, pod borer and leaf footed bug. Blister beetle was the most serious pest of both green gram and black gram and caused yield loss up to 25-30 per cent.

Seasonal abundance of major insect pests of green gram

Aphid and flea beetle were found as major pests. The abundance of aphid and flea beetle were at peak level during third week of September and last week of August, respectively. The second most important insect pests were coreid bug and jassid. They attained the peak level of infestation in the third week of September and last week of August. The blister beetle was more abundant during third week of September (Fig 4).

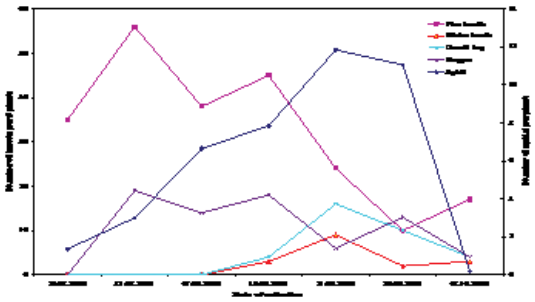


Fig 4. Seasonal abundance of major insect pests of green gram

Seasonal incidence of major insect pests of black gram

Aphid and flea beetle were found economically important pests. The incidence of aphid and flea beetle were at peak level during third week of October and first week of October (Fig 5). The second most important and dominant insect pests were coreid bug, which attained the peak level of infestation in first week of October. The blister beetle was more abundant during third week of September.

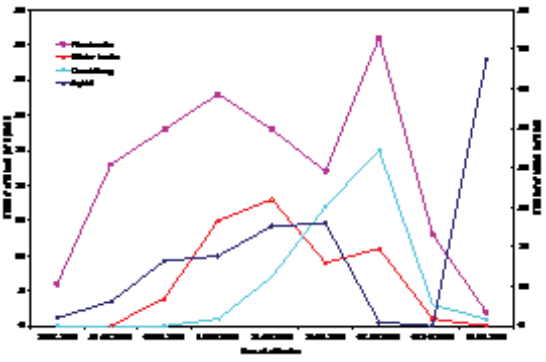


Fig 5. Seasonal incidence of major insect pests of black gram

Ricebean

The major insect pests of ricebean recorded were leaf folder, blister beetle, leaf footed bug and aphids. Blister beetle was the most serious pest and it caused yield loss up to 30-40 per cent.

Seasonal activity of major insect pests of rice bean

Aphid and flea beetle were found economically important insect pests. The activity of aphid and flea beetle were noticed at peak level during first week of December and third week of September. The second dominant insect pests were leaf footed bug and jassid, they attained the peak level of infestation on second week of October and first week of December. The blue butterfly was more abundant during last week of November.

OILSEEDS

Mustard

Seasonal occurrence of major insect pests of mustard

Mustard aphid and painted bug were found economically important pests. The occurrence of mustard aphid and painted bug were noticed during first week of November and third week of November, respectively.

The second important insect pest was flea beetle; it reached the peak level of infestation during last week of November. The cabbage butterfly was more abundant during month of November (Fig 6).

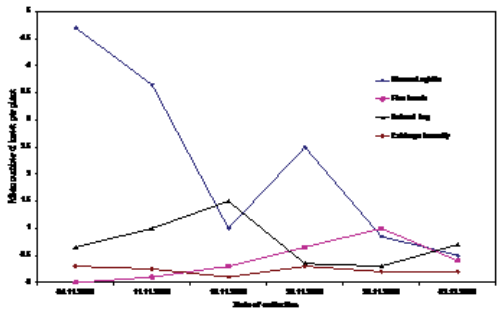


Fig. 6. Seasonal occurrence of major insect pests of mustard

Groundnut

Seasonal abundance of major insect pests of groundnut

Aphid and flea beetle were found economically important. The abundance of aphid and flea beetle were at peak level during third week of September and last week of August. The next dominant insect pest was leaf footed bug, it attained the peak level of infestation in last week of October. The blister beetle was more abundant during first week of October (Fig 7).

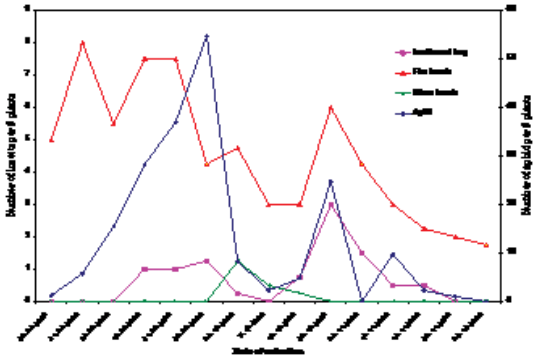


Fig 7. Seasonal abundance of major insect pests of groundnut

Soybean

Soybean was attacked by stem fly, leaf webber/ folder, pod boring weevil, aphids and epilachna beetle which were the most destructive insect pests. Soybean stem fly caused 15-20 per cent yield loss.

Seasonal incidence of major insect pests of soybean

Blister beetle was found economically important. The incidence of blister beetle was noticed at peak level during second week of September. The second most important insect pest was coreid bug, it reached the peak level of infestation in last week of August. The flea beetle was more abundant during second week of September (Fig 8).

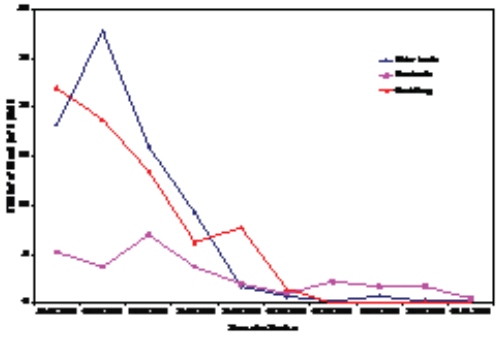


Fig. 8. Seasonal incidence of major insect pests of soybean

FRUITS

Citrus

Insect pests attacking *Khasi* mandarin were citrus leaf miner, lemon butterfly, citrus trunk borer, aphids, psylla, fruit sucking moths, fruit fly, green sting bug, scale and mealy bug.

Papaya

The most important pests recorded were leaf folder and mite. In the nursery, leaf folder was found feeding leaves thereby reducing the photosynthetic activity resulting in low yield of fruits.

Guava

Guava was infested by more than 25 insect pests and among them guava trunk borer, scale, white fly, fruit sucking moths and fruit flies were the most serious pests causing heavy losses. The trunk borer losses in the guava orchard ranged from 25-75 per cent. The fruit sucking moths were major yield and quality limiting factor in guava cultivation. There were 10-15 species of fruit sucking moths infesting the fruits. Fruit sucking bug and armed scales were considered as minor insect pests.

Mango

Most important and serious pests of mango were stone weevil, fruit flies, scale insect, leaf gall, aphids, hoppers, leaf webber, stem borer and shoot borer. Some insect pests like shoot borer, leaf webber, leaf twisting weevil were observed as minor pests.

Litchi

Indigenous varieties are common and grown in the lower altitude. Fruit and stone borer, stink bug, leaf webber and mite were the most serious pests. The fruit and stone borer damage was recorded up to 25 per cent in the litchi orchard.

Seasonal abundance of litchi stinkbug

Litchi stinkbug was found economically important and its incidence was noticed at peak level of infestation during May and July (Fig.9).

VEGETABLES

Tomato

Major insect pests of tomato recorded were Fruit borer (*Helicoverpa armigera*), Fruit fly

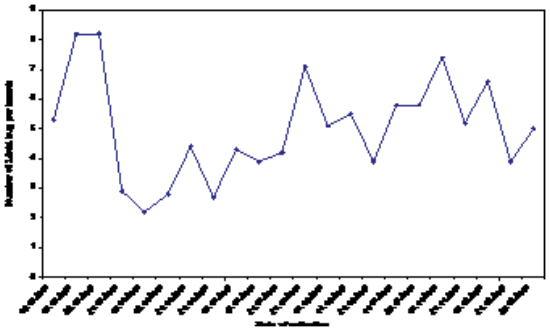


Fig 9. Seasonal abundance of litchi stinkbug in litchi

(*Bactrocera* spp.), Serpentine leaf miner (*Liriomyza trifolii)*, thrips, aphids and jassids.

Seasonal abundance of major insect pests of tomato

Aphids and thrips were found economically important. The abundance of aphids and thrips were noticed during third week of December and last week of December, respectively. The second most important insect pest was fruit borer and it attained the peak level of infestation in last week of February.

Chilli

Fruit fly, *Bactrocera* spp. (Tephritidae, Diptera): Fruit fly was observed as one of the major insect pests of chilli and widely distributed. It is directly affecting the quality and productivity. Freshly hatched maggot feed on fruit pulp, content of fruits and cause premature dropping of fruits and also make them unfit for consumption. The affected fruits were full of water and give foul smell. The infestation ranged between 50-80 per cent (cent per cent infestation in severely affected field).

Aphids, *Aphis gossypii* and *Myzus persicae* (Aphididae, Hemiptera): Aphids were found active from May to November. Cloudy, humid and cold weather was found highly favourable for the multiplication of these insect pests. Aphids infested terminal portion of plant including flowers and fruits. They sucked the sap, reduced the vigour of the plant and secreted honeydew, which attracted ants and developed sooty mould. The pods that developed black colour due to sooty mould lost quality and fetched low price in market.

Brinjal

Shoot and fruit borer, *Leucinodes orbonalis* (Pyralidae, Lepidoptera): Shoot and fruit borer was the most serious pest of brinjal. Larval feeding inside the shoot caused withering of plant or dead hearts and it reduced the plant growth. Larva made feeding tunnels inside the fruit and made the fruits unfit for consumption and marketing. The infestation was as high as 60 per cent on brinjal.

Hadda beetles, *Henosepilachna vigintioctopunctata, Epilachna dodecastigma* (Coccinellidae, Coleoptera): Hadda beetles was observed on brinjal, sometimes becoming serious on it. The grubs and adults scrap the leaves in a characteristic manner and feed. The leaves became lace like appearance or completely skeletonized, turned brown, dry up and fall off.

Leaf webber, *Psara bipunctalis* (Pyraustidae, Lepidoptera): Caterpillars rolled leaves and fed on chlorophyll and remained inside the leaves. The folded leaves wither and dry up. Larvae fed gregariously and skeletonized the leaves.

Brinjal Flea beetle, *Phylliodes balyi* (Chrysomelidae, Coleoptera): Flea beetle was more severe in both nursery and main field. Infested foliage showed numerous, round and irregular holes. Damaged leaves wilted and turned brown and killed or stunted the plant growth.

Aphids, *Aphis gossypii* (Aphididae, Hemiptera): Aphids attacked brinjal during cool dry season. It caused yellowing and curling of young leaves and stunted plant growth. Its predator (Syrphid fly) was also observed.

Capsicum

Spiraling whitefly, *Aleurodicus dispersus* (Aleyrodidae, Hemiptera): It is highly polyphagous and breeds on a variety of plants. Both nymphs and adults were found feeding on the lower surface of the leaves and sometimes on the upper leaf surface. It caused chlorotic spots on the leaves, leaf appeared yellow with green veins and stunted plant growth. Premature defoliation, development of sooty mould on honey dew excreted was also observed.

Cole crops

Insect pests (Table 13) recorded on cole crops were cabbage butterfly, diamond back moth, cabbage head borer, aphids, flea beetle, cabbage semilooper, cut worm and painted bug. Sawfly was recorded as an important pest of cole crops. A number of natural enemies (Table 14) were also recorded at ICAR Research farm, Kolasib, Mizoram.

Table 13. Insect pests and non insect pest complex of broccoli

S. No	Systematic position	Biological group	Stage of crop attack	Nature of the damage	Occurrence and status of pest
A. Insect pests					
1.	Cabbage butterfly, *Pieris brassicae* (Linn.) (Pieridae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling to harvest	Larvae feed on leaves	Regular and major pest
2.	Diamond back moth, *Plutella xylostella* (Linn.) (Plutellidae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Vegetative, flowering and head formation stages	Larvae scrape green tissues and make holes on leaves	Sporadic and major pest
3.	Cabbage aphid, *Brevicoryne brassicae* (Linn.) (Aphididae : Hemiptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling, vegetative, flowering, head formation stages	Suck the sap from leaves, stems and inflorescence	Regular and major pest
4.	Mustard aphid, *Lipaphis erysimi* (Kalt.) (Aphididae : Hemiptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling, vegetative, flowering, head formation stages	Suck the sap from leaves, stems and inflorescence	Regular and major pest
5.	Green peach aphid, *Myzus persicae* (Sulz.) (Aphididae : Hemiptera)	Broccoli, cabbage, cauliflower and knol-khol	Flowering and head formation stages	Suck the sap from leaves, stems and inflorescence	Sporadic and major pest

contd.....

6.	Crucifer flea beetle, *Phyllotreta cruciferae* Goeze. (Chrysomelidae : Coleoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling to harvest	Adults bite shot holes on leaves, nibble the green tissues of inflorescence	Regular and major pest
7.	Striped flea beetle, *Phyllotreta striolata* (F.) (Chrysomelidae : Coleoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling to harvest	Adults bite shot holes on leaves, nibble the green tissues of inflorescence	Regular and major pest
8.	Cabbage borer, *Helulla undalis* (Fabr.) (Pyralidae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Vegetative and head formation stage	Larvae defoliate from margin of leaves and make holes on the heads	Regular and major pest
9.	Tobacco caterpillar, *Spodoptera litura* (Fb.) (Noctuiidae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Vegetative stage to till harves	Larvae defoliate from margin of leaves and make holes on the heads	Regular and major pest
10.	Painted bug, *Bagrada cruciferarum* and *B. hilaris* (Burm.) (Pentatomidae : Hemiptera)	Broccoli, cabbage, cauliflower and knol-khol	Vegetative and head formation stage	Suck the sap from leaves, stems and developing inflorescence	Regular and major pest
11.	Leaf webber, *Crocidolomia binotalis* Zell. (Pyralidae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Vegetative and head formation stage	Larvae make webbings, scrape the green tissues from leaves	Sporadic and major pest
12.	Leafminer, *Chromatomyia* (=*Phytomyza*) *horticola* Gour. (Agromyzidae)	Broccoli, cabbage, cauliflower and knol-khol	Vegetative stage to till harvest	Maggots mine leaves and feeds chlorophyll content	Regular and moderate pest
13.	Mustard sawfly, *Athalia lugens poxima* (Klug.) (Tenthridinidae : Hymenoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling and vegetative stage	Adults bite holes on leaves and defoliate the leaves	Sporadic and major in nursery, moderate pest in main field
14.	Cutworm, *Agrotis ipsilon* (Hufn.) (Noctuiidae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling and vegetative stage	Cutting the seedlings	Sporadic and major in nursery moderate pest in main field
15.	Green semi looper, *Trichoplusia ni* Hb. (Noctuiidae : Lepidoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling, vegetative and flowering stages	Larvae feeds on the leaves	Sporadic and moderate pest
16.	Grasshopper (Acrididae : Orthoptera)	Broccoli, cabbage, cauliflower and knol-khol	Seedling and vegetative stage	Grasshopper feeds on the leaves	Occasional and minor pest
B. Non insect pest					
17.	Red spider mite, *Tetranychus cinnabarinus* Boisd. (Tetranychidae: Acarina)	Broccoli, cabbage, cauliflower and knol-khol	Seedling and vegetative stage	Suck the sap from leaves, stem and inflorescence	Regular and major pest

Seasonal activity of major insect pests of cauliflower

Mustard aphid and cabbage butterfly were found economically important insect pests. The activity of mustard aphid and cabbage butterfly were noticed during third week of February and third week of December, respectively. The second dominant insect pest was painted bug, it attained the peak level of infestation on second week of February. The flea beetle was more abundant during third week of February (Fig.10).

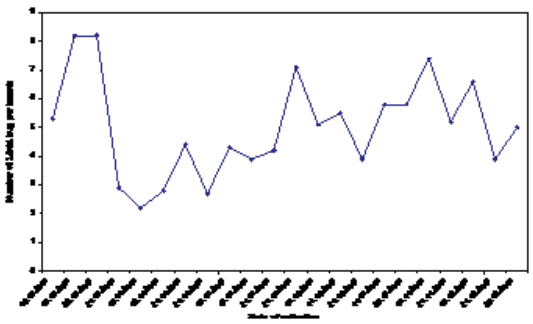


Fig 10. Seasonal activity of major insect pests of cauliflower

Table 14. Natural enemies complex in broccoli

S. No.	Common and scientific name	Family and Order	Host	Population Status
A. Predators				
1.	Ladybird beetle, *Cocinella septempuncpata* Linn.	Coccinellidae, Coleoptera	Aphids	High
2.	Ladybird beetle, *Menochilus sexmaculatus* Fab.	Coccinellidae, Coleoptera	Aphids	Medium
3.	Ladybird beetle, *Coccinella transversalis* Fab.	Coccinellidae, Coleoptera	Aphids	Medium
4.	Syrphid flies (Unidentified)	Syrphidae, Diptera	Aphids	High
5.	Syrphid flies (Unidentified)	Syrphidae, Diptera	Aphids	High
6.	Green lace wing, *Chrysoperla carnea*	Chrysopidae, Neuroptera	Aphids	Medium
7.	Spider (Unidentified)	Acarina	Leaf webber larvae, aphids	Medium
B. Parasitoids				
8.	Parasitoid, *Apanteles glomeratus*	Broconidae, Hymenoptera	Cabbage butterflies and DBM	High
9.	Parasitoid, *Cotesia* spp.	Broconidae, Hymenoptera	Cabbage butterflies and DBM	High
10.	Parasitoid, *Hypasoter ebeninius*	Hymenoptera	Cabbage butterflies	High
11.	Tachniid fly (Unidentified)	Tachniidae, Diptera	Cabbage butterflies	Medium

Evaluation of biopesticides and insecticides against crucifer flea beetle, *Phyllotreta cruciferae* Goeze

The pooled data revealed that application of neem oil 0.03% EC, malathion 50% EC, endosulphan 35% EC, monocrotophos 36% SL, chlorpyriphos 20% EC, cypermethrin 5% EC, chlorpyriphos 50% EC + cypermethrin 5% EC, fenvalerate 20% EC, permethrin 25% EC, dichlorvos 76% EC, phosphamidon 40% SL, dimethoate 30% EC, deltamethrin 2.8% EC and imidacloprid 17.8% SL recorded hundred per cent reduction of flea beetle population. But, neem oil 0.3% EC (0.38/plant) and neem oil 1% EC (0.38/plant) were also effective while untreated check showed maximum population (4.63/plant).

Bio-efficacy of some biopesticides and chemical insecticides against *Lipaphis erysimi* Kalt. on broccoli

The data recorded on population of aphids showed that all the treatments were significantly superior to control. Overall pooled results revealed that all the chemical insecticides were significantly superior to biopesticides i.e. neem based insecticides and control treatment (Fig.11). All the chemical insecticides showed cent per cent reduction in aphid population. Among biopesticides tested, neem oil 0.3% EC recorded significantly minimum aphid population (1.50 aphids / plant) while control recorded maximum aphids population (390.75 aphids / plant).

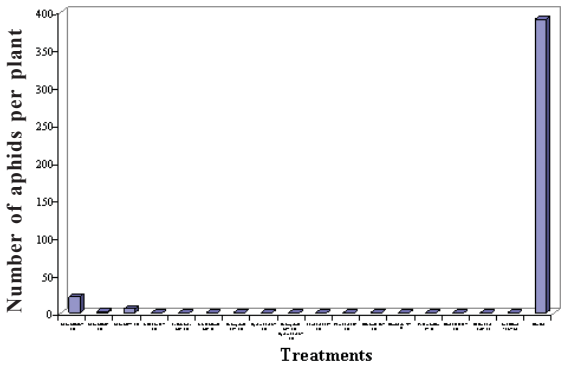


Fig 11. Effect of different biopesticides and chemical insecticides against *L. erysimi* on broccoli

Evaluation of insecticides and biopesticides against diamondback moth, *Plutella xylostella* (L.) on broccoli under field conditions

The result indicated that all the insecticides and biopesticides treatment were significantly superior over control (Fig. 12). *P. xylostella* population ranged between 0 to 5.25 larvae/plant, while control had 12.31 larvae /plant. Spraying of chlorpyriphos 50% EC + cypermethrin 5% EC recorded hundred per cent reduction of *P. xylostella* population followed by malathion 50% EC (0.44 larvae/plant) then followed by chlorpyriphos 20% EC (0.50 larvae/plant) and permethrin 25% EC (0.50 larvae/

plant). But, cypermethrin 10% EC was found least effective in reducing *P. xylostella* population (3.13 larvae /plant).

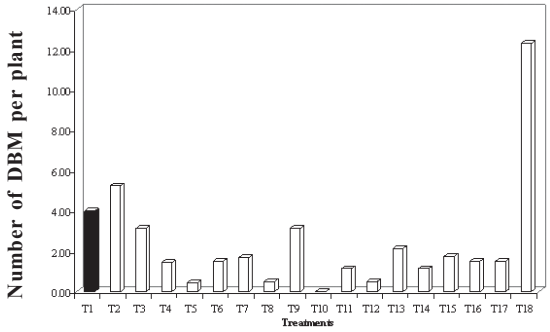


Fig 12. Efficacy of biopesticides and insecticides against *P. xylostella*

Okra

Major insect pests of okra recorded were fruit borer, shoot borer, flower beetle, jassids, aphids, semilooper, leaf roller and fruit bugs. Blister beetle was found causing more than 50-100 per cent loss on okra. Ash weevil and flea beetle were also recorded as major insect of okra.

Seasonal incidence of defoliating insect pests and natural enemies of okra

The okra was invaded by eleven insect pests, one mite and four natural enemies in Mizoram. During the season *Nodostoma* sp. was the first to invade the crop at seedling stage i.e., third week of May. The population of *Nodostoma* sp. per plant varied from 0.10 to 7.10. The peak population (7.10) of *Nodostoma* sp. per plant was noticed in last week of July during the reproductive stage. So, *Nodostoma* sp. was active from the third week of May to first week of August with a peak level of population during month of July.

The abundance of *S. derogota* was recorded from third week of May. The peak level of infestation (0.40 per plant) was noticed during May. The mean population of *S. derogota* varied from 0 to 0.30/plant. The infestation of *A. affaber* commenced from first week of July. The highest per cent infestation was recorded during last week of July and first week of August. The abundance of *M. pustulata* was started from first week of July. The peak population was recorded during first week of July (3.30). The *M. pustulata* population was found varied from 0 to 3.30/plant.

Seasonal incidence of sucking pests of okra

The incidence of *A. gossypii* commenced from second week of June. The *A. gossypii* population reached the peak infestation level (30.50) at last week of June. The aphid population varied from 0 to 30.50 aphids /plant. The *Amrasca biguttula biguttula* was active during second week of June. The peak level of incidence (0.30/plant) was noticed during second week of July. The mean population of *A. biguttula biguttula* varied from 0 to 0.30/ plant. The infestation of *Bemisia tabacci* commenced from third week of May. The highest per cent of infestation (0.80/plant) was recorded during third week of June. The number of whitefly was varied from 0 to 0.80/plant. The infestation of *D. cingulatus* was recorded from second week of July. The peak level of population (10.30) was noticed at first week of August. The mean population of *D. cingulatus* varied between 0 - 10.30/plant. *D. cingulatus* was active from second week of July to first week of August.

Field efficacy of different neem products and insecticides against *Aphis gossypii* (Glov.) on okra

The efficacy of different neem products and chemical insecticides was evaluated against cotton aphid, *Aphis gossypii* (Glov.) during the *kharif* season 2009 The data on mean aphids count per plant showed that cent per cent reduction in the aphids population was observed in malathion 50% EC, monocrotophos 36% EC, dichlorvos 76% EC, imidacloprid 200% SL, cypermethrin 10% EC, chlorpyriphos 20% EC, phosphamidon 40% EC, fenvalerate 20% EC and dimethoate 30% EC. Permethrin 25% EC recorded lowest mean aphid population (0.15 aphids/plant) followed by deltamethrin 28% EC and combination insecticide i.e. chlorpyriphos 50% EC + cypermethrin 5% EC (0.25 aphids/plant) while the highest mean population was observed in untreated check (6.00 aphids/plant).

Bio-efficacy of newer insecticides and neem formulations against okra flea beetle, *Nodostoma* sp.

The efficacy of chemical insecticides and neem formulations was studied for the control of okra flea beetle, *Nodostoma* sp. in okra during *kharif*

season. Overall pooled results revealed that all the treatments were superior over control. Spray of neem oil 0.3 % EC was found most effective (0.77 per plant) against *Nodostoma* sp. However, neem oil 1% EC was least effective. The untreated check recorded maximum flea beetle population (4.24/ plant). Among the insecticides tested, malathion 50% EC was most effective against flea beetle (0.87/ plant) followed by monocrotophos 36% EC (0.90/ plant) and imidacloprid 200% SL (0.90/plant).

SPICES

Ginger

Ginger shoot borer, *Dichorocis punctiferatis* (Pyraustidae, Lepidoptera): It is a serious pest of ginger. The young caterpillars bore through the central shoot of the plant and feed on the growing buds base resulting in withered and dried shoots referred to as 'dead heart'. The presence of a borehole on the pseudostem through which frass is extruded and the withered and yellow central shoot is a characteristic symptom of pest infestation.

Ginger skipper, *Udaspes folus* (Hesperiidae, Lepidoptera): The young larvae were observed to web together nearby leaves and found inside the web, feeding on the green matter. The mature larvae cut and fold leaves and fed on them.

Seasonal occurrence of major insect pests of ginger

Thrips and aphid were found economically important insect pests. The occurrence of thrips and aphids were noticed during second week of August and third week of September, respectively. The second most important insect pest was rhizome borer, it attained the peak level of infestation during the month of October to December. The flea beetle was more abundant during first week of August.

Turmeric

Shoot borer, *Dichorocis punctiferatis* (Pyraustidae, Lepidoptera): It is a serious pest of ginger but also attacked turmeric. The young caterpillars bore through the central shoot of the plant and feed on the growing buds base resulting in withered and dried shoots referred to as 'dead heart'. The presence of a borehole on the stem through which frass is extruded and the withered and yellow central shoot is a characteristic symptom of pest infestation.

Leaf roller, *Udaspes folus* (Hesperiidae, Lepidoptera): The young larvae web together nearby leaves and remains inside the web feed on the green matter. The mature larvae cut and fold leaves and feed on them.

Seasonal activity of major insect pests of turmeric

Thrips and aphid were found economically important and their activities were noticed during third week of September and second week of August, respectively. The second most important and dominant insect pest was rhizome borer; it reached the peak level of infestation during the month of October to December. The flea beetle was more abundant during third and last week of November.

Population dynamics of fruit flies in different horticultural crops

The studies included included trap catches in different crop ecosystems, seasonal catches and peaks, relative recovery of pupae from infested fruits at different intervals after collection and mortality (non emergence) among fruit fly puparia and parasitoid pupae

Fruit fly weekly trap collections during 12 weeks in May to July in tomato, chilli and guava

Overall the catches remained greater in guava crop followed by chillies and lesser in tomato during the twelve week period. The pattern of increase and decline in catches of fruit flies was similar in the three crops.

Fruit fly catches in tomato for twenty weeks during March to July

The catches continued to increase from early March and reached a major peak in mid May. Later a minor peak was seen in early June and the catches sharply declined to reach very low numbers in mid/ late July.

Relative catches of fruit flies in tomato and guava for eighteen weeks during March to July,

In this study over 18 weeks, the pattern of peaks and decline in fruit fly catches were similar in both guava and tomato ecosystem. The first peak in mid May was followed by a sharp decline in end May while minor peak was found in early June in both the crops.

Weekly mean catches in three crops during May to July

In twelve week study of fruit fly trap catches in three crops within farm at Kolasib. Minimum catches were found in tomato, moderate in chillies and high in guava

Share of trap catches of fruit flie in traps kept in three crops during May to July

Overall among the catches in three different crops kept simultaneously in the farm nearly 41% of the catches were in guava followed by 36% in chillies and 23% in tomato (Fig 13).

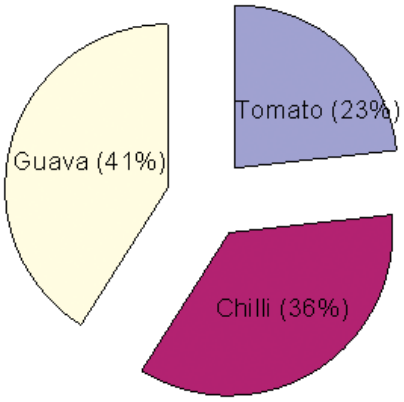


Fig 13. Share of trap catches of fruit flie in traps kept in three crops during May to July, 2009 at ICAR Kolasib

Relative number of fruit fly pupae recovered from guava fruits at three intervals after collection during August to October, 2009

Infested guava fruits yielded smaller number of pupae in the firat week while in the fifth week it was maximum and also a small number in seventh week after fruit collection. This showed that egg laying occured more close to ripening stage and can be staggered over a few weeks with varying age/ sizes of maggots during fruit fall.

Proportion of pupae recovered at three intervals after fruit collection in guava during August to October, 2009

In a study of infested guava fruits (480) collected in late August and observed for emergence of maggots becoming pupae in the soil was found to be greatest (71%) during five weeks after collection while it was low (18%) during seven weeks period and the least (11%) was in week one after collection (Fig 14).

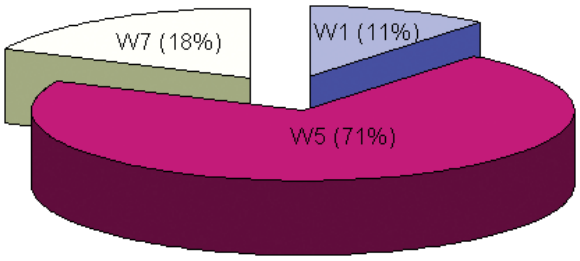


Fig 14. Proportion of pupae recovered at three intervals after fruit collection in guava during August to October, 2009

Proportion of non emergence among fruit fly pupae recovered at three intervals from guava fruits (August to October, 2009)

Among fruit fly puparia recovered during different weeks after fruit collection in guava, the proportion of dead (non emerging) puparia was maximum in week seven followed by week one and least in week five. This showed the mortality caused among pupae which emerged at different periods after fruit collection can differ substantially. Possible mortality factors were dehydration, parasitization and infection.

Recovery and non emergence among fruit fly puparia at three intervals after collection of guava fruits (August to October, 2009)

The overall recovery of fruit fly puparia from infested guava fruits was very high in week five followed by week seven and least in week one. The pattern of mortality (non emergence) mong puparia followed a similar trend as for the numbers recovered.

Relative non emergence among fruit fly pupae and parasitoid pupae recovered in first week after guava fruit collections in August, 2009

It was interesting to note that the emergence of parasitoid pupae occurred only during week one after fruit collection and not later in week 5 or 7. The extent of mortality (non emergence) observed in fruit fly puparia was comparable to the trend among parasitoid pupae recovered in the same week. This suggests that not only fruit fly but the parasitoid also encounters mortality factors to almost the same level.

Summary of findings on fruit flies in Mizoram

Fruit fly catches can differ considerably between guava, chillies and tomato. Peaks in adult catches generally follows similar pattern among the crops. Proportion of fruit fly adults and parasitoid adults emerging successfully from the pupal stage appears to be similar. Parasitoid emergence occurs mostly in one week after fruit collection and not later. Fruit fly puparia emerging from infested guava fruits is maximum at five week after collection followed by week seven and the least in week one. This indicates overlapping egg laying and larval development in ripening guava fruits.

HORTICULTURE

Genotypic variation for economic traits among germplasm of vegetable French bean (*Phaseolus vulgaris* L.) in Mizoram

For variability study in French bean more than thirty land races (Fig 15) were collected from various areas of Mizoram. Moreover, 24 exotic and indigenous collections were also procured from NBPGR Regional Station, Phagli, Shimla, H. P. for evaluation under Mizoram condition.

Fig 15. Land races of French bean collected from Mizoram

Evaluation of germplasm and standardization of agro-techniques of cho-cho, *Sechium edule* (Jacq) Swartz

Thirteen genotypes were collected from different areas, i.e. Kolasib, Kawnpui, Sher Khan, Siphir and Aizwal, and three genotypes from ICAR Barapani for evaluation of their performance at ICAR Kolasib. The nursery was raised for transplanting to main field (Fig 16).

Fig 16. Cho-cho nursery

Effects of date of transplanting and cultivar on growth, yield and quality of cabbage

Five cultivars, namely NS-160 (V1, hybrid), KGMR-1 (V2, hybrid), Ryozeki (V3, hybrid), Golden Acre (V4, variety) and INDAM-1299 (V5, hybrid) were transplanted on three dates, i.e. 13th November (S1), 01st December (S2) and 18th December (S3) 2009. Twenty-five days old seedlings were transplanted at spacing of 50×40 cm in 4×2.5 m plots .There were three replications. The growth and yield of cultivars transplanted on 1st December (S2) was found to be best followed by first transplanting on 13th November (S1) and 18th December (S3) in general. Nevertheless, the head compactness was generally higher in late transplanting, i.e. 18th December (S3). Among five cultivars, KGMR-1 (a public sector hybrid bred by IARI Regional Station, Katrain, H.P.) was found to be highly productive in all three transplanting dates. Although the gross plant weight was maximum for the hybrid, Ryozeki, yet the head weight and yield was not maximum due to lower harvest index. The most popular cabbage variety, Golden Acre (a public sector variety bred by IARI Regional Station, Katrain, H.P.), performed next to KGMR-1 and having maximum harvest index (Table 15).

Table 15. Effects of transplanting time and plant cultivar on growth, yield and quality

Treatments	Gross plant weight (kg)	Net head weight (kg)	Polar length (cm)	Equatorial length (cm)	No. of non-wrapper leaves	Non-wrapper leaf weight(kg)	Harvest index (%)	Head compact-ness	Yield (t/ha)
V1S1	1.670	1.033	14.0	14.3	13.4	0.617	62.0	36.9	36.2
V2S1	2.100	1.186	15.3	14.4	11.8	0.576	57.0	36.2	41.5
V3S1	1.938	0.966	13.6	14.3	14.6	0.963	50.2	35.7	33.8
V4S1	1.506	1.068	13.9	14.7	10.5	0.455	71.6	36.4	37.4
V5S1	1.561	0.884	13.2	12.8	12.2	0.395	56.7	40.8	30.9
V1S2	1.953	1.257	15.6	15.9	13.9	0.681	64.4	32.4	44.0
V2S2	2.279	1.461	16.9	15.9	12.3	0.616	64.1	33.0	51.1
V3S2	2.352	1.217	15.0	15.8	15.3	1.054	51.8	33.4	42.6
V4S2	1.831	1.351	15.4	15.8	10.9	0.500	74.0	35.7	47.3
V5S2	1.776	1.118	14.5	13.9	12.6	0.428	63.0	39.4	39.1
V1S3	1.514	0.942	12.8	12.8	13.2	0.583	62.3	46.5	33.0
V2S3	1.897	1.075	13.9	13.0	11.9	0.530	57.2	44.5	37.6
V3S3	1.783	0.894	12.6	13.2	14.6	0.906	50.4	42.7	31.3
V4S3	1.324	0.946	12.3	13.0	10.6	0.426	72.1	46.5	33.1
V5S3	1.376	0.782	11.7	11.2	11.9	0.365	56.9	53.5	27.4
Avg	1.791	1.079	14.0	14.1	12.7	0.606	60.9	39.6	37.8
SEm	0.108	0.045	0.3	0.3	0.2	0.022	2.1	2.6	1.6
CD(P=0.05)	0.312	0.130	0.8	0.9	0.5	0.064	6.1	7.5	4.5

Effects of nutrient, mulch and irrigation level on growth and yield of carrot

An experiment was conducted having 11 treatment combinations with the objective to integrate fertilizer, vermicompost and organic mulch for better nutrient and irrigation management in carrot cv. Nantes.The 100 % RDF (recommended dose of fertilizer) contains NPK @ 80:60:60 kg/ ha, and 100 % VC (vermicompost) has vermicompost @ 5 t/ ha. The treatment T11 received need based irrigation (full irrigation), while rest 10 treatments (T1-T10) received only 50 % irrigation. Dried grasses and crop residues were used as organic mulch. 5 cm thick mulch was laid just after completion of seed germination, i.e. 25 days after sowing.

All the growth and yield parameters were generally higher in mulched plots in comparison to non-mulched plots (Table 16). Gross plant weight and root weight was maximum in T11 treatment which was at par with T6 and T4 treatments. This is interesting that mulching treatments showed higher shoot growth and lesser root length as comparison to non-mulching treatments. Harvest index was maximum in T10 treatment. Treatment T11 showed maximum root yield followed by T6 and T4 treatment. The present findings indicate that 50-75 % of RDF, vermicompost @ 2.5-4 t/ ha and mulching will sustain the yield potential even with application of only 50 % irrigation water.

Effects of vermicompost, fertilizer and mulching on growth and yield of French bean cv. Arka Komal

The experimental plots 4×2.5 m were replicated three times in RBD. Seed was sown in lines at spacing of 40 cm on 10th November 2009. Plants were thinned and plant to plant spacing was maintained at 10 cm. The 100 % RDF contains NPK @ 30:50:40 kg/ ha and 100 % VC has vermicompost @ 5 t/ ha. All the treatments received only 50 % irrigation. 5 cm thick mulch of dried grasses and crop residues were used for mulching at 25 days after sowing.

All the growth and yield parameters were generally higher in mulched plots as compared to non-mulched plots (Table 17). Nevertheless, nodule numbers on the roots were reduced significantly by application of mulch. There is positive impact of application of vermicompost on growth, nodulation

Table 16. Effect of nutrient, mulch and irrigation on growth and yield of carrot

Treatment	Gross plant weight (g)	Root weight (g)	Shoot weight (g)	Shoot length (cm)	Root length (cm)	Root diameter (cm)	Harvest index (%)	Yield (t/ ha)
T-1	46.6	40.6	5.9	25.6	12.9	2.08	87.2	11.9
T-2	48.4	42.2	6.2	29.7	12.6	2.36	87.1	12.3
T-3	50.3	44.1	6.3	23.5	14.2	2.31	87.6	12.8
T-4	61.5	53.0	8.5	30.9	14.0	2.57	86.2	15.4
T-5	48.6	42.2	6.3	25.5	13.7	2.45	86.9	12.3
T-6	61.4	54.0	7.4	29.0	13.0	2.31	88.0	15.8
T-7	46.2	37.9	8.4	24.9	13.1	2.39	81.9	11.0
T-8	48.4	43.3	5.1	30.9	12.7	2.22	89.4	12.6
T-9	35.4	29.3	6.1	24.5	11.6	1.90	82.8	8.6
T-10	42.7	38.7	4.0	32.2	11.1	2.26	90.7	11.3
T-11	62.0	54.9	7.1	31.3	14.1	2.48	88.4	16.0
Avg	50.1	43.7	6.5	28.0	13.0	2.3	86.9	12.7
SEm	3.6	3.2	0.5	0.7	0.4	0.1	0.4	0.9
CD(*P*=0.05)	10.7	9.5	1.5	2.0	1.1	0.2	1.2	2.8

Table 17. Effects of vermicompost, fertilizer and mulching on growth, nodulation and yield of French bean cv. Arka Komal

Treatment	Days to 50% germi-nation	Shoot length (cm)	Root length (cm)	No. of trifoliate	No. of primary branch	No. of nodule	No. of leaf	Leaf area (cm^2/ leaf)	No. of pod	Single pod weight (g)	Pod length (cm)	Pod yield (t/ha)
T-1	67.0	38.6	16.8	4.5	1.7	28.1	13.4	19.4	12.2	5.7	10.5	7.5
T-2	70.3	40.9	24.1	4.9	2.1	25.6	14.7	24.5	13.2	5.9	11.6	8.3
T-3	66.3	39.8	16.8	4.8	1.9	28.6	14.5	25.2	14.2	6.1	12.4	9.6
T-4	70.3	45.8	22.4	5.0	2.4	25.6	15.0	36.9	15.3	6.9	14.8	12.0
T-5	69.0	38.8	16.0	5.6	2.0	28.3	16.7	23.7	16.3	7.1	13.1	11.8
T-6	72.0	51.2	21.9	6.0	2.5	26.4	17.9	31.6	15.2	8.2	16.2	12.8
T-7	68.3	46.6	18.4	6.1	2.0	29.1	18.2	32.7	13.4	6.3	12.3	8.9
T-8	71.0	55.4	18.6	5.5	2.8	25.7	16.5	40.6	15.1	7.2	12.9	11.7
T-9	69.7	46.4	14.4	5.1	2.3	25.6	15.3	32.3	11.6	5.6	10.9	7.1
T-10	73.0	49.7	21.8	5.0	2.4	24.3	15.0	32.1	12.6	5.9	11.2	8.1
Avg	69.7	45.3	19.1	5.2	2.2	26.7	15.7	29.9	13.9	6.5	12.6	9.8
SEm	0.8	0.6	0.7	0.2	0.1	1.0	0.7	1.3	0.5	0.2	0.3	0.62
CD(*P*=0.05)	2.5	1.8	2.2	0.7	0.2	3.1	2.0	4.0	1.4	0.7	0.8	1.83

and yield of French bean, but lower dose of fertilizer and higher dose of vermicompost had negative effects. The T-5 treatment (50 % dose of each fertilizer and vermicompost) was found to be very suitable for getting higher yield as well as growth in both mulched and non-mulched treatments.

Evaluation of okra cultivars for yield

The experimental plots 5×2.4 m were replicated three times in RBD. The plot size was kept as. Twenty-four hrs water soaked seeds were planted at the spacing of 50×40 cm during 3rd week of March 2009. Plant height was recorded maximum for Prabhani Kranti followed by Green Challenger, NS-810 and Okra-151 (Table 18). Moreover, maximum node and fruit numbers per plant were counted for Prabhani Kranti followed by Green Challenger, Okra-151 and NS-810. Public sector released variety, Prabhani Kranti, was found to be most productive followed by Green Challenger, NS-810 and Okra-151.

Table 18. Performance of okra varieties and hybrids at ICAR Kolasib, Mizoram

Cultivar	Plant height (cm)	Number of node	Inter-nodal length (cm)	Fruit length (cm)	Number of fruits / plant	Single fruit weight (g)	Yield (t/ ha)
NS-810	213.3	28.2	7.6	14.4	24.0	20.4	18.4
Okra-151	189.5	28.6	6.6	15.4	24.2	19.7	17.8
NOL-303	163.3	21.6	7.6	15.1	19.5	18.3	13.4
NOL-101	158.7	21.8	7.3	15.6	19.5	16.7	12.2
Green Challenger	213.8	28.6	7.5	14.5	24.1	22.3	20.2
Prabhani Kranti	257.4	35.8	7.3	13.6	31.6	20.7	24.7
OH-597	151.2	24.3	6.3	15.5	22.2	17.9	14.9
Avg	192.5	27.0	7.2	14.8	23.6	19.4	17.4
SEM ±	3.2	1.7	0.3	0.4	1.6	0.9	1.8
+CD (*P*=0.05)	9.9	5.3	1.0	1.2	4.8	2.8	5.4

Evaluation of turmeric genotypes

Twenty-seven genotypes, including eleven varieties, were evaluated for various traits of economic importance. All the growth parameters, i.e. plant height, stem thickness, number of tillers, leaf length, leaf width and leaf area was taken after 120 days of planting. Top third leaf was chosen to measure the leaf length, leaf width and leaf area. Seven genotypes revealed significantly higher yield which was maximum for Duggirala followed by IISR Pratibha, Roma, RCT-1, Local-16, Local-9 and Local-8. The dry matter content was highest in Rashmi followed by Roma, Local-14, Local-7, Local-10, Local-15, IISR Allepy Supreme, IISR Pratibha, IISR Kedaram, Local-11, RCT-1, Local-6, Local-9, Local-13, Local-12 and Duggirala. None of the genotypes were found tolerant to both major diseases, i.e. leaf spot (*Colletotrichum curcumae* and *C. capsici*) and leaf blotch (*Taphrina maculans*). Nevertheless, Suranjana, BSR-2, Local-14 and Local-15 showed susceptibility to both diseases. The genotypes, namely Duggirala, IISR Pratibha, Roma and RCT-1, hence, recommended for commercial cultivation in Mizoram.

Variability among chilli genotypes in Mizoram

Sixteen genotypes of *Capsicum annum*, two variants of *C. chinense* and two varietal types, i.e. cherry and bird eye chilli of *C. frutescens* were collected from various places of Mizoram. Sufficient variability for flowering habit and fruit numbers (Table 19) was recorded among *Capsicum* species.

Table 19. Variability for flowering habit and fruit numbers among *Capsicum* species

Species	Common name	No. of flowers/ node	No. of fruits/ plant
C. annum	Chilli	1	50-250
C. chinense	Naga chilli	1-5	20-50
C. frutescens	Cherry (C),	1-3	400-980
	Bird eye chilli or Mizo chilli (D)	1-3	200-550

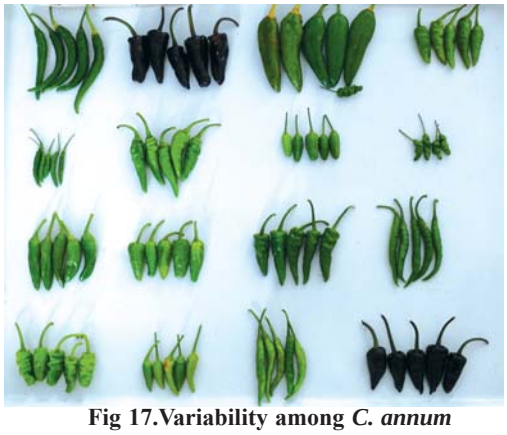


Fig 17.Variability among *C. annum*

Fig 18.A and B: *C. chinense*, C and D: *C. frutescens*

Performance of capsicum in net-house/ green-house

Three hybrids and one variety were evaluated for yield potential under Net-house/ green-house. Twenty-five days old seedlings were transplanted at the spacing of 50×50 cm during mid November 2009. The plant height was measured maximum for Bharat followed by Swarna, Natasha and California Wonder (Table 20). Single fruit weight was recorded maximum for Natasha followed by Swarna, Bharat and minimum for California Wonder, nevertheless California Wonder produced more fruits/ plant. There was incidence of mite, aphid and mosaic disease under Net-house. The percentage of healthy plants was maximum for Swarna followed by Bharat and minimum healthy plants were in California Wonder. The cultivar Swarna showed maximum yield potential per unit area followed by Bharat and Natasha.

Wild *Abelmoschus*

Wild *Abelmoschus* was collected from Kolasib district which is very near to *A. manihot*. The race is resistant to yellow vein mosaic virus and could be utilized in further breeding programmes. The details of plant morphology are in Table 21.

INTEGRATED FARMING SYSTEM

Assessment of technology in watershed based integrated farming systems in north eastern hills region

Agri - Horti System: In this system soybean, ginger, turmeric and groundnut were grown.

In Soybean, seeds were sown by treating with bio-fertilizers and application of lime was done @ 1.0 t/ha. The crop recorded an average seed yield of 1.6-1.7 t/ha. The yield of turmeric (RCT-1) was 22-26 t/ha and ginger var. Nadia recorded yield of 15-17 t/ha.

Horti - Silvi - Pastoral system: Different crops were grown whose performance in the system was as follows-

1. *Banana:* Banana var. Giant Cavendish and Grand Naine performed better with the yield of 20-22 t/ha and 28-31 t/ha, respectively.
2. *Peach:* Peach var. TA 170 and Flordasun produced 17.0 and 20.0 fruits/plant, respectively.
3. *Aonla:* 100 seedlings of aonla were planted during 2004 and they attained the height of 4.0 m.
4. *Guava:* About 150 plants of guava var. Allahabad Safeda were planted and produced 70 - 80 fruits /plant and yielded of 10-11 t/ha.
5. *Passion Fruit:* About 200 new seedlings of purple passion fruit were planted during 2008-2009.

Table 20. Performance of capsicum cultivars under net-house/ green-house

Cultivar	Plant height (cm)	Number of fruits/ plant	Fruit weight (g)	Fruit production (kg/ plant)	Healthy plant (%)	Yield (kg/ 100 m^2)
California Wonder	63.3	13.3	68.6	0.914	24	60.9
Bharat	113.3	11.3	78.8	0.891	40	99.0
Natasha	88.9	13.0	96.7	1.257	28	97.8
Swarna	98.0	9.8	83.4	0.813	48	108.4
Average	90.9	11.8	81.9	1.0	35	91.5

Table 21. Morphology of wild *Abelmoschus* species

Particular	Plant part	Trait
Plant colour	Leaf	Green
	Petiole	Reddish
	Stem	Reddish
	Petal	Yellow
	Immature pod	Green
	Epicalyx	Reddish tinge
	Pedicel	Reddish tinge
	Seed	Black
Flower and pod traits	No. of epicalyx	5-6
	No. of fruit segment	5
	Pod length	6-7 cm
	Pedicel length	7-8 cm
	Epicalyx length	3-4 cm
Seed test weight (1000 seed wt.)	11.7 g (As comparison to 66.1 g for normal okra seed)	
Trichome density on plant parts	Stem > Pod > Pedicel > Epicalyx > Leaf	

6. *Mandarin:* Two year old plants of Khasi mandarin attained the height of 3.0-3.5 m.
7. *Hatkora:* One hundred hatkora was planted in 2005 but only 70% plants are surviving.
8. *Pineapple:* Thirty thousand suckers of Kew were planted and maintained in double row system. The yield was 25-27 t/ha.
9. *Tree bean: Parkia roxberghii* was bearing 65 - 75 pods/plant

Dairy component

A total number of seven cows, three heifers and eight calves are maintained in the dairy unit. The lactating and pregnant cows were stall fed with napier, para grass and Congo signal.

Animal Science

Studies on bovine bacterial mastitis

Five mastitic milk samples were collected from Kolasib and these samples were isolated and tested by MCMT and sensitivity conducted. *Staphylococcus* and *E.Coli* were isolated. Most of the cows suffered from Clinical Mastitis and one cow suffered from sub-clinical mastitis. Antibiotic sensitivity testperformed and it was found susceptible to- Ciprofloxacin, Norfloxacin, Oxytetracycline, Cephalexin, Gentamicin and Enrofloxacin but resistant to-Amoxycylin, Erythromycin. Nine milk samples from nine individual cows were collected from Saiha district and the milk samples were found negative from Mastitis.

Piggery

One Large White Yorkshire (LWY) sow (Fig 1) was reared in the farm to study the size of the litter.The litter size was 13(4 M+ 59F) with an average litter weight at time of birth was 1.55 kgs and litter weight at the time of weaning were 11.10 kgs. Interval between first furrowing and second furrowing was studied under ICAR farm conditions. The time taken for the next parturition was found to be 7 months.

Feeding trials were conducted and the piglets were divided into 3 Groups. The average body weight of all 3 groups of piglets was recorded at regular intervals for a period of 5 months. During

Fig 1. LWY Sow with piglets at ICAR Farm

the period of report, the average monthly body weight of Group-1 (75% of concentrate feeds + 25% of *Spilanthus* sp) till five months were 16.62 kg, 21.75 kg, 29.6 kg, 37 kg and 46 kg respectively. The average monthly body weight of Group-2 (75% of concentrate feed+25 % of Ipomea *batata*) till five months were 15.25 kg, 20.37 kg, 26.70 kg, 29 kg and 32 kg. The average monthly body weight of Group-3 (fed with only standard concentrate feed) till five months were 11.5 kg,15.75 kg,20.6 kg,31 kg and 38 kg.The growth rate of piglets among the 3 groups were found to be highest in group-1 followed by group-3 (Control group) and then group-2.There was no significant difference between the body weight gain of piglets in control and treatment groups.The feed cost was significantly reduced in Ankasa (*Spilanthus* Sp)and Kawlbahra (*Ipomea batata*) fed groups than the control groups

Veterinary care

Most common ailments in pigs were found to be maggoted wound piglet, diarrohea and skin disease.The pig and piglets were treated promptly by dressing with antiseptic solution and Himax in maggoted wound and in case of piglet diarrohea the faecal samples were collected aseptically and processed in the laboratory to identify the causative organism and sensitivity test was done and specific antibiotic treatment was given to the piglets.In case of skin disease the piglet were treated with Vetclox forte and Avil. Deworming of pig and piglets were done at regular interval by anthelmentics. Accordingly insemination was done in the farm through artificial insemination with the help of AH and Vety Deptt.

Dairy

Management of livestock in the centre

During the year 2009-10, out of four numbers of heifers three of the pregnant animal parturated and were shifted to the dairy milch cow block (Fig 2). Two of the unproductive bulls and three milch cows were discarded and sold. Eight calves (3M+5F) and four bulls were maintained in the dairy unit. Eight cows gave birth and one cow suffered from dystocia (abnormal posture) and live calf was relieved and the dam was given due post partum care. One of the cows suffered from *Babesia* spp. infection and the blood samples were collected aseptically and after laboratory analysis the cow as treated with parentral Berenil, Avil, Melonex, Ferritas, Polyvet along with other supplements. Another cow had sub-clinical mastitis and the animal was treated by hot fomentation and udder massage with mastilep besides providing other necessary supplements. One cow suffered from maggoted wound and after prompt treatment with Himax and dressing with Potassium Permanganate recovered from infestation. The average milk production per day was around 33 litres.

The total milk production during the year was 11624.169 liters. The lactating, pregnant cows, Heifers, bulls and calves were stall fed with Napier, Para grass, Congo signal etc. apart from supplementing with concentrate feeds mixed with mineral mixture purchased from Govt.Feed Mill, Tanhril.

Fig 2. Milch cows at ICAR Dairy farm

Veterinary care

The most common ailments in cattle were found to be mastitis maggot infestation and Babesiosis. All the infested animals were specifically treated after laboratory diagnosis. Regular and routine examination of each quarter of cows were done. All the animals were vaccinated against F MD. It was observed that housefly was the major problem in dairy unit and control measures were taken by spraying Deltamethrin 0.03 % conc. and Allethrin0.01 % conc.

The net income of Rs. 3, 80,905 (Rupees three lakhs eighty thousand nine hundred and five only) was earned from the livestock units during 2009-10, out of which a revenue of Rs. 2, 36,205(Rupees two lakhs thirty six thousand two hundred and five only) was generated from dairy by sale of milk alone.

Revenue generation

A total revenue of Rs 3, 80, 905 (Rupees three lakh eighty thousand nine hundred and five only), was generated during the 2009-2010 and a maximum revenue was generated through the sale of milk followed by sale of cattle and piglets etc.

Sale	Amount(Rs)
Bull	44600.00
Cattle	77000.00
Piglets	23100.00
Milk	236205.00
Total :	3,80,905.00

NATIONAL AGRICULTURAL INNOVATION PROJECT

Livelihood improvement and empowerment of rural poor through sustainable farming systems in northeast India

1. Improvement of livelihood by introduction of improved technology for citrus, passion fruit and banana cultivation

Introduced improved technology for citrus cultivation, passion fruit cultivation, banana cultivation and management practices for citrus rejuvenation.

2. Introduction and development of integrated farming system technology

Cultivated agricultural crops such as rice, maize, green gram, black gram, pea, mustard, soybean, rice bean, horticultural crops *viz*., cole crops, bhendi, banana, citrus, apple etc., Planted some forest tree seedlings like subabul, tree beans etc., constructed one water storage structure and constructed pig shed, poultry shed and cow shed.

3. Improvement of livelihood by vegetable cultivation

Thirty farmers were selected for cultivation of various vegetables and around 6000 m^2 sloppy land was terraced for cultivation.Various seasonal vegetables like okra cv. Arka Anamika; tomato cvs. Pusa Rohini, Avinash-2, Sel-2, Pusa Ruby; cabbage cv. Golden Acre; pea cv. Arkel; Chinese mustard (Auntam); and turmeric cv. RCT-1 were sown/ transplanted. The productivity of pea cv. Arkel ranged from 6.0-8.0 t/ha to various farmers field which was sown during 1st week of November 2008. The okra cv. Arka Anamika performed well and its performance varied from 70-100 q/ ha to various farmers field.

4. Soil water conservation in adopted village

Thirty farmers were selected, their part *Jhum* land was converted into terrace land and encouraged them for the cultivation of crops in terrace flat land instead of slope land. Farmers were motivated for the annual crops like maize, soybean, lentil, pea, mustard etc. The result of the technology introduction showed that the farmers were enthusiastic for further expansion in there *Jhum* land.

Output of different interventions in terms of enhancement in productivity, income etc

- Terrace: 3.2 ha
- The okra cvs., Arka Anamika and Punjab Padmini performed good with productivity of 70-115 q/ ha
- The productivity of turmeric cv. RCT-1 was recorded 110-150 q/ ha
- The knol-khol cv. Early Vienna yielded 60-70 q/ ha.
- The productivity of cabbage (Pusa Mukta, KGMR-1, Dlue Diamond) ranged from 150-185 q/ ha.
- Introduction of organic mulching reduces the water scarcity problem during October-March.
- Milk: 2 lit (approx) in the morning and 2 lit (approx) in the evening
- Sold: 3 lit everyday @ Rs 40 per lit
- Earned Rs. 8000 towards selling of piglets
- Banana: Rs 500 per month
- Antawm and brinjal: Rs 1000-1500 per year
- Mango: Rs 3000
- Pineapple: Rs 3000
- Orange: Rs 10,000
- Passion fruit: Rs 10 per 15 fruits

Success stories/up scalable technologies

Farmer name: Noliansanga

Terrace: No of terrace: 15. Length and Width : 15 x 1.0 meter per terrace

Crops planted: Banana: 1000, Lemon: 30, Pineapple: 50, Mango: 60,

Yield: Banana : Rs. 500 per month, Khangh : Rs. 600 in a year

Poultry: Earned Rs. 6000

Pigs: Earned Rs. 8000, Brought new piglet for Rs. 3500

Cow: Milk: 2 lit (approx) in the morning and 2 lit (approx) in the evening, Sold: 3 lit everyday @ Rs. 40 per lit

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

Genotype × environment interaction on quality of turmeric

Eleven varieties were evaluated for various traits of economic importance. All the growth parameters, i.e. plant height, stem thickness, number of tillers, leaf length, leaf width and leaf area was taken after 120 days of planting. Top third leaf was chosen to measure the leaf length, leaf width and leaf area. The maximum yield was recorded for Duggirala which is at par with IISR Pratibha, Roma and RCT-1. Moreover, dry matter content was found to be highest in Rashmi followed by Roma, IISR Allepy Supreme, IISR Pratibha, IISR Kedaram and RCT-1. Only two cultivars, i.e. Narendra Haldi-1 and

Rajendra Sonia showed field level tolerance to leaf spot (*Colletotrichum curcumae* and *C. capsici*). However leaf blotch (*Taphrina maculans*) incidence was recorded in four genotypes, namely Suranjana, Narendra Haldi-1, BSR-2 and Rajendra Sonia. Leaf spot and leaf blotch was found in Suranjana and BSR-2 simultaneously. The incidence of both diseases, leaf spot and leaf blotch, were noticed during October 2009. Four cultivars, namely Duggirala, IISR Pratibha, Roma and RCT-1 were recommended for commercial cultivation in Mizoram.

Genotype × environment interaction on quality of ginger

Eight varieties were evaluated for various traits of economic importance. All the growth parameters, i.e. plant height, stem thickness, number of tillers, leaf length, leaf width and leaf area were taken after 120 days of planting (Table 22). Top 5-7th leaves were chosen to measure the leaf length, leaf width and leaf area. Leaf area was highest for Himgiri which was at par with Nadia and Nisapui (Local). The maximum yield was recorded for Nadia followed by Himgiri, Nisapui (Local), Mahima and Varda.

Network research project on management of soft rot of ginger

Three locations, i.e. Kolasib, Bukpui and Nisapui were surveyed to collect the genotypes from farmers' field. The cultivar Nadia realized maximum yield followed by local collection from Nisapui,

Table 22. Performance of ginger genotypes in terraced land at Kolasib, Mizoram

Genotype	Yield (t/ ha)	Soft rot incidence (%)
Thingpui	10.0	15-25
Thingaria	15.0	20-25
Thinglaidum	12.0	20-35
Nadia	19.5	5-10
Local (collected from Nisapui)	16.0	10-15
Mahima	12.0	20-25
Rejatha	8.0	15-30
Suprabha	9.0	20-35
Varda	12.0	30-40

Thigaria, Mahima, Varda, Thinglaidum, Thingpui, Suprabha and lowest for Rejatha (Table 22) in terraced plots. The minimum soft rot incidence was in Nadia followed by Nisapui Local and Thingpui. In general, the incidence of soft rot was found to be more in terraced field as compared to sloppy land, nevertheless vice-versa for productivity (Table 23).

Table 23. Performance of ginger genotypes on sloppy land Kolasib, Mizoram

Genotype	Yield (t/ ha)	Soft rot incidence (%)
Thingpui	7.5	5-15
Thingaria	11.0	10-15
Thinglaidum	9.5	10-15
Nadia	12.5	0-5

NAGALAND CENTRE

Weather Report

Air temperature

The mean maximum and minimum temperatures ranged from 23.53 to 32.70 ^{0}C and 8.16 to 25.77 ^{0}C, respectively. The highest maximum temperature of 37.30 ^{0}C was recorded on 23rd May, whereas the lowest minimum temperature of 5.10 ^{0}C was recorded on 12th January. June was the hottest month and January was the coolest month of the year (Table 1).

Relative humidity

The average monthly maximum and minimum relative humidity varied from 73.8 to 85.07 % and 24.36 to 66.23 %, respectively. Based on the average data from 2009-10, the highest relative humidity was recorded from the months of July to October and the morning hour was more humid as compared to the afternoon hours (Table 1).

Rainfall

The total annual rainfall received during the year 2009-10 (April 09 to March 10) was 977.90 mm from 99 rainy days. The maximum rainfall was recorded in the month of July (219mm) followed by September (188.70mm), whereas, November and January were recorded as dry the months (Table 1).

Pan evaporation

The total monthly pan evaporation was recorded less than the total monthly rainfall during June'09 – Oct '09 (Table 1).

Soil temperature

Soil temperature was recorded both in the morning and evening from 5 to15 cm depth and it showed a decreasing trend with the increase in soil depth (Table 1).

Water Resources

Water budgeting of Nagaland

Analysis based on the average rainfall data from 1998 – 2009 showed that Nagaland received the normal annual precipitation of about 1616.42 mm. The State receives about 26.80 BCM of rainfall, out of which about 12.87 BCM was lost as the evapotranspiration. Most of the rain water was drained into the streams as surface runoff and quick baseflow and some quantity of water gets stored in few farm ponds constructed on the hill terraces. However, due to high seepage rate (about 45-70 litre/m^2/day), the water retention capacity of these small farm ponds reduced drastically. Recently, some technological interventions have been made for storing water in low-cost micro-rainwater harvesting structures (*Jalkunds*), baseflow harvesting structures, concrete storage tanks, constructing check dams on the perennial springs, rooftop rainwater harvesting structure etc.

In Nagaland, onset date of South-West monsoon normally starts on 1st June and it normally ceases during 5th to 12th October. The average winter (January-February), pre-monsoon (March-May), monsoon (June-September), and post-monsoon

Table 1. Average monthly weather data of Nagaland

Air temperature (°C)		R.H. (%)		Pan evaporation (mm)	Total rainfall (mm)	Soil temperature (°C) (5 cm)		Soil temperature (°C) (15 cm)	
Max.	Min.	Max.	Min.			Min.	Max.	Min.	Max.
23.53 (Jan. 2010) – 32.70 (June 2009) **(29.36*)**	8.16 (Jan. 2010) – 25.77(July 2009) **(18.48*)**	73.86 (Feb 2010)– 85.07 (Sept. 2009)	24.36 (Feb 2010) – 66.23(Aug. 2009) **(46.80)**	39.80 (Dec. 2009) – 146.30(May 2009) **(88.06*)**	977.90	2.90 (Jan. 2010) – 18.16 (July 2009) **(12.02*)**	15.31 (Jan. 2010) – 25.48 (July 2009) **(21.26*)**	2.82 (Jan. 2010) – 15.63 (July 2009) **(10.55*)**	9.97 (Jan. 2010) – 21.86 (May 2009) **(18.43*)**

*The values in the parentheses are the monthly average values during April 1, 2009– March 31, 2010.

(October-December) seasonal rainfall distribution patterns in Nagaland was 34.91, 326.89, 1077.90, and 176.72 mm, respectively (Fig. 1). Analysis of 12 years weather data (1998-2009) on annual and monthly rainfall distribution and potential evapotranspiration (ET_o) (Figs. 2 a & b) indicated that there was a decreasing trend in the total rainfall pattern over the years considering the drought years (Fig. 3) of 1998 (34.79 % deficit than normal) and 2009 (40.11 % deficit than normal) and water surplus years of 2000 (37.51 % above normal), 2004 (11.27 % above normal) and 2007 (27.23 % above normal).

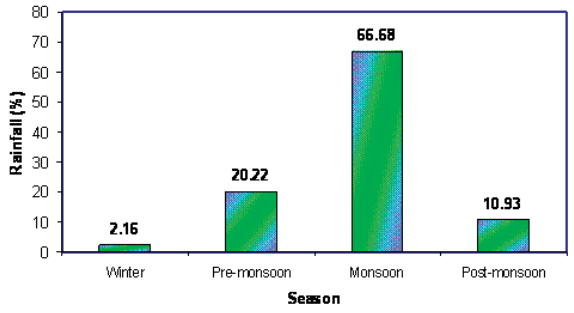


Fig 1. Seasonal normal rainfall distribution pattern in Nagaland

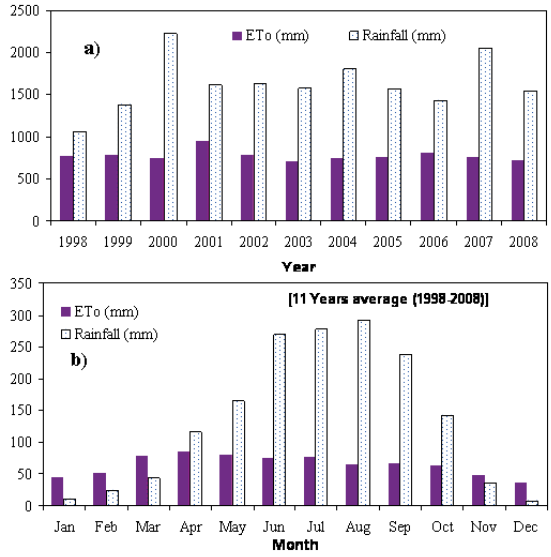


Fig 2. a) Annual and b) monthly normal rainfall and evapotranspiration (ET_o) distribution patterns in Nagaland

The net annual water demand for Nagaland in 2001 was about 83.47 million cubic metres (MCM) excluding agriculture sector. Considering a constant decadal population growth rate of 64.53%, the net

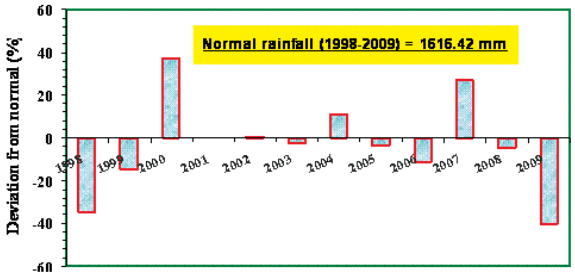


Fig 3. Deviation pattern of annual rainfall from the normal in Nagaland

water demands for Nagaland (excluding agriculture sector) in 2011, 2021, 2031, 2041, and 2051 are projected to be about 137.34, 225.96, 371.78, 611.68, and 1006.40 MCM $year^{-1}$, respectively.

For prioritization of the water needs, water poverty mapping of an area was carried out depending on the physical availability of water resources, access to water for domestic and agricultural sectors, capacity of the stakeholder to manage water, the ways of water use in various sectors, and environmental integrity with respect to water and ecosystem goods and services from the flora and fauna. A case study on the water poverty mapping based on household surveys in Lampong Sheanghah village of Mon District showed that all the households fared very poorly in terms of the most components of the water poverty index (WPI), i.e., water use (0.15), water resource (0.38), water access (0.40), and capacity (0.40) with an overall value of 0.44. This revealed that "access to water resources" and 'stakeholders' capacity to manage water" were the two major factors contributing to water poverty in this area. Nagaland has a WPI value less than that of the Indian national average of 0.51.

AGRONOMY

Integrated nutrient management in paddy var. RCM 9

The soil of the experimental site was slightly clay loam, acidic (pH = 5.2), high in organic carbon (1.95%), deficient in available nitrogen (236.20 kg/ha), moderate in phosphorous (12.30 kg/ha) and moderate to high in available potash (200.20 kg/

ha). The experiment was laid out SPD with three replications. The main plot treatments consisted of four organic sources viz. crop residue (M_1), vermicompost (M_2), bio fertilizers (M_3) and mixed of crop residue, vermicompost, biofertilizers (M_4). The sub plot treatments consisted of different combination of chemical fertilizers viz. control (S_1), 50% NPK (S_2), 75% NPK (S_3), and 100% NPK (S_4). In the main plot treatment, the highest no. of effective tillers/hill, panicle length, no. of grains/ panicle and grain yield were recorded in M_4 which were closely followed by M_3 (Table 2). In the sub plot treatment maximum plant height, no. of effective tillers/ hill, no. of grains/ panicle and grain yield were observed in S_3 which were closely followed by S_4. This might be due to appropriate combination of organic and inorganic sources of nutrients.

INM in maize var. Vijay Composite

The experiment was also conducted on maize crop with the similar set of treatments as INM on paddy in main and sub plots. In the main plot treatments, the maximum plant height, no of rows/ cob and no of kernels/ row were recorded in M_2. However, the highest grain yield was observed in M_4 (2.35 t/ha). In the sub plot, the treatment S_4 resulted in the highest plant height, no of plants/m^2, no of rows/cob and no of kernels/ row and grain yield. This might be due to higher response of the maize crops to wards more nutrients (Table 3).

RCRT trials in upland paddy

In the upland conditions, RCPL 1-115 recorded the highest grain yield (5.80 t/ha), followed by RCPL 1- 117(4.80 t/ha) (Table 4).

Table 2. Growth and yield attributes of paddy under INM

Main plots	Plant height at harvest (cm)	No. of effective tillers/ hill	Panicle length (cm)	No. of grains / panicle	Grain yield (t/ ha)
Main plots					
M_1	103.14	13.20	20.20	198.40	3.62
M_2	102.02	14.00	22.30	190.70	3.70
M_3	100.38	14.60	23.00	182.43	3.80
M_4	101.28	19.50	23.80	213.24	3.80
Sub plots					
S_1	98.21	13.80	19.80	186.00	3.50
S_2	103.15	13.80	20.80	182.60	3.60
S_3	101.84	15.30	24.00	196.20	4.02
S_4	102.28	15.00	24.20	192.50	4.00

Table 3. Growth and yield attributes of maize under INM

Main plots	Plant height (cm)	No of plants / m^2	No. of rows /cobs	No. of kernels / row	Grain yield (t/ ha)
Main plots					
M_1	230.40	8.20	12	32	1.55
M_2	245.30	8.30	13	36	2.17
M_3	228.52	8.50	12	33	2.03
M_4	233.45	8.50	12	32	2.35
Sub-plots					
S_1	232.52	8.20	12	29	1.38
S_2	240.64	8.30	12	32	2.10
S_3	243.50	8.30	13	32	2.25
S_4	252.50	8.40	13	36	2.35

Table 4. Yield attributes and yields of upland paddy

Varieties	Plant height (cm)	No. of effective tillers/ hill	Panicle length (cm)	Grains / panicle	Grain yield (t/ha)
BHALUM – 1	95.12	9.17	25.73	7.33	2.45
BHALUM – 2	113.05	5.83	23.20	6.17	2.77
RCPL 1-45	119.65	7.00	19.53	7.17	3.02
RCPL 1- 46	110.75	7.33	25.50	7.17	1.2
RCPL 1-113	129.37	10.17	21.08	7.33	3.63
RCPL 1-114	102.08	6.00	21.67	10.00	3.90
RCPL 1-115	104.27	5.83	20.27	12.17	5.80
RCPL 1- 116	130.52	6.67	19.90	10.67	3.98
RCPL 1 - 117	109.32	5.67	21.35	10.00	4.80

RCRT trials in aromatic paddy

A varietal trial on aromatic paddy indicated that the highest yield was recorded in IET -16313, closely followed by Shasarang and IET-16332 (Table 5).

Table 5. Yield attributes and yields of aromatic paddy

Varieties	Plant height (cm)	No. of effective tillers/ hill	Panicle length (cm)	No. of spike/ plant	Yield (t/ha)
RCM-11	228.12	15.22	28.83	11.22	3.18
IET - 17281	92.03	17.44	26.47	11.00	4.12
AR-3	100.59	19.78	25.16	11.89	4.04
Lamphan	108.92	14.33	26.93	10.89	3.49
IET 16332	112.14	15.78	30.33	10.56	4.77
Shasarang	97.20	12.11	24.86	12.22	4.77
IET-16313	110.27	13.11	25.40	10.56	5.51

RCRT trials in lowland paddy

Thirteen paddy varieties were tested under lowland condition for growth and yield. Among the varieties evaluated, TRC 87-251, IET – 18572 and RCM-16 recorded the highest yield potential of 5.13, 4.70 and 4.67, respectively (Table 6). Eighteen lowland paddy varieties were evaluated for their growth and yield parameters. Among them, IET-18581 recorded the highest yield of 4.63 t/ha.

Varietal evaluation in groundnut

Eleven varieties of groundnut were evaluated for their yield potential. The maximum yield was recorded in FESEG-10 (3.04 t/ha) which was followed by NRCG CS-148, GG–7 and ICGS–76 (Table 7).

Table 6. Yield attributes and yields of lowland paddy varieties

Varieties	Plant height (cm)	No. of effective tillers/ hill	Panicle length (cm)	No. of spike/ plant	Yield (t/ha)
RCM-13	106.82	3.22	25.83	11.11	4.03
RCM-14	110.88	3.22	25.19	10.11	3.03
RCM-15	111.47	2.89	31.06	11.67	4.00
RCM-16	99.40	3.33	25.83	10.56	4.67
RCM-17	102.83	2.78	26.74	9.89	3.33
IET-16313	107.22	3.67	26.24	11.78	3.77
IET-16332	111.52	3.44	26.30	11.44	3.97
IET-17276	106.74	3.11	27.51	10.00	1.95
IET-17278	95.52	3.67	26.22	8.67	2.35
IET-17281	92.70	3.22	24.97	11.11	2.03
IET-18564	107.20	3.44	26.11	11.11	2.30
IET-18572	104.68	3.33	25.94	13.44	4.70
TRC-87-251	100.24	2.56	26.06	10.56	5.13
Lampanha	94.04	9.00	23.72	10.89	2.78
AR-3	108.52	12.78	29.41	9.00	2.50
BM-9820	110.79	10.33	27.90	9.89	2.45
Shasarang	92.59	12.22	25.01	10.89	4.37
IET-18564	115.74	10.11	25.97	10.11	3.83
IET- 18581	118.71	14.33	25.52	10.78	4.63
IET-18572	94.07	15.33	25.28	11.44	3.52
IET-18571	92.27	15.44	24.83	12.00	2.92
RCM-22	86.02	15.00	26.70	13.00	3.05
RCM-21	88.86	13.22	25.09	11.56	3.08
RCM-20	102.88	10.22	27.68	10.00	1.72
RCM-19	107.10	13.00	26.32	12.44	2.57
RCM-18	109.27	10.44	23.49	11.11	2.27
RCM-17	102.41	11.44	26.96	11.33	1.97
RCM-16	95.93	12.11	26.14	11.22	3.07
RCM-15	98.71	12.67	25.74	11.44	3.85
RCM-14	92.54	16.11	27.24	11.89	3.03
RCM-11	97.43	10.33	26.96	14.11	2.30

Table 7. Yield attributes and yields of groundnut varieties

Varieties	Shoot length (cm)	Root length (cm)	No.of branches / plant	No. of pods / plant	Pod weight (g)	Yield (t/ha)
FESEG – 10	80.00	18.00	20.50	45.20	60.00	3.04
GG – 20	56.50	16.50	22.60	37.80	69.40	2.48
FESEG – 8	98.64	16.50	15.00	30.85	62.50	1.98
CSMG – 84-1	64.25	15.20	28.00	40.00	74.84	2.64
NRCG CS –281	73.45	15.00	17.50	42.50	70.48	2.58
NRCG CS-148	99.50	13.50	18.00	50.60	60.47	3.00
TG – 42	63.60	18.00	10.50	42.67	58.30	2.58
GIRNAR – 1	209.65	20.00	12.00	32.45	69.50	2.19
ICGS – 76	82.50	18.00	17.50	54.60	50.50	2.70
GG – 7	70.00	14.50	8.40	32.00	52.40	2.95
JL – 24	72.50	13.70	12.50	33.60	50.40	2.02

Evaluation of rapeseed and mustard varieties

Thirteen varieties of rapeseed and mustard were evaluated for their yield potential during 2009-10. The maximum yield was recorded in PT-303 (2.323 t/ha) which was followed by TS-38 and RCT-1 (Table 8).

Table 8. Yield attributes and yields of rapeseed and mustard varieties

Varieties	Plant height (cm)	No. of branches	No. of siliqua /plant	No. of seed/ siliqua	Yield (t/ha)
RCT-1	70.70	6.00	75.0	23.0	1.04
RCT-2	67.60	6.20	63.0	16.0	0.54
SCRT-1-2	66.30	4.00	48.3	23.0	0.61
SCRT-1-3	117.10	10.0	68.0	12.0	0.57
SEJ-2	116.10	4.00	70.4	11.0	0.18
JD-6	98.90	8.00	54.0	16.0	0.17
PT-303	91.70	6.00	68.2	15.0	2.32
PT-507	91.9	5.20	53.0	11.0	0.31
NDRE-4	99.20	16.40	136.3	15.0	0.13
KRANTI	111.5	4.50	76.2	15.0	0.13
BHAVANI	83.8	5.50	83.2	16.0	0.43
TORIA					
M-27	67.60	4.40	48.3	18.0	0.70
TS-38	85.80	3.50	87.2	13.0	1.24

Varietal evaluation trials in linseed

Under AICRP on linseed, 21 promising lines were evaluated under foot hills of Nagaland during *Rabi* season of 2009-10. Line 90221 exhibited the highest grain yield (0.67 t/ha) followed by the line 90204 (0.54 t/ha). The lowest yield was recorded in the line 90222, 90206 90215 and 90215 due to heavy infestation of diseases and pests (Table 9).

Under rainfed condition, line 90113 exhibited the highest grain yield (0.58 t/ha) followed by the line 90101 (0.41 t/ha). The line 90113 performed very well under the rainfed conditions of Nagaland (Table 10).

HORTICULTURE

Production of nucleus/basic seed and planting material

About 10,000 nos. of Assam lemon cuttings, 5000 nos. of *Khasi* mandarin seedlings, 1000 nos. of rough lemon seedlings, 5000 nos. of black pepper cuttings, and 50 kg French bean seeds were produced.

Table 9. Performance of various linseed varieties under irrigated conditions

Varieties	Plant height (cm)	No.of branches / plant	No. of effective capsule/ plant	No. of seed /capsule	Test weight (g)	Yield (t/ha)
IVT (I)- 90201	53.3	4.33	59.0	8.00	5.53	0.26
IVT (I) – 90202	47.9	5.67	48.0	7.0	6.37	0.35
IVT (I) -90203	52.3	4.67	56.30	7.67	6.52	0.39
IVT (I) – 90204	52.4	5.33	53.33	4.33	6.85	0.54
IVT (I) -90205	56.1	13.0	59.33	4.60	4.43	0.24
IVT (I) – 90206	56.1	4.0	21.33	8.00	3.98	0.20
IVT (I) – 90207	50.6	6.35	45.33	8.00	4.00	0.25
IVT (I) – 90208	49.8	6.33	102.00	7.77	4.87	0.45
IVT (I) – 90209	68.8	6.67	65.0	8.00	5.65	0.48
IVT (I) -90210	53.8	14.3	56.67	8.00	4.83	0.35
IVT (I) – 90211	50.7	4.67	40.0	6.67	3.78	0.37
IVT (I) – 90212	54.1	4.0	44.0	9.0	3.53	0.29
IVT (I) – 90213	55.2	6.0	64.67	8.33	6.35	0.53
IVT (I) – 90214	54.7	17.00	80.00	8.00	4.36	0.29
IVT (I) – 90215	54.9	5.67	49.67	8.33	3.54	0.21
IVT (I) – 90216	44.2	5.07	56.0	7.50	7.00	0.51
IVT (I) – 90217	69.3	5.07	50.00	8.00	5.40	0.47
IVT (I) – 90218	46.8	8.67	57.33	7.77	4.74	0.31
IVT (I) – 90219	47.6	4.67	25.33	8.00	5.62	0.47
IVT (I) – 90220	57.9	4.33	44.33	8.00	5.00	0.43
IVT (I) – 90221	51.9	7.33	47.34	8.00	6.95	0.67
IVT (I) – 90222	43.9	8.00	46.20	8.00	3.58	0.18

Table 10. Performance of various linseed varieties under rainfed conditions

Varieties	Plant height (cm)	No.of branches / plant	No. of effective capsule/ plant	No. of seed /capsule	Test weight (g)	Yield (t/ha)
IVT (R)- 90101	59.9	7.25	74.9	8.00	5.42	0.41
IVT (R) – 90102	55.3	6.20	81.8	7.55	4.56	0.37
IVT (R) -90103	58.9	4.00	75.5	6.25	3.45	0.09
IVT (R) – 90104	44.8	5.33	58.5	6.22	4.06	0.33
IVT (R) -90105	51.0	2.33	89.1	5.80	3.00	0.15
IVT (R) –90106	43.9	2.56	75.5	5.25	3.00	0.14
IVT (R) – 90107	49.0	3.56	94.6	5.00	3.46	0.23
IVT (R) – 90108	43.0	2.56	35.1	4.95	2.95	0.17
IVT (R) – 90109	39.9	2.00	68.4	5.00	3.00	0.19
IVT (R) -90110	47.60	2.45	62.7	4.60	2.84	0.17
IVT (R) – 90111	39.5	3.90	55.5	5.04	3.40	0.31
IVT (R) – 90112	43.0	5.32	51.3	6.00	4.12	0.37
IVT (R) – 90113	44.5	8.00	68.9	8.00	5.78	0.58
IVT (R) – 90114	51.5	3.50	65.6	6.21	3.00	0.17

AGROFORESTRY

Evaluation of growth performance of *Jatropha curcas*

Eleven provenances were screened for the growth performance of jatropha (Table 11). Among various provenances, Molvum provenance exhibited the highest plant height (2.55 m), followed by Pelham (2.40 m). The lowest plant height was recorded in Rangapahar (1.40 m). Highest stem diameter was recorded in Piphema provenance (8.02 cm) followed by Ruzaphema (7.55 cm). The maximum number of branches per plant were recorded in Molvum (12.50), followed by Dhansiripar (10.0). The average plant height and stem diameter of jatropha collected from all the provenances were found to be 1.73 m and 6.84 cm, respectively. Similarly, the overall average no. of branches/ plant was recorded as 7.30 after 3 years of growth.

The crop productivity was significantly low (Table 12) in the under storey plots of Jatropha mainly due to heavy shade and competition for light, soil moisture and nutrients between woody perennial and annuals. Hence, the intercropping is not suggested with jatropha.

Restoration of *Jhum* fallow lands through agroforestry interventions

In all, 43.5 ha of degraded lands were rehabilitated during the period under report (Table 13). As the common folks of the state mainly depend on shifting (slash and burn) cultivation, most of the rejuvenization works were taken up on *Jhum* fallow

Table 11. Growth of *Jatropha curcas* after three years of plantation (Progeny Trial- 2009)

Name of genotypes	Plant height (m)	Stem diameter (cm)	No. of branches/ plant
Jalukie	1.67± 0.02	7.33±0.42	6.70±0.10
Jharnapani	1.54±0.09	6.75±0.10	6.30±0.44
Medziphema	1.71±0.07	7.33±0.30	4.30±0.26
Molvum	2.55±0.20	6.83±0.15	12.50±0.40
Piphema	2.40±0.39	8.02±0.21	9.00±1.30
Rûzaphema	1.65±0.06	7.55±0.08	6.30±0.46
Seithekiema	1.59±0.02	5.95±0.17	5.80±0.26
Khatkati	1.60±0.07	6.03±0.26	4.60±0.40
Rangapahar	1.40±0.02	5.63±0.12	8.00±0.26
Dhansiripar	1.67±0.09	6.87±0.14	10.00±0.30
Tolbi basti	1.63±0.06	6.91±0.13	7.30±0.66

Table 12. Intercropping trial (June, 2009) with *Jatropha curcas*

Name of intercrop	Yield of intercrop (kg/ha)	Yield (kg/ha)
Groundnut	103.73 ± 5.37	
Sesamum	134.50 ±34.37	380
Green gram	106.83±0.43	(i.e.,400-500 g/tree)
Paddy	131.10 ±25.47	

and abandoned agricultural lands through agrisilviculture, agrihorticulture, and agrisilvipastoral agroforestry systems (AFS). Likewise, marshy lands were rehabilitated through integrated agro-aquaculture models. Details of the different sites along with area covered and models established have been given below:

Table 13. Details of the project sites taken up for restoration

Sites	District	Area covered (ha)	Model(s) developed
Pfutsro	Phek	10.0	Agrisilviculture
Wokha Village	Wokha	12.0	Agrisilviculture
Bade	Dimapur	3.0	Agrihortisilviculture
Medziphema village		1.0	Agrisilviculture
Medziphema village		1.5	Agrihorticulture
Phiphema		4.0	Hortipastoral
Sukhovi		3.0	Agroaquaculture
Saijang			
	Peren	3.0	Agrihorticulture
Kejanglwa		3.5	Agrihorticulture
Gaili		2.5	Agrihorticulture
Total		**43.5**	

ANIMAL PRODUCTION

Mega seed Project on Pig

Ghungroo (Fig 4) and Large Black (Fig 5) breeds are being reared under the project. All the measures were taken up to prevent the pigs from infectious diseases regular vaccination and deworming was done.The body weight of piglets of both the breeds was recorded on weekly interval up to weaning and thereafter at monthly interval till they were six months old. The growth performance of the improved breeds is given below (Tables 14 and 15).

Piglets produced during the year

Since infrastructure i.e. pigsty was completed and handed over to the Centre in the February end of the last financial year. A total number of 244 piglets were produced. A pig sty of 5060 sq. ft area was constructed.

Table 14. Pre-weaning growth performance of Ghungroo and Large Black X pigs

Age	Breed	
	Ghungroo (kg)	Large Black X (kg)
Birth (O)	0.94 ± 0.10	1.34 ± 0.26
1st week	1.98 ± 0.41	2.97 ± 0.33
2nd week	3.58 ± 0.55	5.00 ± 0.63
3rd week	4.44 ± 0.46	6.52 ± 1.16
4th week	5.11 ± 0.55	8.38 ± 0.90
5th week	5.90 ± 0.72	9.92 ± 1.11
6th week	6.94 ± 0.63	10.92 ± 1.20
7th week	7.89 ± 0.86	12.00 ± 1.38
8th week	9.17 ± 1.09	13.83 ± 1.47

Table 15. Post-weaning growth performance of Ghungroo and Large Black X pigs up to 6 months of age

Age	Breed	
	Ghungroo (kg)	Large Black X (kg)
Initial body weight	9.17 ± 0.09	13.83 ± 1.47
3rd month	22.67 ± 1.20	22.42 ± 1.16
4th month	31.56 ± 1.72	32.60 ± 2.41
5th month	49.33 ± 4.87	53.33 ± 1.40
6th month	57.94 ± 5.13	62.83 ± 2.50

Fig 4. Ghungroo with piglets

Fig 5. Large Black X with piglets

Poultry Seed Project

Parent stock rearing: Parent stock of Vanaraja (Fig.6) and Gramapriya (Fig. 7) received on 15th Sept. 2009 at the centre from PDP, Hyderabad and reared in 04 nos. of existing poultry sheds. Feeding regime was followed as per the formulation received from PDP, Hyderabad. Recording of month wise mortality, body weight at two weeks interval during growing stage (Table 16), monthly egg production (Table 17) and weekly egg weight were recorded.

Fig 6. Gramapriya parent stock (28th weeks old)

Fig 7. Vanaraja parent stock (28th weeks old)

The mortality was recorded highest in the initial month with 29 nos. in Gramapriya and 17 nos. in Vanaraja parent stock mainly due to weakness and debility. At the later stage of growth, the other causes of mortality were found to be liver rupture, enteritis, choke, intussusceptions, pneumonia, trauma, shock, prolapses of oviduct and egg-bound condition. Cannibalism was also observed during 8th to 10th week. Preventive measures like regular vaccination, deworming, debeaking, trimming of nails and timely treatment were done. The mortality was recorded to be 17.64% in Gramapriya and 12.73% in Vanaraja parent stock.

Table 16. Body weight record of poultry birds

Age	Average body weight of Vanaraja (g)		Average body wt. of Gramapriya (g)	
Initial body wt.	53.88 ±4.12		45.86 ±3.88	
2nd week	195.54 ± 37.13		108.84 ± 20.06	
4th week	464.08 ± 72.01		209.4 ± 46.49	
6th week	749.34±126.83		343.68 ± 89.92	
8th week	1294.88 ± 225.17		512.60 ±104.30	
10th week	1661.74 ±249.31		660.46 ± 98.36	
	Male	**Female**	**Male**	**Female**
12th week	2142.94 ±201.42	1725.66 ±267.80	1014.69 ±224.33	789.72 ±111.71
14th week	2500.06 ±230.90	1940.34 ±269.15	1192.82 ±195.37	948.79 ±126.25
16th week	2773.44 ±301.02	2086.94 ±257.69	1359.82 ±177.47	1077.77 ±205.20
18th week	3079.72 ±295.63	2286.44 ±245.77	1581.82 ±181.50	1255.62 ±142.18
20th week	3263.91 ±286.17	2498.59 ±214.75	1980.91 ±294.20	1398.87 ±144.15

Body weight of 50 nos. of birds identified by leg band is weighed till 10th week of age.

Body weight of 50 nos. of birds identified by leg band are weighed for each variety of 25 males and 25 females birds from 12th week until 20th week.

Table 17. Monthly egg production record

Egg production of Vanaraja Age at 1st Lay: 142 days (20th weeks)			**Egg production of Gramapriya** Age at 1st Lay: 161 days (23rd weeks)		
Month	**Total egg (nos.)**	**Cumulative**	**Month**	**Total egg (nos.)**	**Cumulative**
February'10	328	328	February'10	46	46
March'10	3487	3815	March'10	2765	2811

The initial average egg weight was recorded in Vanaraja (20th week) and Gramapriya (24th week) birds weighing 40.32g and 47.90g, respectively. At 29th week, average weight of eggs of Vanaraja and Gramapriya birds were 50.82g and 50.06g, respectively.

Fig 8. Hatchery unit

Fig 9. Fertile Vanaraja and Gramapriya eggs

Bird distribution: Existing incubator (Figs. 8 and 9) of 600 capacities is being utilized for hatching purpose. First batch of chicks were hatch out on 2nd week of April, 2010 with hatching percentage of 90% in Vanaraja chicks and 65% in Gramapriya chicks, respectively. The hatched out chicks (Figs. 10 and 11) are being kept at the centre for distribution after 30 days to the farmers.

Fig 10. One day-old Vanaraja chicks

Fig 11. One day-old Gramapriya chicks

The project can fulfill the nutritional demand as well as help in generating subsidiary source of income and gainful employment to unemployed youth in Nagaland. Due to the better performance of Vanaraja birds, the demand is very high. However, Gramapriya, an egg variety chicken is introduced at the centre for the first time of its kind to popularize and distribute to the farmers and down trodden people in the poor/tribal belt of the state.

ANIMAL HEALTH

Microbiological analysis of samples from different animals: During the report period rectal and vaginal swabs of 70 pigs were analyzed for presence of pathogenic bacteria of zoonotic importance. *Aeromonas spp., Edwardsiella spp., Escherichia coli, Klebsiella pneumoniae, Enterobacter spp., Proteus spp., Citrobacter spp., Salmonella spp* and *Pseudomonas spp*. were isolated from pigs and their environment. Ducks and fishes were also screened for carriage of pathogens of public health significance and similar pathogenic bacteria, as from pigs, were isolated from ducks and fishes from our own pond.

Postmortem examination of two pigs died of "sudden death syndrome": No pathogen was detected in spleen or heart on bacteriological culture test. Both the pigs had consolidated lungs but no other organ had lesions. However, in one of the dead pigs anthrax like bacilli were isolated from heart blood but on further characterization they were proved to be anthracoids only.

Project work and experiments on Akhuni

Animal experiments on Axone on pigs: Axone, fermented soybean of Nagas' (Aakhuni) is used to make curries and to flavour their traditional foods. It is acclaimed to be highly beneficial by the tribal people but no scientific investigation has yet been reported. Similar fermented soybean products with different names and varying methodology of fermentation are common in other parts of North Eastern Hill (NEH) Region of India, Eastern Nepal and East Asian countries. In this study, Aakhuni was incorporated at the rate of 0.5% in the recommended ration of Ghunghroo sows with suckling piglets and also in grower pig ration while control groups were fed with recommended feed, respectively. Three sows were fed with recommended (control) and three with Aakhuni added (test) feed for a period of 48 days, starting on 3rd day of farrowing till weaning of piglets on 51 days of age. In grower stage (11 week old), a group of 6 pigs were fed on test and other on control feed for 43 days. Pigs were weighed weekly and observed for diarrhoea or any other illness daily. On 30th day of the experiment, suckling piglets of both the groups were vaccinated with 2 ml of *Salmonella choleraesuis* bacterin and boostered on 34th day of experiment. Blood was collected on zero day and 19th day of vaccination for detecting *Salmonella choleraesuis* antibodies in serum. It was observed that only 7% piglets from sows fed on test feed had diarrhoea but no mortality was recorded till the end of experiment whereas more than 57% piglets had diarrhoea and 14% died in control group. Average total body weight gain by piglets fed with test feed was recorded to be 8.6±0.18 kg/piglet, which was significantly higher ($P< 0.01$) than piglets of control group (5.71±0.12 kg/piglet). In grower pigs also, total body weight gain in 43 days was significantly high ($P< 0.01$) in the test group (16.25±1.24 Kg/pig) than in control (13.63±0.63 kg/pig). However, in both of the experiments no significant difference was detected in feed consumption at any point of time in sows. Average *Salmonella choleraesuis* antibody titres in serum samples of piglets with sows fed with the test feed (Log2 6.6±1.21) were not significantly different from the titres of control group (Log2 6.7±0.55). The study revealed the probiotic value of the Aakhuni for pigs which significantly improved weight gain in suckling as well as in growing pigs. Further, it protected piglets against diarrhoea, a common problem in piggery but had no significant effect on humoral immune response against *Salmonella choleraesuis*.

Microbiological analysis of Axone: On analysis of 177 samples of Axone for total bacterial count, coliform count, aerobic spore count, anaerobic spore count and yeast and mold counts, *Bacillus* spp. (*B. subtilis* and *B. coagulans*/ *Lactobacillus sporogenes* and other *Bacillus spp*.) were detected in all the samples in high numbers (5.66 to 10.55 Log10/ gm), anaerobic spores in 87 samples (<100 per gram), coliform in 66 samples (2.94 to 10.67 Log10/ gm) and yeast and molds in 114 samples (2.76 to 5.54 Log10/gm). Total plate count varied from 7.78 to 12.98 Log10/ gm. The common coliforms identified were *Enterobacter spp.* (29.5%), *Citrobacter spp.* (8%), *Proteus* spp. (52%), *Klebsiella spp.* (8%) and *Morgenella spp.* (6%). Some of the Axone samples were also positive for *Pseudomonas spp*. (15%) and *Aeromonas spp.* (one). Only few *Bacillus* spp., but most of the other bacterial isolates had multiple drug resistance. Many (15) of the *B. coagulans* isolates from Axone inhibited enterotoxigenic and enteropathogenic *Escherichia coli* in vitro.

SIKKIM CENTRE

Weather Report

The Meteorological data of Sikkim Centre for the year 2009- 2010 is presented in Table 1. The total annual rainfall was 2652.36 mm. The highest rainfall 462.52mm was recorded in July. There was no rain in January. The highest maximum temperature 28 ºC was recorded in June while lowest minimum temperature 7 ºC was in January.

Table 1. Meteorological data of Sikkim Centre for the year 2009- 2010

Month	Temperature		Relative Humidity		Rainfall (mm)	Evaporation (mm)	Sunshine (hr)
	Max	Min	Max	Min			
Apr	25.8	15.4	84.8	49.3	233.5	3.6	2.9
May	26.2	16.5	86.4	53.0	325.9	4.0	4.3
Jun	28.0	19.4	88.6	63.0	454.64	3.8	2.3
Jul	27.0	20.5	89.0	70.0	462.52	3.5	2.0
Aug	26.8	19.6	90.0	70.7	409.8	3.2	2.2
Sep	27.6	19.2	87.0	60.5	212.9	4.0	3.9
Oct	25.5	16.1	87.6	51.6	229.0	3.3	5.5
Nov	20.6	15.9	85.9	50.5	2.2	1.9	3.6
Dec	17.0	13.0	88.0	52.0	04.8	1.0	0.0
Jan	17.0	7.0	82.0	41.0	0.0	2.0	3.0
Feb	19.0	9.0	81.0	39.0	16.3	2.0	3.0
Mar	23.0	14.0	82.0	48.0	300.8	2.0	2.0
Total	283.5	185.6	1032.3	648.6	2652.36	34.3	34.7
Average	23.6	15.5	86.0	54.0		2.86	2.89

HORTICULTURE

Polyembryony in citrus

Polyembryony was studied in Rough Lemon (Fig 1).The degree of polyembryony in mandarin and Rough lemon was 65.30 and 62.80 %, respectively. The per cent occurrence of one seedling/seed was 48.76 and 50.24, respectively. The degree of polyembryony increased with the increase in the occurrence of two or more number of seedlings. The mean ratio of one seedling/seed and multiple seedlings/seed was recorded to be 0.93:1. The ratio increased with the decrease in the degree of polyembryony.

Fig 1. Polyembryony in citrus

Physico-chemical and sensorial attributes of Sikkim Mandarin

The fruits of East and North districts were bigger and heavier and had more number of seeds/fruit, while fruit of South district was smaller and had less number of seeds. Thin peel, more fruit firmness and the maximum juice percentage were recorded under North district. The maximum TSS (12.0 ºBrix), reducing sugar (6.20%) and total sugar (9.49%) were recorded in the fruits of East district while that of West district had maximum peel thickness (3.86mm), poor firmness (4.5 lb/sq.inch), minimum acidity (1.34%) and maximum TSS/acid (7.98) and sugar/acid ratio (5.63). The fruits of South district were highly acidic and had minimum TSS/acid ratio (4.71) and sugar/acid ratio (3.05). The fruits of West and East districts had more scores for sensorial attributes in respect of flavour, sweetness and overall impression of juice. Fruits from South district had poor sensorial attributes due to more sourness and less sweetness.

Prevalence of Citrus Tristeza Virus (CTV) in mandarin

The prevalence of CTV virus in mandarin was studied by DAS-ELISA using polyclonal antibody. The major mandarin growing belts of Sikkim were

infected with CTV. The CTV incidence in North, South and West districts was more than 70%. The incidence was lower in East district. The high incidence of CTV in mandarin without showing characteristics symptoms indicates the presence of mild strain of CTV virus. About 50% of plants were moderately infected and more than 1/3rd of plants were severely infected with CTV. In North district, more than 80% plants were either moderately or severely infected while in South district, plants were mainly moderately CTV infected. In East district the intensity of mildly infected plants was more (30%), while the intensity of severely CTV infected plants was less (20%). The maximum per cent of severely CTV infected plant (70%) and the minimum per cent of mildly infected plants were recorded in West district.

Fig 2. CTV incidence in Sikkim

Strawberry

Chandler and Ofra were found to be the best performing varieties of strawberry with the fruit yield of 800g/plant and 750g/plant, respectively. Planting during September gave maximum yield (780g/ plant) with higher TSS/Acid ratio. Etna and Belruby produced maximum number of suckers, 20 and 18, respectively under open conditions. TSS/Acid ratio of the fruits grown under polyhouse was better than the open conditions. Mulching with *Sacharum* spp. gave 70% marketable yield followed by tree leaves and paddy straw. Plant mortality was recorded maximum under black polythene mulching followed by paddy straw. Protocol for strawberry jam has been standardized

Chilli

Germplasm evaluation

Germplasm were evaluated for plant growth habit, leaf and fruit character, yield, quality and disease severity. Maximum fruit yield/plant was recorded in Collection-6 (1270 g/plant) at the spacing of 1x1 m. Three collections of cherry pepper were observed for upright fruiting and 12 collections for downward fruiting character. Expected return/ha was calculated at the market price of Rs. 100/kg and it was found that cherry pepper cultivation can give a return of more than Rs. 10.0 lakhs / year

Mulching in cherry pepper

To standardize mulching material black polythene, white polythene, forest leaf and *Schima wallichi* leaf mulch were used. Plant wilting was recorded minimum (21%) in *Schima wallichi* mulched plants followed by forest leaf mulch and black polythene in cherry pepper. Maximum plant mortality (75%) was recorded in control plots. Chilli pepper showed very less wilting (11%) in *Schima wallichi* mulching.

Shelf life of cherry pepper

Cherry pepper was stored under room temperature and at 4^0C temperature for evaluation of storage life. Maximum shelf life of 21 days was recorded at 4°C, whereas chilli could be stored only for 6 days under room temperature (Fig 3).

Fig 3. Cherry peppers

Sprinkler irrigation in vegetables

Sprinkler irrigation is being proved to very feasible and an important techniques to increase water use efficiency during lean period (November -

February). Through this method about 50% less water is required than that of channel irrigation. Moreover the yield of vegetable was also increased by 15%. The frequency of irrigation was twice in a week and each irrigation has the water application rate at 4 l/m^2.

ENTOMOLOGY

Eco- friendly management of insect pests in rice

Stem borer, leaf folder, whorl maggot and gundhi bug were found as important pests of rice in Sikkim. Stem borer and leaf folder population was found maximum during August-September. The whorl maggot caused maximum damage in the second fortnight of July. Gundhi bug population was found maximum when the crop attained the milking stage (first fortnight of October). Species composition of rice stem borer was monitored. Although all the five species of stem borer were observed but yellow stem borer, *Scirpophaga incertulas* was found dominant followed by striped borer, *Chilo suppressalis*. Spiders, Apanteles, dragon flies and *Coccinellid* beetle are some potential natural enemies in rice ecosystem of Sikkim.

Out of fifty rice entries screened against pests, twelve (Bachi, Basmati Attey, RCRT-FG, RC Mani-6, RCPL-1-126, Surkey Marsie, Ramzira, Kalami, Dhoot-kati, Lungnilaphaw, RC Maniphaw-4, and Tulasi) were found promising.

Fig 4. Infestation of citrus aphid

Bio- rational management of insect pests in Sikkim Mandarin

Leaf miner, lemon butterfly, leaf roller, looper caterpillar, aphids (Fig.4), whitefly, *Spodoptera*, scale insect, mealy bug and semi looper were important pests in citrus nursery. In the main field the incidence of trunk borer, bark eating caterpillar and shoot borer are common. The orchards of all the surveyed areas were infested (26-35%) with fruit fly. The adults and grubs of lady bird beetle, *Menochilus sexmaculata* and *Coccinella septempunctata* were observed as potential predators in all the surveyed orchards.

Bacillus thuringiencis (Delfin 3G) was found most effective to control lemon butterfly while Agrospray (Servo) was found effective against aphids and leaf miner in Sikkim Mandarin orchard. Five different traps were evaluated against fruit fly in citrus orchard. Amongst them Methyl eugenol + Ethanol + Malathion (4:5:1) showed promising result by trapping 40.54 adults/week

Bio-rational management of insect pests of major spices

A new but potential pest has been recorded in chilli. Tea mosquito bug, *Helopeltis theivora* is a major pest of tea in Assam and West Bengal. In Sikkim, the infestation of *Helopeltis* (Fig 5) was recorded for the first time in chilli. Both nymphs and adults suck the sap of the leaves and shoots and produce numerous sunken brown spots. One fully matured nymph can produce more than 100 spots.

Nimbicidine @ 3 ml/l was found effective against shoot borer, leaf roller and grasshopper of ginger

Fig 5. Infestation of nymphs of *H. theivora*

followed by Neemazal @ 3 ml/l. Entomopathogenic fungi (*Metarhizium* and *Beauveria*) were found effective against white grub. Servo Agro-spray 6 ml/l was found effective to control aphids and white flies in chilli and *Bacillus thuringiencis* (Delfin 3G) 2g/l was found effective against cutworm. Neem formulations like Nimbicidine and Neemazal @ 3 ml/l and Delfin 3G 2 ml/l were found effective against leaf eating caterpillar. From the survey it was observed that the adults and grubs of lady bird beetle, *Menochilus sexmaculata* and *Coccinella septempunctata* were observed as potential predator (Fig 6).

Fig 6.Grub of lady bird beetle predating on aphid in chilli

SOIL SCIENCE

Integrated nutrient management in maize

An experiment was undertaken on organic nutrition of maize during the main season of March 2009 with var. Vivek Sankul Makka-11. Dolomite was applied for soil acidity management @ 2 t ha^{-1}. Mixed compost, neem cake, azophos seed treatment and vermicompost were applied as sole or in different combinations as sources of nutrition. The yields of the crop ranged from 1,600 to 4,450 kg ha^{-1}.

Studies were conducted on soybean-mustard rotation during 2009-10 with integrated nutrient management in the main crop and evaluating the effect of residual nutrients on mustard with one irrigation. 10 treatment combinations of chemical fertilizers as starter dose, mixed compost, neem cake and dolomite in nine combinations and one without nitrogen (control) were applied on soybean var. PK-1024 during kharif 2009. N:P:K @ 30:40:30 was applied alone and in conjunction with neem cake and dolomite @ 2 t ha^{-1}. Yield obtained with neem cake 1 t ha^{-1} + mixed compost 2.5 t ha^{-1} + dolomite (3,240 kg ha^{-1}) was statistically at par with integrated nutrient management through urea +SSP+MOP @ 30:40:30 + dolomite @ 2 t ha^{-1} + neem cake @ 0.5 t ha^{-1} (3,135 kg ha^{-1}).

Short duration, high yielding mustard variety M-27 was sown in November 2009 in the same soybean plots under integrated nutrient management and was irrigated once at the flowering stage. Conjunctive application of urea + SSP + MOP @ 30:30:30 + dolomite @ 2 t ha^{-1} + Neem cake @ 0.5 t ha^{-1} produced the highest grain yield (8.12 q ha^{-1}) and the treatment of neem cake 1 t ha^{-1} + mixed compost 2.5 t ha^{-1} + dolomite produced yield of (7.11 q ha^{-1}) on the residual soil nutrients.

INM in Rice

Studies were conducted in kharif 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. 25 day-old seedlings were transplanted with 20 x 15 cm spacing between rows and hills, 2 seedlings were placed at each hill in plots of 10m^2. The performance of three improved varieties - Pant Dhan-10, VL Dhan-61 and Pusa Sugandh-II and one local cultivar 'Attey' under organic nutrition and conventional system was continued. The rice grain yields ranged from 2.32 to 3.84 t ha^{-1} with mixed compost; 2.25 to 4.43 t ha^{-1} with mixed compost and neem cake as compared with 2.12 to 4.04 t ha^{-1} rice grain yield with 3-split urea application. The no fertilizer (control) yield ranged from 1.20 to 1.64 t ha^{-1}.

Organic nutrition in buck wheat

Studies were undertaken on organic nutrition of buckwheat with local cultivar "Mithe". The crop was sown in two spacing of 20 x 20 and 30 x 30 cm in four replications on which six treatments were imposed. Five treatment combinations of mixed compost, neem cake and seed treatment with azophos along with control were basally applied at

sowing. Observations on yield and yield attributes and soils were recorded. The highest grain yield of buckwheat was recorded with organic nutrition management through mixed compost 5 t ha^{-1} + neem cake 0.5 t ha^{-1} was 1550 kg ha^{-1}.

Studies were conducted on organic nutrition of mustard during November 2009 with var. M-27. The highest yield (1,140 kg ha^{-1}) was recorded with the treatment mixed compost @ 5 t ha^{-1} + vermicompost @ 1 t ha^{-1} + neem cake @ 1 t ha^{-1} + dolomite @ 1 t ha^{-1} which was followed by mixed compost @ 5 t ha^{-1} + vermicompost @ 1 t + dolomite @ 1 t ha^{-1} that produced (915 kg ha^{-1}).

ANIMAL NUTRITION

In vitro fermentation study was conducted in seven tree fodder, three jungle grasses and one root sample. Fresh cow dung buffered and fortified with minerals was used as inoculums. Results showed a wide variability in gas production among samples at different time intervals (Table 1 & 2). After 96 hours of incubation, the volume of total gas and carbon dioxide ranged between 66.8 to 234.7 and 18 to 157 cc per mg of samples on dry matter basis. The value for methane production in the present study was 37.2 to 78.4 % of the total gas produced. The observed inoculums pH varied from 8.21 to 8.51 was significant ($P<0.01$) however, apparently could not affect the fermentation pattern.

Total gas production in various samples increased and differs significantly after 12, 24 and 96 hours of incubation period. The lowest methane production was observed in Tapioca root (37.23%) followed by tree fodder *Ficus bengalensis* (38.74%). Tapioca root is low in crude fiber which is directly correlated with the lowest methane production in the present study. The proportion of methane with respect to its ability to produce total fermentable gas when incubated with fresh faces was highest in Utis followed by Dallopate, Udasey and Elamy. The chemical composition of fodder samples could not be correlated with production of total gas and methane in the present study. However, an increasing trend of methane production in fodders containing low ether extract content could be noted. On the basis of present study it was concluded that the level of crude fibre and ether extract content of the fodder plant may play anti-methanogenic role and change the fermentation pattern.

LIVESTOCK PRODUCTION AND MANAGEMENT

Reproductive disorder of bovine in Sikkim

During the reported period of study, the survey was made for reproductive disorder of bovines in all the four districts of Sikkim. A total of 1,270 cases were recorded and analyzed. Anoestrus was the major problems (24.41%) followed by delayed

Table 1. Total gas, carbon-dioxide and methane production (cc/g DM) and methane roportion (%) of total gas after 96 hours of incubation with fresh faecal inoculum

Common name	Botanical name	Total gas volume/g	Volume of CO2 /g	Volume of methane/g	Methane (%)
Bardar	*Ficus bengalensis*	161.6^{b}	99.5^{b}	62.0^{ab}	38.7^{a}
Bilaunae	*Maesa chisia*	103.6^{ab}	45.0^{a}	58.6^{ab}	58.5^{ab}
Dallopate	-	74.7^{a}	28.0^{a}	46.7^{a}	64.3^{bc}
Jhimani	*Eurva japonica*	127.6^{ab}	62.2^{ab}	65.4^{ab}	51.7^{ab}
Khasre	*Ficus hirata*	125.8^{ab}	58.0^{ab}	67.8^{ab}	59.4^{ab}
Khankappa	*Evoidia frarinifolia*	122.6^{ab}	54.9^{ab}	67.6^{ab}	56.4^{ab}
Utis	-	66.8^{a}	18.1^{a}	48.7^{a}	78.4^{c}
Arupate leaves	*Collocasia*	96.8^{a}	53.6^{ab}	43.2^{a}	43.3^{ab}
Elamey	*Ageratum conyzoides*	75.4^{a}	29.0^{a}	46.4^{a}	$63.^{0bc}$
Udasey	-	80.9^{a}	31.0^{a}	49.9^{a}	61.7^{bc}
Ful tarul	*Manihot esculenta*	234.7^{c}	156.6^{c}	78.8^{b}	37.2^{a}

Table 2. Chemical composition of samples incubated for in-*vitro* gas production

Common name	Organic matter	Nitrogen	Ether extract	Crude fiber	Total ash	Acid insoluble ash
Bardra	90.79	2.23	1.35	15.65	9.21	2.96
Bilawnae	93.82	2.17	1.61	18.87	6.18	0.28
Dallopate	95.69	2.12	0.98	24.93	4.31	0.60
Jhimani	95.15	1.83	1.29	19.72	4.85	1.67
kasre Khanew	90.12	3.04	1.00	38.87	9.88	0.49
Kankappa	93.86	3.12	1.92	15.25	6.14	1.01
Utis	96.41	2.46	0.79	20.60	3.59	1.27
Aropate	85.35	2.35	1.73	34.39	14.65	5.55
Elamy	81.37	1.99	1.40	14.03	18.63	10.87
Udasey	86.60	2.32	0.84	17.24	13.40	7.47
Fultarul	-	1.83	0.11	5.73	-	-

maturity (21.65%), repeat breeding (14.17%), mastitis (13.38%), abortion (9.45%) and dystocia (0.09%).

Genetic improvement of Sikkim local goats for litter size

A total of 19 kiddings were obtained from Sikkim local goat's with a twinning and triplet incidence 42.11% and 10.53% respectively. The over all sex ratio was 1:0.8. However, in twins the ratio was 1:1.67 while in triplet 1:0.5.

Data on reproductive performance of Sikkim local goat was recorded during the study period. Gestation period, weight at first service, age at first service, weight at first kidding, age at first kidding, interkidding interval, conception rate and service period were found to be 147.25±0.78 days, 15.40±0.52 kg, 13.95±0.60 months, 19.10±0.84 kg, 18.75±0.54 months, 267.25±1.5 days, 82%, 190±0.84 days, respectively.

The average body weight of male and female kids was 1.65±0.14 kg and 1.48±0.09 kg at birth; 8.45±0.52 kg and 7.50±0.32 kg at 6 months of age; 14.80±0.58 kg and 13.75±0.65 kg at 12 months age, respectively.

Biometrical performance of Sikkim local goats

The average height, body length, hearth girth and abdominal girth of female kids at birth, 6 months and 12 months age were found to be 26.60±0.22, 21.30±0.32, 25.80±0.39, 27.42±0.21 cm; 42.50±0.66, 37.24±0.72, 46.52±0.72, 49.24±0.78 cm and 50.54±0.92, 41.5±00.88, 53.10±0.90, 55.70±0.74 cm, respectively. The same parameters in male kids at birth, 6 months and 12 months of age were recorded 26.74±0.11, 20.40±0.24, 26.7±0.32, 28.4±0.46 cm; 45.40±0.62, 36.50±0.52, 49.50±0.62, 52.00±0.72 cm and 52.50±0.98, 44.70±0.82, 56.72±0.88, 59.54±1.10 cm, respectively.

The average growth rate of male and female kids from birth to 12 months of age was 36±0.12 and 34±0.10 g/d respectively. The growth rate of castrated male kids was higher (46.10±0.22g/d) than uncastrated male kids. The growth rate of single male and female kids was higher (54.50±0.12 and 47.75±0.32 g/d) than twins and triplet male and female kids.

ANIMAL HEALTH

Mastitis

A total of 85 milk samples collected from bovine mastitis cases in and around Gangtok were examined for bacterial pathogen. Seven (8.23%) milk samples were found positive for mastitis by CMT. The major bacterial pathogens recovered were *Staphylococcus* spp. *and E. coli.* The isolates were subjected for antibiogram study against 18 different antibiotic discs. The results showed a varying degree of sensitivity, highest sensitivity to enrofloxacin followed by chloramphenicol and tetracycline.

Enteric pathogen

A total of 130 yak faecal samples collected from Gnathang village of East Sikkim were examined for

enteric pathogens like *Salmonella* spp. *E.coli*. 70(53.8%) samples were found positive for *E.coli* and all the samples were negative for *Salmonella.*

Prevalence of gastrointestinal parasites

A total of 5,126 animals were examined during the study period. An overall prevalence of 31.31% helminthic infection was observed. Among the different animals examined, the occurrence of GI helminthic infestation was found to be higher in goats (52.02%) than that of cattle (22.37 %) and yaks (14.86%). The mixed infection of trematode, cestode and nematodes with coccidian oocysts were found higher in goats than in other animals. The mean egg per gram value was also higher in goats as compared to cattle and yaks. The prevalence of GI-helminthes was higher in subtropical and high humid zone (35.93%) followed by Temperate and humid area (32.93%) as compared to Sub alpine low humid zone (15.59%) and alpine dry area (14.34 %). The helminthic infection was higher during the month of July to September with the highest peak in September (70.93%) in goats and cattle (30.82%) as compared to yaks in March (21.27%). This may be due to high rainfall and favourable temperature (25-28.0^{0}C), which is congenial for the development of parasitic infection. Monthly evaluation of the data revealed that strongyles especially *Haemonchus* spp. was the most prevalent parasite in all three animals throughout the year in Sikkim.

Gastrointestinal nematodiasis

The intensity of infestation in terms of eggs per gram (epg) of faeces ranged from 100-3,900 in goats, 100-2,100 in cattle and 100-400 in yaks. The maximum epg in goats was recorded in the month of September (mean epg value 2,833.33) with epg ranges from 700-3,900. In cattle, the intensity of epg was maximum in the month of June to September (200-2,100), whereas in yaks, mean epg of 82.561 was found in the month of April. This indicated that during North- East monsoon maximum animals used to get infection with various GI-helminthes in the pasture.

Of the 51 GI-tract of goats examined, helminthic infestation with an overall prevalence of 62.78% were found to harbour. Among the various endoparasites, nematodes (62.78%) were found higher followed by trematodes (27.45%) and cestodes (13.72%). Among nematodes, *Haemonchus* spp. was predominant (62.78%) followed by *Oesophagostomum* (43.13%), *Bunostomum* spp. (25.49%), *Nematodirus* spp. (9.80%), *Trichuris* spp. (7.84%) and *Trochostrongylus* spp. (5.88%). Average worm burden (176.0- 288.0) was higher in the month of August-October followed by the month of November (154.0).

TRIPURA CENTRE

Weather Report

The total rainfall received during 2009-10 was 2478.8 mm (Table 1). About 70% rainfall was received during the monsoon period (June to September), 8% as a post monsoon shower (October to December) and 19% rainfall in summer season (April and May). The total rainy days were 114 days. The maximum rainfall (506.8mm) in a month was recorded in July with 19 rainy days. However, August showed the presence of the highest number of rainy days (21) with 313.3 mm rainfall. Maximum and minimum air temperatures were found to vary from 27.4 to 33.7^{0}C and 9.2 to 25.4^{0}C, respectively. May was the hottest and January was the coolest month of the year. The temperature difference between maximum and minimum was from 3.8 to 15.2^{0}C. The temperature difference was recorded highest during January and lowest during April. Soil temperature was recorded from 5 and 20cm depths both in morning and evening (Table 2). Soil temperature showed an increasing trend along with the depth. Relative humidity in the morning varied from 60 to 91 percent but in the afternoon 49 to 77 percent. The months from June to September showed the highest relative humidity and in the evening during winter season it was recorded lowest. Average monthly wind velocity was found to vary from 1.5 to 8.2 km per hour. During summer and monsoon wind speed were observed to have high wind velocity. Monthly average sunshine hour, on an average ranged from from 3.5 to 7.4 hours per day. As usual, winter and summer were sunnier than monsoon. Wind in most of the times remained Westerly except few months during monsoon and winter. During post monsoon season and winter wind direction in the afternoon remained North Westerly.

In order to disseminate the weather information and its forecast for minimizing the losses due to weather in agriculture, the Integrated Agromet Advisory Services of ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra and Indian Meteorological Department, Meteorological Centre, Agartala jointly started a SMS service for farmers of the state. The service was inaugurated

Table 2. Monthly average soil temperature

Month	Soil temperature (^{0}C)					
	Morning			Evening		
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm
Apr	27.8	29.0	29.9	38.9	36.7	34.1
May	26.6	27.6	28.6	36.2	33.5	32.3
Jun	26.9	27.8	28.8	35.4	33.8	32.1
Jul	26.7	27.7	28.6	34.6	32.9	31.5
Aug	26.8	27.7	28.6	33.4	32.4	30.8
Sep	27.0	27.8	28.7	33.6	32.7	30.9
Oct	25.1	26.0	27.0	33.3	32.3	31.1
Nov	21.7	22.8	23.9	32.6	31.2	29.7
Dec	16.7	17.8	19.2	27.6	33.4	23.3
Jan	15.6	16.6	17.5	25.4	23.4	21.0
Feb	18.4	19.7	20.9	32.2	29.5	26.7
Mar	24.7	25.8	27.1	38.9	36.5	32.7

Table 1. Meteorological data of Lembucherra during 2009-10

Month	Rain (mm)	Rainy days	Evap (mm)	Temperature		Wind speed (kmph)	Wind direction		Sun shine (Hr)	Relative Humidity (%)	
				Max^{0}C	Min^{0}C		Morn	Even		Morn	Even
Apr	70.4	4	155.7	27.4	23.6	6.6	W	W	7.4	82	60
May	399.3	15	128.3	33.7	24.4	5.9	W	W	6.4	82	67
Jun	477.7	20	119.2	33.5	25.2	6.4	SW	W	5.4	85	71
Jul	506.8	19	125.2	32.3	25.4	8.2	W	W	5.2	87	75
Aug	313.3	21	101.6	32.3	25.3	5.5	SW	W	3.5	89	77
Sep	431.0	20	101.3	32.6	25.1	3.8	SW	W	5.1	91	74
Oct	186.6	10	117.9	31.4	22.4	2.2	W	W	6.5	77	74
Nov	18.0	1	120.9	29.5	18.1	1.7	W	NW	6.8	72	67
Dec	0.0	0	103.8	25.6	12.9	1.5	W	NW	1.9	72	66
Jan	0.0	0	98.6	24.4	9.2	2.1	W	NW	5.6	60	63
Feb	0.0	0	120.3	28.9	13.8	2.6	SW	NW	6.0	73	49
Mar	75.7	4	160.1	34.0	21.4	5.1	W	NW	6.3	75	58

by Hon'ble Chief Minister of the State Shri Manik Sarkar on 30th Jan 2010 in a Farmers' Meet at the centre. Farmers may get the location specific weather forecast five days in advance. Presently, the forecast is updated twice in a week and will be available at district level. Farmers may type FC<location syntax><ddmmyy> going into "Text Message" leaving no blank and send to 9436949600. The syntax for West Tripura is WST, South Tripura SOU, North Tripura NOR and Dhalai DLI. The location specific real weather information may also be stored into the system through mobile network from different registered users. The data sent, will automatically be stored into the system memory and brief weather information will automatically be generated and loaded into the web page (tsu.trp.nic.in/agromet). Alarm for severe weather, possible outbreak of pest and insect attacks will automatically be generated and disseminated to the registered farmers. This is as designed by the National Informatics Centre, Govt of India, Agartala. The system may also be used for providing block level weather information without much change.

RICE

Rice improvement programme

Three lines were nominated to All India Coordinated Rice Improvement Project trials. Details of the lines are given in table 3.

TRC 2005 -3 was promoted to AVT 1 on the basis of its performance and yield superiority over the checks.

Hybridization and selection

Further 9 lines were made ready for nominations to AICRIP in 2010 from developed lines at the centre and INGER nurseries performed better in station trial as well as in PVS. The details of new lines were made ready for nominations

Maintenance and purification of germplasm

Local landraces, upland and lowland varieties from Tripura were raised in *kharif* season for maintenance and purification.

Rice Improvement AICRP programmes

Five trials in *kharif* 2009 and one trial in *boro* 2008-09 were conducted at this centre. Due to non availability of paddy lands at the centre all trials except boro 2008-09 were conducted on farmers' plot.

Initial varietal trial irrigated medium early

Sixty four entries including checks were evaluated. Yield of the entries ranged from 7.60 t/ ha to 3.07 t/ha. Top five entries are listed in Table 4.

Table 4. Performance of rice lines under IVT (irrigated medium early)

IET No.	Plant ht (cm)	Panicle / sq. m.	Grain yield (t/ ha)
21576	110	374.6	7.60
21564	125	380.3	7.44
21581	116	373.6	7.16
21567	125	368.3	6.85
21586	95	362.3	6.71

Advance varietal trial -1 (irrigated medium)

Forty nine entries were evaluated. Yields ranged from 7.22 t/ha to 3.13 t/ha. Top five entries are listed in Table 5.

Table 3. Performance of rice lines under AICRP

Trial	Designation	Cross	Days to 50% flower	Grain type	Local trial yield (t/ha)
IVT IM	TRC-05-8-4-42-8-3-7 (TRC-2005-1)	Pyzum x BPT 5204	103	MS	5.97
IVT IM	TRC-05-8-41-3-9-2-5 (TRC 2005-2)	Pyzum X BPT 5204	107	MS	6.61
IVT IME	TRC-05-2-6-4-39-3-6 (TRC-2005-3)	Jagannath X Jaya	93	LS	6.02

Table 5. Performance of rice lines under AVT (irrigated medium)

IET No.	Plant ht (cm)	Panicle / sq. m.	Grain yield (t/ ha)
20931	118	390	7.22
20114	121	259	6.58
20735	124	373	6.43
20904	108	318	6.35
20881	111	463	6.29

Initial varietal trial (irrigated medium)

Sixty four entries were evaluated. Yields in the trial ranged from 8.39 t/ha to 2.62 t/ha. Top five entries are given in Table 6.

Table 6. Performance of rice lines under IVT (irrigated medium)

IET No.	Plant ht (cm)	Panicle / sq. m.	Grain yield (t/ ha)
21531	140	355.3	8.39
21511	122	405	8.23
21536	126	329.6	8.17
21512	126	449.3	8.11
21538	119	483.3	7.30

Aromatic short grain observational nursery 2009

Twenty one entries were evaluated in the nursery. Yields ranged from 4.17 t/ha to 1.62 t/ha. Top 5 entries are listed in Table 7.

Table 7. Performance of top five aromatic rice entries under observational trials

IET No.	Plant ht (cm)	Panicle / sq. m.	Grain yield (t/ ha)
21276	106	336	4.17
21261	114	455	4.08
21265	156	306	3.99
21272	124	373	3.84
21263	134	383	3.4

Initial varietal trial aromatic short grain

Sixteen Aromatic Short Grain entries were evaluated. Yields ranged from 3.09 t/ha to 1.88 t/ha. Only one entry IET 19713 could surpass the checks. Top five yielders are given in Table 8.

Table 8. Performance of rice lines under IVT (aromatic short grain)

IET No.	Plant ht (cm)	Panicle / sq. m.	Grain yield (t/ ha)
19713	152	396	3.09
Kalanamak (check)	161	361	3.07
Badshabhog (check)	153	281	3.03
Kali Khasa	176	354	2.99
21050	165	284	2.46

Initial varietal trial boro

Fourteen entries were evaluated in boro season. Yield levels in the trial ranged from 8.18 t/ha to 4.48 t/ha. Top five entries are given in Table 9.

Table 9. Performance of top five rice lines under IVT boro

IET No.	Plant ht (cm)	Days to flower	Panicles / sq. m.	Yield (t/ha)
21255	125	113	341	8.18
21258	115	106	412	7.54
21252	102	109	422	7.26
21254	119	110	342	6.96
IR -64	102	116	355	6.80

IRRI – INDIA UPLAND SHUTTLE BREEDING NETWORK PROJECT

Advance yield trial (80-100 rainfed high fertility (RNFHF), control)

- 72 entries were tried under Alpha Lattice design
- A seed rate of 60 kg / ha with a row spacing of 20 cm was used
- Direct seeding with a fertilizer dose of 60:30:30 kg/ha was adapted.

NB. *Major drought spells were from Oct 11 to till harvest with only 2 rainy days on 17 0ct. and 16 Nov.*

Table 10. Summary statistics for measured traits for AVT 80-100 RNFHF (control)

Variate	Minimum	Maximum	Mean	Std. dev.	CV (%)
Days to 50% flower	56	83	68.4	7.0	3.19
Plant height	85	155	124.3	10.5	6.95
Yield (kg / ha)	754.5	3988.5	2276.4	817.2	30.6
Lodging (%)	0	100	50.2	35.4	-
Days to harvest	98	111.5	104.1	2.4	-
No. of panicles / plant	4.5	14	9.4	2.2	-

Table 11. Performance of top 5 rice entries AVT 80-100 RNFHF (control)

Entries	DTF	Plant ht. (cm)	Grain yield (t/ha)	Lodging (%)	Days to harvest	Panicle /plant
RR 509-6-B-2	74	137.5	3.99	5	105.5	10
IR 83868-B-B-258-CRA-3-1	77	135	3.92	50	103.5	9
RR 222-1	67	130	3.91	62.5	104.5	13.5
BAU 446-06	61.5	131.5	3.62	100	102	11
RR 451-2821-2-1	67	134	3.57	75	104.5	9

Table 12. Performance of top five entries under AYT 80-100 RNFLF (stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)	Lodging (%)	Days to harvest	Paninle /plant
RR 616-B-2-54-1	64	127.5	2.43	50	92	5.5
IR 83871-B-B-239-CRA-5-1	64	92.5	2.26	45	96.5	5
RR 451-2821-2-1	60	112.5	2.20	95	100	5.5
IR 84898-B-171-CRA-43-1	65	132.5	2.14	90	91	9
RR 616-B-2-66-4	65	105	2.02	0	102	7.5

Observational yield trial (stress)

- Experimental design: Alpha Lattice
- Number of entries: 117
- Rate of seeding: 60 kg / ha
- Space between rows: 20 cm
- Method of establishment: Direct Seeded
- Fertilizer application: 20:10:10

Table 13. Summary statistics for measured traits of observational yield trial (OYT - Stress)

Variate	Minimum	Maximum	Mean	Std. dev.
Days to 50% flower	52	77	67.2	5.5
Plant height	85	142	115.4	10.7
Yield (kg / ha)	170	2810	1222.5	629.4
Lodging (%)	0	95	10.5	22.2
Days to harvest	88	104.5	98.1	3.9
No. of panicles / plant	3.5	13	7.0	1.7

Table 14. Performance of top 5 entries under observational yield trial (OYT Stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)	Lodging` (%)	Days to Harvest	Panicle /plant
IR 82589-B-B-2-2	66	115.5	2.81	0	97	9.5
IR 82589-B-B-147-2	67	109	2.72	0	98	6.5
IR 82589-B-B-7-3	71	112.5	2.60	0	99	6.5
IR 82590-B-B-102-4	72	114	2.60	0	101	6
IR 82589-B-B-84-3	67.5	115	2.36	0	98	8.5

Drought donors (stress)

- Experimental design: Alpha Lattice
- Number of entries: 24
- Rate of seeding: 60 kg / ha
- Space between rows: 20 cm
- Method of establishment: Direct Seeded
- Fertilizer application: 20:10:10

Drought donors (Control)

- Experimental design: Alpha Lattice
- Number of entries: 24
- Rate of seeding: 60 kg / ha
- Space between rows: 20 cm
- Method of establishment: Direct Seeded
- Fertilizer application: 60:30:30

Table 15. Summary statistics for measured traits under drought donors (Stress)

Variate	Minimum	Maximum	Mean	Std. dev.	CV(%)
Days to 50% flower	53	71.3	63	4	3.53
Plant height	79.3	172.3	109.8	19.5	7.99
Yield (kg / ha)	333.4	1733.7	984.5	498.6	42.47
Lodging (%)	40	100	80.8	17.1	-
Days to harvest	89	98	94.3	2.1	-
No. of panicles / sq. m.	534	151.3	380.2	106.6	-

Table 16. Performance of top 5 donors under drought donors (Stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)	Lodging (%)	Days to harvest	Pan /plant
RR 345-2	65.0	107.0	2.02	40.0	98.0	242.7
RR 366-5	63.0	80.0	1.96	73.3	94.3	442.3
Vandana	63.0	107.3	1.73	95.0	93.0	534.0
DDR 105	65.0	146.7	1.62	76.7	94.7	337.7
Dular	65.7	83.0	1.60	63.3	94.7	509.0

Table 17. Performance of top five donors under drought donors (control)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)	Lodging (%)	Days to harvest	Pan /plant
RR 348-6	57.0	93.5	3.21	0.0	98.0	12.5
Annada	65.5	100.0	3.07	0.0	100.5	11.0
RR 345-2	58.0	136.5	3.01	32.5	101.0	13.0
Salumpikit	79.0	157.5	2.74	12.5	105.0	9.0
Anjali	56.5	125.0	2.67	50.0	99.0	11.0

IRRI –India Drought Breeding Network

Table 18. Performance of top five entries underAYT 100-120 (control)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 79913-B-399-B-2	73	145	4.36
IR 78875-207-B-1-B	75	137	4.35
IR 84894-B-143-CRA-17-1	70	152	4.15
IR 78908-105-B-2-B	71	152	3.92
NDR 1045-2	73	128	3.74

Table 19. Top five entries under AYT 100 - 120 reproductive stress

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 80013-B-141-4-1	66	107	2.89
IR 84899-B-185-CRA-5-1	68	82	2.69
IR 81063-B-94-U-3-2	65	109	2.68
IR 81044-B-112-U-4-2	70	114	2.68
IR 78875-207-B-1-B	60	107	2.65

Table 20. Advance yield trial (100 -120 rainfed severe stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 79970-B-47-1	71	126	3.93
IR 78908-105-B-2-B	71	138	3.62
IR 80013-B-141-4-1	75	130	3.60
NDR 1119	73	123	3.49
IR 70215-70-CPA-3-4-1-3	72	1777	3.43

Table 21. Advance yield trial greater than 120 days (control)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 78875-207-B-B-13-14	74	138	5.65
IR 80461-B-7-1	68	112	5.61
IR 75417-R-R-R-R-267-3	72	162	4.51
CB 5754	72	134	4.17
IR 78908-140-B-1-B-B	67	150	4.03

Table 22. Advance yield trial greater than 120 Days (reproductive stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
CB 5755	75	110	2.88
IR 78875-207-B-B-13-14	75	121	2.64
IR 80508-B-194-2-B	73	122	2.59
IR 84882-B-121-CRA-3-1	75	101	2.56
NDR 1135	72	127	2.53

Table 23. Advance yield trial greater than 120 days (rainfed severe stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 78875-207-B-B-13-14	74	121	3.21
NDR 1135	72	121	2.67
IR 77080-B-34-3	72	117	2.56
Sambha Mahsuri	92	97	2.44
IR 80508-B-194-2-B	70	123	2.29

Table 24. IR64 isogenic lines (control)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 77298-14-1-2-1	66	124	4.82
IR 77298-14-1-2-15	72	129	4.77
IR 77298-14-1-2-10	66	124	4.71
IR 77298-14-1-2-19	69	115	4.35
IR 77298-14-1-2-13	66	125	4.28

Table 25. IR 64 isogenic lines (reproductive stress)

Entries	Days to flower	Plant ht (cm)	Grain yield (t/ha)
IR 77298-14-1-2-15	76	94	2.12
ADAY SEL	74	161	2.06
IR 77298-14-1-2-1	71	93	1.89
IR 77298-12-7-25	70	91	1.74
IR 77298-14-1-2-19	69	85	1.66

RICE DISEASE

Influence of host resistance on the incidence of sheath blight disease

Varietal response to sheath blight disease (*Rhizoctonia solani*) was studied both in field and in potted plants with artificial inoculation. None of the genotypes showed high level of resistance.The disease was less in the genotypes like, NDR-97, Garomaloti, Bati, Aduma, 540177, IC 526713, IC, 540249, IC 540179, IC 540237, RCPL 1-115, RCPL 1-114, RCPL 1-46, RCPL 1-116, Bhalum-1 and Bhalum-2 when compared to IC 540275. The results of pot culture study indicated that the spot size in Aduma was minimum (2.63cm) followed by IC 540275 (3.10cm), NDR-97 (3.17cm), Garomalati (3.20cm) and Bhalum-1 (3.27cm). In all cases number of spots was more or less similar.

Efficacy of biocontrol agent in minimizing sheath blight disease in rice

Field evaluation of different biocontrol agents collected from markets and soils were tested with the rice variety TRC-27-251. The results indicated that different strains of *Trichoderma viride*, *Trichoderma* sp. and *Pseudomonas fluorescens*, *Gliocladium virens* and *T. harzianum* + *T. viride* mixture showed different effects in minimizing the disease. In most cases, effect was negligible except *Pseudomonas fluorescens* (Guard) where yield was also increased. Under in vitro conditions, in all ten biocontrol agents, viz. *Trichoderma viride* (Guard, Amit biotech, Howrah), *T.* sp., (Jay Biotech, Kolkata), *T. viride* (Nagaland, personal collection), *T.* sp. (ICAR, Tripura, personal collection), *T. viride* (Meghalaya, personal collection), *T. viride* (Carbogurd, Dr. Rajan Laboratories, Chennai), *P. fluorescens* (Sedoj, Jay Biotech, Kolkata), *P. fluorescens* (Rakshak, Amit biotech, Howrah), *Bacillus subtilis* (Fighter, Dr. Rajan Laboratories, Chennai) and *G.virens* (Assam, personal collection) were tested. The results revealed that cell free extract of both *T. viride* (Amit) and *P. fluorescens* (Amit) minimized the mycelial growth (Figs 1 A, B & C).

Evaluation of fungicides to control sheath blight disease in rice

Seven fungicides, viz., carbendazim 0.05%, chlorothalonil (0.2%), mancozeb, 0.2%, benomyl (0.1%), tricyclazole (0.1%), hexaconazole (0.025) and propiconazole 0.025%, were tested in field and in laboratory. Under field condition, all the fungicides except mancozeb and tricyclazole were effective against the disease. However, both propiconazole and hexaconazole showed toxic effects to the plant by decreasing plant's height. For *in vitro* study, bioassay of fungicides was done. Blotting paper of 3 cm diameter was dipped in different fungicide solutions and kept in inoculated PDA medium. Incubation was done for 72 hrs at 28 ± 1^0C. The inhibition zone and characteristics of mycelial growth were noted. The results (Fig. 2 A & B) revealed that the systemic fungicides, carbendazim, hexaconazole and propiconazole as well as contact fungicide, chlorothalonil, were effective against the

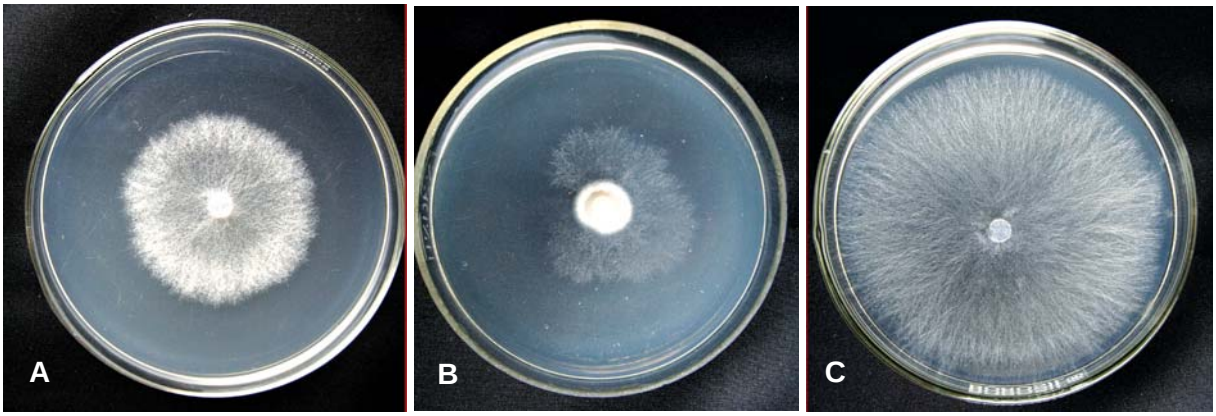


Fig 1. Effect of cell free extract of biocontrol agents on the growth of *Rhizoctonia solani* A. *Trichoderma viride* (Amit) 100µl, B. *Pseudomonas fluorescens* (Amit) 500 µl C. Control

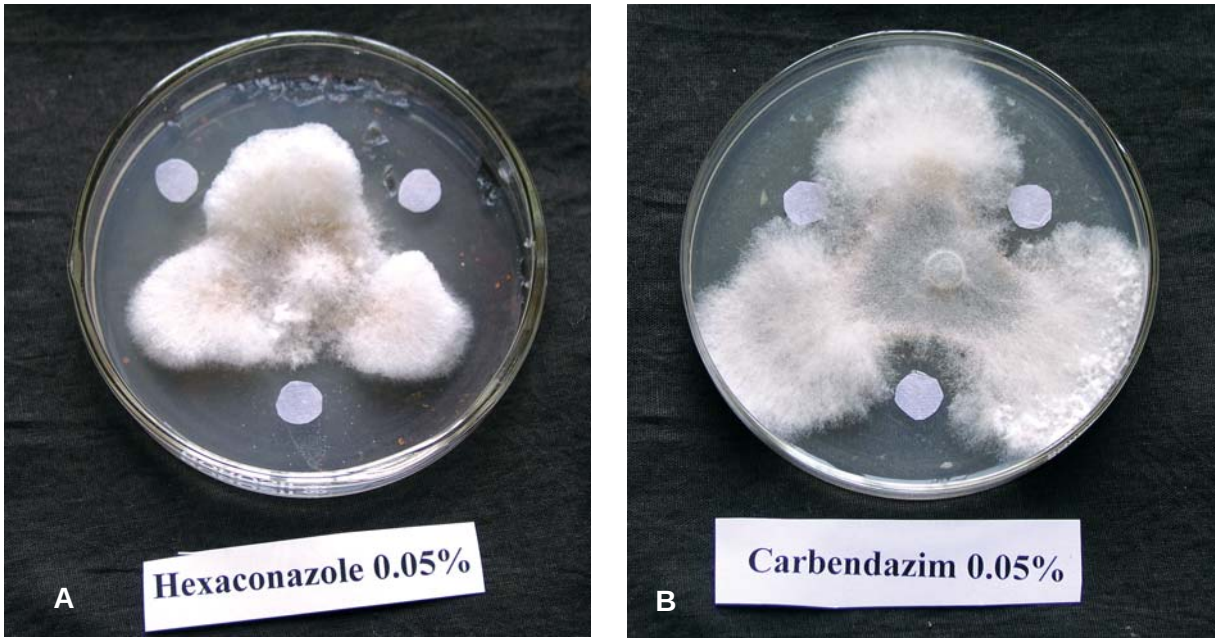


Fig 2. Bioassay of fungicides against sheath blight pathogen of rice. A. Hexaconazole 0.05% showing inhibition of mycelial growth; B. Carbendazim 0.05% showing inhibition of mycelial growth

pathogen, although in later case zone of inhibition was not measurable but killing of mycelia in contact with filter paper was clearly visible.

MAIZE

Sheath blight disease incidence was studied in 52 genotypes during kharif crop season 2009. The disease was found to affect all the genotypes studied. Its intensity was found more in late sown crop. The genotypes like DMR-102 and DMR-108 showed resistant with disease score 1.9 & 1.7 in 1-5 scale, respectively (Table 26).

PULSES

Varietal improvement

TRCP-8 (Field pea, *Pisum sativum* L.) IC 563364 was recommended for Uttarkhand hills, Jammu & Kashmir and North Eastern states of India by CVRC and was submitted to central subcommittee on crop standards notification and release of varieties.

Field pea var.TRCP-8 was released by His Excellency Governor of Tripura, Dr. D. Y. Patil, during Spring / Summer Pulses Group Meet 2010 held at Pragna Bhavan, Agartala on 27th January 2010 (Fig 3) The slient feature of the variety is given below.

Salient features of "TRCP-8"

- TRCP - 8 was developed from the cross "T-163 x DMR 7" at ICAR Research Complex for NEH Region, Tripura Centre, Lembucherra – 799 210, Tripura .
- TRCP – 8 ranked 1st on the basis of yield of 4 year testing (1.40 t/ha)

Table 26. Sheath blight disease incidence in maize genotypes

Date of sowing	Number of genotypes	Range of disease score in 1-5 scale on 60 DAS	Resistant (R) / Susceptible (S)/ Remarks
18.4.09	17	1.2-2.2	Not clear due to low disease incidence
28.4.09	9	1.8-2.4	Not clear due to low disease incidence
12.5.09	26	1.7-4.0	DMR-102 (R); DMR- 108 (R)

- The proposed strain TRCP - 8 has shown significant yield superiority of 70.56% over the check HUDP - 15 and 32.84 % over DMR – 7, 24% over Rachana and 22. 55 % over IPFD 1-10 Average superioriority at 4, 20, 20, and 16 locations, respectively) during 2005-06 to 2008-09.
- TRCP - 8 ranked first at 6 locations and top in first non-significant group at 11 locations out of 20 locations tested in NHZ.
- TRCP – 8 exhibited multi-location disease resistance to Powdery Mildew and Rust, which are very important diseases of field pea in NHZ.
- TRCP – 8 exhibited tolerance to pod borer and stem fly.
- TRCP – 8 exhibited good tolerance to *M. incognita* and *M. javanica* at different locations.
- It has Medium bold seed size spherical and cream coloured seed
- TRCP - 8 (1.97 t/ ha) has shown better response to lower dose fertilizer application of 20: 20: 20 kg NPK/ha as compared to check varieties and qualified varieties. At recommended doses of fertilizer also TRCP – 8 out yielded check varieties and qualified varieties at Lembucherra.
- TRCP - 8 also performed much better (2.02 t / ha) than the check varieties and qualified varieties under late sown condition.

Fig 3. Release of TRCP- 8 by His Excellency Governor of Tripura, Dr. D. Y. Patil, during Spring / Summer Pulses Group Meet 2010 held at Pragna Bhavan, Agartala on 27th January 2010

Table 27. Plant Description of TRCP -8, field pea (*Pisum sativum* L.)

Parameters	Characters
Growth habit	Tall and vigorous
Leaf: Simple or compound	Simple
Leaf: Leaflets	Present
Leaf: Axil colour	Green
Stem: Colour	Light green
Stem: Anthocyanin colouration	Absent
Foliage Colour	Green
Flower: Standard petal Colour	white
Pod: Number / Axil	Double
Pod: Curvature	Absent
Pod: Shape of distal part	Blunt
Pod: Intensity of Green Colour	Green
Plant: Height	Long
Seed	Straw white
Seed: Shape	Spherical
Seed: Surface	Smooth
Seed: Cotyledon colour	Creamy
Seed: Weight of 1000 seeds	Medium
Seed: Testa mottling	Absent
Agronomic traits	
Days to 50% flowering	97 (49 – 168) days
Days to maturity	140 (87 – 207) days
Plant height (cm)	98 (47 – 161) cm
100 seed weight	18.94 (15.7 – 24.2)
Protein percentage	19.86
Disease and Pest Reaction	Resistant to Powdery mildew and rust. Tolerant to pod borer and stem fly. Tolerant to *M. incognita* and *M. javanica* at different locations.

Another Variety TRCP -9 developed from cross "DMR 7 x T- 163" also qualified for VIC proposal in 2009. However, its proposal was not submitted to CVRC due to the fact TRCP – 8 and TRCP – 9 both qualified for VIC proposal in the same year. Proposal will be submitted to SVRC for release of TRCP – 9.

AICRP MULLaRP

Urdbean

Urdbean AVT2 kharif 2009: 5 entries were evaluated.

Table 28. Performance of top 5 Urdbean entries under AVT *kharif*

Entry	Yield (t / ha)
KU-203	1.18
KU-201	1.11
KU-202	0.98
KU-205	0.83
KU-204	0.72

Urdbean IVT kharif 20009: 14 entries were evaluated.

Table 29. Performance of top Urdbean 5 entries of urdbean IVT *kharif*

Entry	Yield (t / ha)
KU-260	1.22
KU-279	1.21
KU-265	1.16
KU-268	1.14
KU-252	1.09

Mungbean IVT *kharif* 2009: 24 entries were evaluated.

Table 30. Performance of top 5 entries of mungbean IVT *kharif*

Entry	Yield (t / ha)
KM-09-159	1.78
KM-09-152	1.61
KM-09-155	1.59
KM-09-165	1.38
KM-09-172	1.37

Special trial Urdbean 2009-10: 11 entries were evaluated.

Table 31. Performance of entries of urdbean special trial

Entry	Yield (t / ha)
WBU-108	1.315
KU-963	1.138
MASH-1008	1.088
PU-40	1.009
LBS-752	0.993
TU-942	0.981
MASH-114	0.968
LBG-20	0.966
UTTARA	0.940
PU-31	0.932
SEKHAR-1	0.803

Mungbean

Mungbean Special Trial *kharif* 2009: 18 entries were evaluated.

Table 32. Performance of entries of mungbean under special trial -*kharif*

Entry	Yield (t / ha)
IPM-0723	1.875
IPM-99-125	1.735
OUM-11-5	1.419
PUSA -9531	1.280
RMG-492	1.179
KM-2241	1.148
PUSA-9072	1.144
Pusa Vishal	1.137
COGG -912	1.082
SAMRAT	1.043
IPM-02-17	1.043
PUSA RATNA	1.025
TM-962	1.019
PANT M 4	0.996
TARM-1	0.950
HUM-1	0.888
PANT M 5	0.749.
SML-668	0.454

Mungbean AVT 1 *kharif* 2009-10: 13 entries were evaluated.

Table 33. Performance of top 5 entries of mungbean under AVT 1 *kharif*

Entry	Yield (t / ha)
KM-09-106	1.583
KM-09-112	1.107
KM-09-108	1.020
KM-09-101	0.960
KM-09-102	0.867

Front line demonstrations in pulses (spring / summer 2009)

A total of 127 FLDs were conducted on mungbean var. HUM -12 and urdbean var. PU – 31. The demonstrations were conducted to test the effect of Sulfur application and urea spray. Based on the average yield advantage it was found that Sulfur application @ 20 kg/ha resulted in 9.5 percent yield gain for HUM -12. However, for urdbean the yield gain was only 5.4 percent.Sprays of 2% urea could increase the yield in mungbean by 6.3 percent

In *kharif* 2009, 139 FLDs were conducted of which eighty one were on blackgram and 58 on greengram. In black gram for FLD plots variety PU -31 Truthfully Labeled seed produced by us was given with standard package technology; whereas, for check plots farmers used local seed and own practice. In greengram HUM – 16 Truthfully Labeled seed produced was given along with standard package of practices for FLD plots, whereas, for check plots farmer's seed of local Sona Mumg and farmer's practice was followed. FLDs were conducted at 10 locations viz. Bagabasa, Bagma, Barabhaia, Koroiamura, South Bagma, West Kufilong and Mirza in South Tripura and Batapura in West Tripura under Khowai sub division. Blackgram FLDs recorded a yield advantage of 18.9 per cent and greengram FLDs recorded an average yield advantage of 15.8 per cent

OILSEEDS

Groundnut

Evaluation of recently released cultivars of groundnut in acid soil

Fourteen varieties, viz., ICGS-76, GG-2, GG-13, TG 37A, FeESG-10, FeESG-8, K-134, GG-6, SB XI, GG-11, Kaushal, GG-4, GG-2, GG-8 were evaluated.The variety GG-13 produced the highest pod yield (2.88 t/ha) and the lowest pod yield (0.43 t/ha) was in FeESG-8.Data are presented in (Table 34).

Seven recently released cultivars were evaluated for yield and disease reaction (Table 35). The results revealed that leaf spot disease was comparatively low (2.87) in GG-20 and ICGS-76 (score 4.1) in 1-9 scale. However, ICGS-76 was more prone to rust. The varieties like, FeESG-10 and FeESG-8 showed high leaf spot disease incidence (disease score: 6.33 – 6.70) although FeESG-10 was resistant to rust. The rest of the varieties were intermediate in disease reaction. As regards the yield was concerned, both

Table 34. Productivity parameters of groundnut varieties

Groundnut variety	No.of pod /plant	Pod weight (g/plant)	Seed weight (g/plant)	Plant weight (g/plant)	100 seed weight (g)	Shelling %	Productivity(t/ha)	
							Pod	Haulm
ICGS-76	16.10	23.77	17.66	18.77	56.6	49.99	1.08	1.25
GG-2	11.33	13.66	9.99	16.88	50.0	50.00	1.85	1.51
GG-13	10.88	14.77	10.10	28.21	56.6	49.99	2.88	1.71
TG 37A	18.99	22.77	15.66	14.44	40.0	50.06	1.62	1.41
FeESG-10	12.85	11.22	7.88	13.88	40.0	45.45	0.50	0.55
FeESG-8	5.11	3.99	2.99	12.44	53.3	53.36	0.43	0.64
K-134	11.32	8.88	6.77	13.33	50.0	50.00	0.80	1.12
GG-6	20.44	15.66	12.33	23.77	36.6	47.41	1.31	1.50
SB XI	20.55	15.22	10.99	28.99	33.3	49.20	1.33	1.62
GG-11	11.66	21.22	14.55	36.99	53.3	57.50	2.35	1.16
Kaushal	13.66	19.22	13.88	26.66	43.3	42.03	1.86	1.86
GG-4	16.77	16.77	12.44	20.88	33.3	55.71	0.98	1.21
GG-2	14.99	12.11	9.21	15.44	43.3	53.33	1.41	0.94
GG-8	14.33	16.32	13.66	23.33	40.0	46.29	1.43	1.18
SE (±)	1.17	1.28	1.04	2.05	2.4	2.53	0.12	0.11
CD(*P*=0.05)	1.81	1.89	1.70	2.39	8.1	2.66	0.57	0.55

GG-20 and ICGS-76 gave higher yield during the season.

Table 35. Performances of released cultivars of groundnut during *kharif* and *rabi* seasons

Variety	Disease score in 1-9 scale		Yield/plot (5 sq.m.) (kg)
	Leaf spot	Rust	
FeESG-8	6.70	3.40	1.300
FeESG-10	6.33	1.90	1.050
GG-5	5.23	2.00	0.750
GG-7	4.47	1.80	1.350
GG-11	5.37	1.76	0.500
GG-20	2.87	1.80	1.820
ICGS-76	4.10	3.57	1.627

Yield performance of groundnut in various intercropping options

Groundnut varieties viz. GG-7, FeESG-10, FeESG-8 were grown in intercropping (2:2) with rice, sesamum, and mung. The NPK dose applied was 40:60:50 kg/ha in combination with cowdung (5 t/ha). Treatments were; T1- Sesamum sole crop, T2- Mung sole crop, T3- Rice sole crop,T4- Groundnut (GG-7) sole crop, T5- Groundnut (FeESG-8) sole crop, T6- Groundnut (FeESG-10) sole crop, T7- Groundnut (GG-7) + rice, T8 - Groundnut (FeESG-8) + rice, T9- Groundnut (FeESG-10) + rice, T10- Groundnut (GG-7) + ssamum, T11- Groundnut (FeESG-8) + sesamum, T12- Groundnut (FeESG-10) + sesamum, T13- Groundnut (GG-7) + mung, T14- Groundnut (FeESG-8) + mung, T15- Groundnut (FeESG-10) + mung. The productivity result indicated that FeESG-10 in combination with rice produced the highest yield (1.57 t/ha) followed by the combination with GG-7 and mung (0.97 t/ha).

Identification of confectionary/ large seeded groundnut varieties

A total 10 nos. of confectionary /large seeded groundnut varieties viz., GG-20, HNG-10, ICGS 76, BAU 13, TPG 41, GG-7 Somnath, NRCGCS 148, and NRCGCS 268 AND NRCGCS 281 were grown in RBD design with 3 replications. NPK (40:60:50) in combination with 5t cowdung/ha was applied. The results indicated that the groundnut variety BAU 13 showed the highest pod, seed and plant weight followed by the variety HNG 10.

Nutrition of bold seeded groundnut in acid soils

The experiment on nutrition of groundnut (var. GG 7) was carried out with the treatment, viz., T1- control, T2 –P50, T3- K100 , T4 –Lime (2.5 t/ha),T5-P50 + Lime, T6- P50 + K100 +Lime, T7- P50 + K100 +Lime +13 Kg Boric acid /ha , T8-P50 + K 100 + Lime + 10 t cowdung /ha. The productivity parameters indicated that the treatment T8 after the application of phosphate (50 kg P2O5 /ha), Potash (100 K2O /ha), Lime (2.5 t/ha) and cowdung (10 t/ha) could produce the highest pod yield of 1.12 t /ha with 14.66 no.of pod and 19.55 g pod weight / Plant.

Evaluation of germplasm and advanced breeding lines of groundnut

Screening of groundnut germplasm against the soil acidic condition was carried out with 66 nos of germplasm. Various vegetative growth parameters of 66 nos of groundnut after 35 days of sowing were recorded and root length varied from 8.17 to 22.06 cm/plant, shoot length, 12.56 to 40.20 cm/plant, no.of secondary root, 10 to 43.16, no.of nodule, 5.66 to 110.66, nodule weight, 0.34 to 0.004 g/plant, root weight, 0.14 to 19.02 g/plant and shoot weight, 4.40 to 29.47 g/plant. Similar nature of variability in groundnut under soil acidic condition was recorded at 65 days after sowing. There was a wide variation in no. of pod from 2.33 to 17.66, pod weight from 2.66 to 22.0 g/plant, seed weight from 1.0 to 15.33 g/plant and plant weight from 2.66 to 36.66 g/plant in groundnut at harvesting. The decline in vegetative/production parameters at 35 and 65 days after sowing and at harvesting indicated that the variety of groundnut is sensitive under soil acidity but the increase in vegetative/production parameters indicated the presence of tolerance behavior of groundnut under soil acidity.

The groundnut germplasms were evaluated for their disease reaction under natural conditions. The diseases, like leaf spot, rust, wilt/stem rot diseases were found during kharif crop season. The leaf spot disease was observed in all the genotypes of core collection. However, the leaf spot disease incidence was low, showing resistance with 2 - 3 disease score

in 1-9 scale, both under fertilized and unfertilized condition in the genotypes like, NRCG 955, NRCG 12297, NRCG 12487, NRCG 12291, NRCG 12393, NRCG 12968 and NRCG 11985. Rust was more in the genotypes like NRCG 12879, NRCG 2190, NRCG 11197, and NRCG 11656. The genotypes, like, NRCG 11811, NRCG 10572, NRCG 11450, NRCG 12264, NRCG 11126 and NRCG 12700, were more affected by wilt disease than others.

Field pea

Four released varieties, viz. TRCP-8, Rachna, IPFDI-10 and DMR-7, of field pea were studied for their disease reaction under field condition during *Rabi* crop season, the blight disease was found as predominant during the season. Among the varieties, the disease was highest with mean disease score of 5.11 in 0-9 scale in DMR-7 while least with disease score of 1.83 in IPFDI-10.

VEGETABLES

Tomato

Management of leaf curl disease of tomato under field condition

Influence of host resistance on the incidence leaf curl disease of tomato

Fifteen genotypes including 3 hybrids were given trial in rows with earlier detected susceptible variety, BT-1, as infective row at every 4th row. Three replicates were kept in all cases, except BT-1. The disease was studied after 45 and 55 days of transplantation. It was found that all the tested genotypes were more tolerant than BT-1. However, the disease was least in hybrid, Trishul, and variety, Tura Local wit 23.33% disease on 55 days after transplantation (Table 36). The disease was considerably less in the hybrid, Al rounder, and varieties, BT-10, H-24, BT-117-5-3-1, Type-1 and Hisar Arun (Sel-7). Considering the yield, the hybrids, Trishul and Al rounder, were better than all the varieties. Further, the disease showed different symptoms, i.e. leaf curl with mosaic appearance in presence of other viral attacks.

Effect of biopesticides for the control of leaf curl disease in tomato

The experiment was carried out with BT-1 tomato variety. Commercial neem oil (0.1%), neem leaf extract (10%), neem twig extract (10%) and control were used as spray in 2 × 2.5m plot. The biopesticides were sprayed at 10 days interval for 4 times and disease was studied on 45 and 55 days after transplantation. The results presented in Table 37 indicated that none of the materials were effective in minimizing the disease considerably, although, fruit yield was observed increasedwhile neem leaf extract was used.

Effect of insecticides for the control of leaf curl disease in tomato

The experiment was carried out with BT-1 tomato variety. Seven insecticides viz. carbofuran (1g/plant, soil application), monochrotophos (0.1%, spray), malathion (0.1%, spray), dimethoate (0.1%, spray), imidachloprid (0.1%, spray), chloropyriphos + cypermethrin mixture (0.1%, spray), carbosulfan (0.1%, spray), were applied at 10 days interval for four times. The data recorded in Table 38 indicated that disease intensity at later stage was less in almost all pesticide applied plot, except, cypermethrin + chloropyriphos applied one. The fruit yield was also increased in the pesticide applied plot. Monochrotophos and imidachloprid were found to be the most effective in controlling the vector pest, *Bemisia tabaci*.

MUSHROOM

Evaluation of different strains of paddy straw mushroom

Seven strains of paddy straw mushroom (*Volvarielle volvacea)* were evaluated by using cube method. Spawning was done on 6 and 7 August. Each cube was prepared with 3kg paddy straw.The strains took 11-14 days for fruiting.The highest yield was recorded inVV-08and lowest inVV-11.Data are presented in Table 38a.

Table 36. Influence of host resistance on the incidence of leaf curl disease of tomato

Genotypes	Leaf curl disease incidence at different growth stages (%)		Number of fruits/ 10 plants	Yield (kg)/ 10 plants
	45 day after transplantation	55 days after transplantation		
BT-1	60 (± 17.89)	80 (±16.73)	542 (± 103)	15.4 (± 2.92)
S-22	40 (± 30.00)	60 (± 34.64)	363 (± 51)	18.3 (± 5.13)
BT-10	23.33 (± 25.17)	36.67 (± 11.55)	279 (± 65)	18.37 (± 5.97)
Trishul	23.33 (± 20.82)	23.33 (± 20.82)	536 (± 40)	25.08 (± 2.85)
H-24	30 (± 10.00)	36.67 (± 11.55)	769 (± 457)	22.27 (± 9.02)
Alrounder	36.67 (± 5.77)	36.67 (± 5.77)	610 (± 278)	25.00 (± 8.43)
Sel-1	46.67 (± 20.82)	50 (± 26.46)	372 (± 91)	19.45 (± 7.81)
BT-117-5-3-1	26.67 (± 15.27)	33.33 (± 20.82)	516 (± 108)	20.17 (± 4.19)
CKVT-17	33.33 (± 15.27)	73.33 (± 30.55)	672 (± 300)	22.2 (± 8.21)
S. Local	30 (± 20.00)	40 (± 10.00)	1041 (± 571)	17.77 (± 11.21)
Type-1	30 (± 17.32)	33.33 (± 11.55)	495 (± 46)	14.58 (± 3.29)
A. Abha	20 (± 17.32)	40 (± 10.00)	635 (± 141)	20.12 (± 3.02)
T. Local	13.33 (± 15.27)	23.33 (± 5.77)	1148 (± 191)	19.72 (± 3.73)
H.Arun	20 (± 17.32)	36.67 (± 25.17)	543 (± 170)	21.25 (± 7.02)
Hybrid608	40 (± 26.46)	50 (± 30.00)	289 (± 53)	11.01 (± 1.40)

* Figures in parentheses are standard deviation.

Table 37. Effect of biopesticides for the control of leaf curl disease in tomato

Biopesticide	Leaf curl disease incidence at different growth stages (%)		Number of fruits/plot	Yield (kg) / plot
	45 day after transplantation	55 days after transplantation		
Neem oil	50.55 (± 9.18)	97.22 (± 4.81)	759 (± 100)	20.57 (± 0.48)
Neem leaf extract	54.54 (± 7.87)	100 (± 0.00)	937 (± 375)	26.32 (± 7.36)
Neem twig extract	55.55 (± 4.81)	94.45 (± 4.81)	732 (± 153)	21.17 (± 5.80)
Control (without spray)	61.87 (± 32.47)	100 (± 0.00)	483 (± 156)	16.07 (± 7.96)

* Figures in parentheses are standard deviation.

Table 38. Effect of chemical pesticides for the control of leaf curl disease in tomato

Chemical pesticide	Leaf curl disease incidence at different growth stages (%)		Number of fruits/plot	Yield (kg)/ plot
	45 DAT#	55 DAT#		
Carbofuran	45.2 (± 16.08)	54.04 (± 7.44)	598 (± 219)	13.5 (± 2.69)
Monochrotophos	31.31 (± 3.50)	34.09 (± 7.23)	624 (± 49)	16.03 (± 2.34)
Malathion	33.33 (± 10.49)	41.16 (± 4.57)	644 (± 210)	15.37 (± 4.11)
Dimethoate	31.56 (± 13.17)	52.78 (± 12.73)	551 (± 83)	14.78 (± 1.60)
Imidachloprid	23.99 (± 19.23)	38.89 (± 4.81)	808 (± 76)	19.47 (± 3.74)
Cypermethrin + Chloropyriphos	39.65 (± 23.43)	61.11(± 24.06)	360 (± 67)	11.0 (± 2.28)
Carbosulfan	32.32 (± 4.63)	47.22 (± 6.61)	562 (± 29)	14.71 (± 1.74)
Control	38.89 (± 17.34)	70.44 (± 3.27)	398 (± 154)	10.48 (± 3.95)

* Figures in parentheses are standard deviation. # DAT= days after transplantation

Table 39.Yield performance of paddy straw mushroom strains

Strains	Days to harvest	Yield (g/bed)	Biological Efficiency (%)
VV-02	12	595	19.8
VV-06	11	597	19.9
VV-07	12	470	15.7
VV-08	12	610	20.3
VV-09	12	490	16.3
VV-10	13	280	9.3
VV-11	14	232	7.7

Performances of different species of oyster mushroom

Pleurotus sajor-caju, P. florida and P. flabellatus were evaluated.All the three species produced more or less same yield (Table 40) but the number of days required for fruit body production in *P. sajor-caju* was least, while, that was highest in *P. flabellatus*.

Table 40. Performances of different species of oyster mushroom on rice straw

Mushroom species	Date of spawning	Days required for fruit body	Yield (g)/ kg substrate
Pleurotus sajor-caju	15.12.2009	20	569.17
Pleurotus florida	15.12.2009	24	547.50
Pleurotus flabellatus	15.12.2009	27	633.33

Effects of different inorganic and organic amendments in mushroom bed on fruit body production of oyster mushroom

Rice straw treated with 5% and 10% solutions of $CaCO_3$ and lime had no beneficial effect in yield of oyster mushroom. In another experiment, the organic amendments like *Kuro (*commercial rice bran) and *Bhushi* (commercial wheat bran) were mixed with the rice straw substrate after disinfection. The results showed detrimental effect of both the materials.

Jatropha

Four types of trials, viz., progeny trial, agrisilviculture trial, package of practices and multi national trial were undertaken under National Network Programme on Jatropha.

Identifying suitable jatropha progeny for Tripura

Eighteen seed sources were planted on 9th May' 06 and growth characteristics estimated upto November '09. Leaf curl disease was noticed in Jatropha and the per cent occurrence varied from 13 to 88 with maximum in Jatropha from Udaipur (South Tripura) and lowest in Jatropha (Madhya Pradesh). Male /Female ratio underwent a variation from 15.28 to 49.05 with fruit yield from 297 to 1952.78 g/plant. Seed yield was variable from 155.33 to 617 g/plant with the shelling percent from 42.51 to 55.05.1st flowering was recorded in the month of April '09. After 3rd year of plantation, Jatropha from Dimapara (South Garo Hills) showed the maximum fruit yield (1.952 kg/tree) with 31.63 % recovery and Jatropha from Madhya Pradesh showed the lowest production of fruit yield (0.297 kg/tree) with 52.16 % recovery. Out of the progeny material from Tripura, Jatropha from Mohanpur (West Tripura) showed the maximum production of fruit (0.9 kg/ tree) with 37.94 % recovery. There was an increment of the purning on the secondary branches of Jatropha. Jatropha from Dimapara (south Garo Hills) showed the maximum no of secondary branches (21-36) thus indicating the maximum fruit/seed yield after 3 years of planting.

Jatropha based agrisilviculture

In the agri silviculture trial planted in May' 06 in spacing of 4 x 3 m, growth characteristics was recorded. In the agri-silviculture trial, three crops, viz., okra (var. Hybrid 152), cowpea (var. YB -8) and rice (TRC-87-251) were grown. Jatropha from Mendipather (East Garo Hills) had the maximum basal diameter of 12.50 cm with 36 no of secondary branches. Fruit yield was also maximum (1183 g/ plant) in Jatropha from Mendipathar (East Garo Hills). Male /Female ratio was variable from 19.24 to 28.88. Disease (leaf curl) occurrence varied from 20 to 55.6 %. In the interspaces of jatropha from Ri bhoi (Mawahati), there was maximum production of okra (4500 kg/ha). Cowpea showed the maximum production (7650 kg/ha) in the interspaces of jatropha from East Garo Hills (Medipathar). Rice also showed the maximum production of 1890 kg/

ha in the interspaces of jatropha from Dimapara (South Garo Hill).

Package of practice for jatropha

In the package of practices trial with the fertilizer dose of 26 g urea, 100 g SSP, 16 g MOP and 1 kg cowdung, growth characteristics were estimated. Basal diameter was maximum (11.3 cm) in jatropha from East Garo Hill (Mendipathar) and lowest (7.25 cm) in Jatropha from Madhya Pradesh. The occurrence of leaf curl disease in Jatropha was comparatively low in the experiment under package of practices. Fruit yield in Jatropha from Udiapur (Rajasthan) was 538 g /tree with 51.9 % recovery.

National provenance trial on jatropha

A National trial with the following materials, viz. LBJJ-23 (Ranchi), NDJC-1 (Faizabad), TFRI -07 (Jabalpur), JIP-12-520621 (Jammu), JJ2 (Jabalpur), Panth JCP-1 (Uttarakhand) 7), JCP-2 (Uttarakhand), PDKVNOV -19 (Akola) was laid out in 2008. Jatropha planted from seed samples of LBJJ-23 showed the maximum basal diameter of 5.74 cm with 1.55 primary branches and height of 1.28 m. The lowest basal diameter (4.32 cm) was noted in Jatropha planted from Panth-JCP-1 with 1 no of primary branches and height of 0.89 m. Jatropha from PDKVNOV -19 (Akola) showed the highest occurrence of leaf curl disease (63 %) and the lowest occurrence (3.01 %) was noted in jatropha from TFRI-07 (Jabalpur). After 3 years of planting, jatropha from South Garo Hills (Dimapara) in Meghalaya produced 1952.78 g fruit /plant and 617.77 g seed/plant with 31 % seed recovery. Jatropha from Mohanpur (West Tripura) produced 900.33 g fruit /plant and 341.66 g seed/plant with 37 % seed recovery.

Propagation of jatropha through stem cutting

Stem cutting collected from different places of Tripura were planted in 2007 in ICAR Research farm. Male /Female ratio of the materials varied from 12.60 to 102 with fruit yield from 23 to 258.33 g/plant.

Jatropha in undulated uplands

It was indicated that the fruit yield of the jatropha planted in undulated terrains underwent a variation from 48.00 to 510.00 g/plant. Jatropha from North Tripura (Dharmanagar) showed the highest production of jatropha (510 g /tree). Hybrid Napier was grown as fodder in the interspaces of jatropha in the hilly terrain and productivity of green fodder was 50 t /ha (Table 41).

Use of leguminous tree leaf for crop nutrition

To investigate the effect of tree leaf sources from hedge plantation (viz., *Gliricidia maculata*, *Indigoferra tinctoria*, *Tephrosia candida* and *Crotolaria tetragona*), green leaf (10 t/ha) with 50 % before sowing of the crop and 50 % as leaf mulch were applied in the crops grown in the terrace. The results indicated that the productivity of upland rice (var. NDR -97) in the terrace land after the application of tree leaf was found to be raised from 1.50 to 2.12 t/ha, 1.72 to 1.90 t/ha and 1.12 to 2.15 t/ha over fertilizer after the application of *Indigoferra, Tephrosia* and *Gliricidia* green leaf, respectively. With the application of tree leaf, viz., *Tephrosia* and *Gliricidia*, seed yield of

Table 41. Performance of jatropha in undulated upland after 3 years

Position of Uplands Jatropha		Male flower (Nos)	Female flower (Nos)	Male / female ratio	Fruit yield (g/plant)	Seed yield (g/plant)
1st	West Tripura (Mohanpur)	3013.00	167.4	17.99	450.00	150
2nd	South Tripura (Udaypur)	606.5	73.5	8.25	219.00	73.00
2nd	North Tripura (Dharmanagar)	404.16	16.16	25.00	48.00	17.66
2nd	Rajasthan (Udaipur)	229.16	31.16	7.35	275.00	112.00
4th	North Tripura (Dharmanagar)	3063.8	170.2	18.02	510.00	270
4th	East Garo Hills (Meghalaya)	2278.00	126.55	18.00	378.00	126
4th	Rajasthan (Udaipur)	1036.16	60.33	17.17	280.00	60.00
	Mean	**1518.68**	**92.18**	**15.96**	**308.57**	**115.52**

sesamum (var. B-67) though showed a decline from 0.89 to0.75 t/ha and 0.64 to 0.57 t/ha as compared to fertilizer alone but the haulm yield was raised from 2.74 to 2.86 t/ha and 2.29 to 2.52 t/ha, respectively. The application of tree leaf, viz., *Indigoferra and Gliricidia* could produce a rise in bhindi (var. okra 152) from 1.70 to 3.79 t/ha and 1.34 to 1.61 t/ha but *Tephrosia* leaf could show a decline in bhindi from 3.13 to 2.16 t/ha over fertilizer application. In mustard (var. TRC -1-1-5-1), tree leaf manuring, an increase in seed yield from 0.26 to 0.51 t/ha, 0.93 to 0.96 t/ha and 0.50 to 0.84 t /ha over the fertilizer application and the maximum increase in the productivity was noted after the application of *Indigoferra*. The application of *Gliricidia* leaf @10 t/ha resulted a rise in radish (var. Ivory white) from 53.13 to 58.89 t/ha over fertilizer while two other leaf sources (*Indigoferra*/ *Tephrosia*) had less radish productivity than the fertilizer application. In carrot (var. king kuroda), the application of green tree leaf @ 10 t/ha increased the carrot productivity from 7.50 to 13.75 t/ha, though 20.8 % increase in carrot productivity over fertilizer was noted after the application of *Tephrosia* leaf. An experiment was also conducted with organic manuring, viz., cowdung (2 t/ha), cowdung (5 t/ha), cowdung (10 t/ha), Biofertilizer + 5 t cowdung/ha, Biofertilizer + 10 t cowdung/ha in upland rice (var, TRC-87-261) and mung (var. Ratna) alone and their intercrops. Biofertilizers applied were rhizobium, PSB and Azotobacter inoculated @100 g/kg seed. The application of organic manuring was found to raise the rice equivalent yield of mung as sole crop from 2.90 to 3.68 t/ha. But the combination of rice + mung (1:1) could produce rice equivalent of 2.92 and 3.84 t/ha after the application of cowdung (5 t/ ha) and Biofertilizer + 5 t cowdung/ha, respectively thus indicating an increase of 13.6 to 21.5 % over the sole crop of mung. On the other hand, the combination of mung and rice (2:2) showed the reduction in rice equivalent yield as compared to the sole crop of mung. An experiment was conducted with treatments [T1 - Fertilizer (20:60:40), T2– Cowdung (10 t/ha), T3– Fertlizer + Cowdung, T4- ½ fertilizer + cowdung and T5– ½ fertilizer + cowdung + PSB + rhizobium] in field pea (var. TRC –P8). Pod yield was found to be increased from 1.88 to 3.69 tha and the corresponding rise in seed and hulm yield was from 1.34 to 2.68 t/ha and 3.60 to 4.74 t/ha, respectively.

Soil health card

Soil samples (0-15 cm) were collected from 31 farmers' club in South Tripura. It was observed that soil pH varied from 3.02 to 6.92 thus indicating the change in soil acidity from strongly acidic to mild acidic. Organic carbon, nitrogen and phosphorus underwent a variation from very low to very high in status. Availability of potassium was found to be low. Calcium availability was also varying from low to high. There was a wide variation in sulphur from low to high with 58.42% coefficient of variation. Among the micronutrients, soils were having a high concentration of Fe (critical limit 4.5 mg/kg), some soils were low in Mn availability but majority of soils are containing high Mn content (critical limit 2.0 mg/kg). Both Cu and Zn varied from 0.16-5.86 mg/kg and 0.33-8.30 mg/ kg, respectively thus indicating deficiency (critical limit 0.6 mg/kg for Zn and 0.2 mg/kg for Cu) in some soils and abundant supply in most of the soils (Table 42).

Table 42. Average soil test report of farmers' club in South Tripura

Parameter	Range	Mean	S.D	C.V. (%)
pH	3.02-6.92	4.97	0.49	9.85
Organic carbon (%)	0.1-1.86	0.62	0.29	46.77
Nitrogen (kg/ha)	8.12-578.31	199.44	35.94	18.02
Phosphorus (kg/ha)	0.37-120.37	11.13	9.51	85.54
Potassium (kg/ha)	1.66-97.50	15.76	5.39	34.20
Calcium {c mole (p^+)/kg}	0.04-44.25	1.97	0.91	46.19
Sulphur (kg/ha)	0.12-571.25	67.99	39.72	58.42
Iron (mg/kg)	9.10-35.61	26.41	3.94	14.91
Mn (mg/kg)	0.88-22.80	12.17	5.43	44.61
Cu(mg/kg)	0.16-5.86	1.73	0.53	30.63
Zn(mg/kg)	0.33-8.30	2.04	0.72	35.29

AGROFORESTRY

In the arboretum maintained at Tripura Centre, there are 12 tree species, viz., *Acacia auriculiformis, Morus alba. Leucaena leucocephala, Dalbergia sisoo, Gliricidia maculata, Azadirachta indica, Michelia champaca, Eucalyptus hybrid, Tectona grandis, Gmelina arborea, Samania saman, Albizzia lebbeck.* Various crops were grown in association with forest tree species and their productivity in

Horti-Silvi systems are presented in Table 43 and 44.

Table 43. Productivity of pineapple

Forest trees	Fruit weight (g)	Fruit yield (t/ ha)
Leucaena leucocephala	890	14.85
Dalbergia sisoo	820	7.03
Eucalyptus hybrid	743	12.69
Azadirachta indica	815	10.82
Tectona grandis	657	12.42
Albizzia lebbeck	760	10.04
Samania saman	816	15.21
Morus alba	790	10.98
Gmelina arborea	705	11.11
Michelia champaca	620	5.58
Mean	**762**	**11.07**

Table 44. Productivity of *Dioscorea alata*

Forest trees	Productivity (kg/ plant)	Productivity (t/ ha)
Leucaena leucocephala	2.39	10.18
Azadirachta indica	3.22	6.36
Albizzia lebbeck	1.08	4.55
Samania saman	2.58	5.69
Morus alba	2.34	8.68
Michelia champaca	1.28	5.13
Mean	**2.15**	**6.77**

Black pepper was grown in a 3- tier system with *Azadirachta indica* and *Michelia champaca* and the average productivity of 1.25 kg/plant was obtained (Figs 4 & 5).

Fig 4. Dioscorea + Forest Tree

Fig 5. Black pepper + Forest Tree

The programme of agroforestry was also undertaken in 1.7 ha of farmer's land with a no. of forest trees and rubber plantation. Out of the total area of 1.7 ha under this project, the area under pineapple vars. Kew and Queen was 1.04 ha. An attempt was made to develop agroforestry based land use system with pineapple and *Dioscorea*, planted in 1225 m^2 and 223 m^2 of land, respectively. Pineapple planted through sucker in the plot took 18 months to come to the flowering stage. The productivity of okra in association with rubber varied from 0.65 to 0.75 t/ha and green leaf of patchouli collected from the area under the shade of arecanut was 1.35 t/ha with the production of 0.33 t/ha dry leaf having a market value of Rs 4333.

FARMING SYSTEM RESEARCH

A number of crop combinations were undertaken under farming system research with the aim to make the cropping intensity 300 %. An attempt was made to combine different crops (Figs 6 & 7) under

Fig 6. Sloppy land utilization through Banana + Gamahar (*Gmelina arborea*)

Fig 7. Potato crop under farming

farming system research. Some promising combinations are documented in Table 45.

ANIMAL SCIENCES

Dairy Cattle

The crossbred cattle (23 number including calf) were maintained at the livestock farm. The animals were fed on green fodder available, straw and concentrate mixture. The animals were vacinated timely against FMD, HS and BQ as well as dewormed at 6 months interval for adult and 3 months interval for calf. Revenue of Rs. 1,30,687.00 was collected from the sale of milk during 2009-10. The cow dung was used for making compost which was used for fodder cultivation and also supplied to other divisions. Research work on enhancing fertility in cattle using biotechniques has been undertaken.

Table 45. Some promising combinations

Crop sequence	Variety	Unit area m^2	Productivity (t/ ha)	Cost of cultivation (Rs/unit area)	Gross return (Rs/unit area)	Net return (Rs/unit area)	B: C ratio
Banana	Sabri	384	1.77	1080/-	6400/-	5320/-	5.93
Green gram - Broccoli	HUM 12 Everest	180	1.19 21.1	2470/-	8675/-	6250/-	3.51
Duck-fish culture	Khaki Cambell Composite fish	326	6503 nos egg 3.02 t fish/ ha	3370/-	9552/-	6182/-	2.83
Broom grass	Local	108	14,444 bundles (9.38 t/ha)	620/-	1560/-	940/-	2.52
Ridge gourd- bitter gourd- bottle gourd	Local	190	1.05 0.95 14.11	2800/-	5740/-	2940/-	2.05
Cowpea-Maize-Cabbage/ Cauliflower	Kashi kanchan TRM 5-BC78/	472	3.6 4.87 26.2	10,276/-	18,288/-	8004/-	1.77
Green gram-Potato	Snowheart Hum 12 TPS (II/67)	80	28.8 1.56 17.0	1190/-	1985/-	795/-	1.67

Pig

The crossbed (Hampshire X Local) pigs were maintained at the centre. Two pairs of local 'Mali' pigs (Fig 8) were introduced from the State Farm of ARD, Govt. of Tripura. A pilot study on productive and reproductive traits of 'Mali' pigs was undertaken. The pig farm offered a service to provide crossbred piglets to the farmers for backyard pig farming.

Fig 8. 'Mali' pig of Tripura

Goat

Phenotypic characterization for variation in kidding size in Black Bengal goats

The objective of the study was to generate some phenotypic descriptors for determining the kidding size during pregnancy in Black Bengal goats. Two-stage stratified random sample survey based monthly phenotypic data on 383 pregnant Black Bengal goats were recorded during 5 months of pregnancy period and one set of observation after kidding in 23 villages of 3 districts of Tripura viz., West Tripura, South Tripura and Dhalai. A complete time-series data on 383 goats were analyzed using one-way Analysis of Variance (ANOVA) considering observed kidding size as the only source of variation to investigate if linear type quantitative phenotypic traits influenced the kidding size of prolific Black Bengal goats. Duncan test was applied to compare pair wise mean difference probabilities. The mean comparison through one-way analysis of variance has detected significant differences among most of the linear body measurements (such as head rump length, body length, wither height, croup height, heart girth, punch girth, pelvic triangle area etc.) in Black Bengal goats during different months of pregnancy. Out of 383 does, 60.83 % of does gave birth of twin kids followed by 30.81 % birth of single kid. The incidence of triplet births was 8.36 % with a prolificacy of 177.54%, averaging 1.78 kids per doe. Among the selected goats under study, 68.40% goats were black in hair coat colour and 43.10% goats with black hair color were recorded to give twin birth, though such association was not significant ($p>0.05$). The goats with bigger ear as well as longer neck showed the tendency to give birth of more kids. The ear length ranged between 12.14 and 12.87 cm. and neck length was recorded to be between 21.59 and 24.94 cm.

The stepwise discriminant function analysis was done to recognize the most probable descriptors. Based on stepwise discriminant analysis, curved head- rump length and distance between tuber major bones were found to be good indicators for higher kidding size starting from 3rd month of pregnancy, while heart girth and punch girth were good indicators during 4th and 5th months of pregnancy. The fitted linear trend or simple regression lines for descriptors indicated that udder height (from ground) decreased significantly due to advancement in pregnancy (months) for kidding size 3 (Figs 9 & 10). Chest height (from ground) was found to decrease significantly due to advancement in pregnancy (months) for kidding size 2.

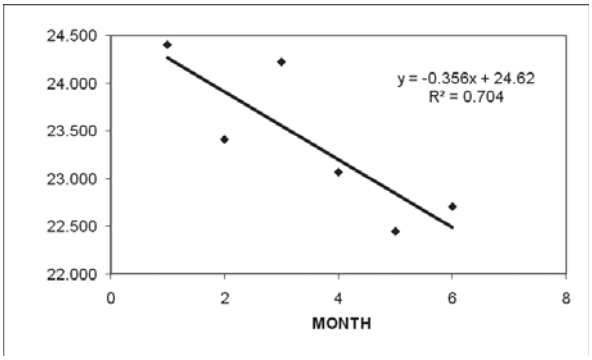


Fig 9. Regression line for 'Udder height (from ground)' for kidding size 3

Determination of ovulation rate in cyclic Black Bengal goats using both ultrasonographic (USG) examination as well as laparatomy operation

To investigate the ovulation rate in cyclic Back Bengal goats under National Fund for Basic and

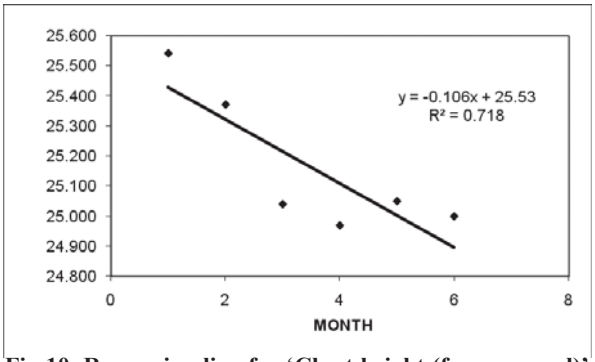


Fig 10. Regression line for 'Chest height (from ground)' for kidding size 2

Strategic Research in Agriculture (NFBSRA) project, 9 goats were subjected to transrectal ultrasonography (USG) examination at standing position on 10th day of estrous cycle, using 7.5 MHz linear transducer with B-mode. The USG observations (Fig 11) were confirmed through laparatomy operation on the same day for counting corpus lutea (CL) in ovaries (Fig 12) *in vivo*

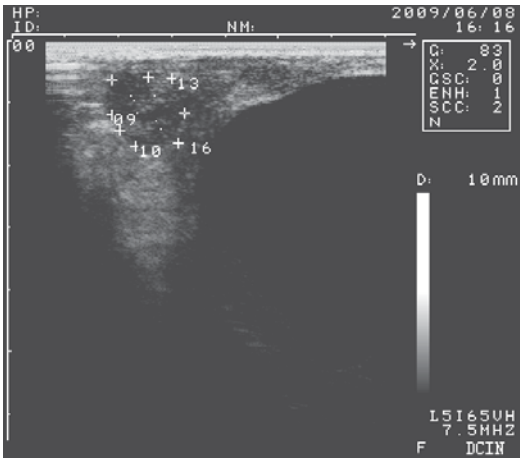


Fig 11. USG image showing two CLs in left ovary of goat on 10th day of the estrous cycle

Fig 12. Arrow indicating two CLs in left ovary of goat on 10th day of the estrous cycle

condition. Out of 9 goats, 33.33 % of cyclic goats showed single ovulation which was taken place in right ovary in all cases. The incidence of two ovulations was recorded in 22.22% of goats, while 44.45% of cyclic goats exhibited three or more than three ovulations during the estrous cycle. Both USG examination and laparatomy operation indicated multiple ovulations in Black Bengal goats were common.

Prediction of kidding size based on plasma follicle stimulating hormone (FSH) and luteinizing hormone (LH) profiles during growing period and peri-pubertal stage in female Black Bengal goats

The female kids born were subjected to the weekly blood sampling schedule from the day 1 age upto the day of confirmation of conception by USG, covering the growing stage and peripubertal period. Estrus was checked with vasectomized (teaser) buck. The plasma samples harvested from the collected blood samples were utilized for the estimation of FSH and LH following enzyme immunoassay (EIA) technique. The time period was assigned to day in relation to the day of conception. The FSH and LH data (Figs 13 & 14) was normalized considering the day of conception as '0' day and the data generated before the conception was utilized for statistical analysis. Based on the record of kidding size, the goats were categorized in three groups, viz. single, twin and triplet kidding size groups. Plasma LH concentrations in goats under the triplet kidding size group were higher ($p<0.05$) as compared to twin kidding size group during the growing period and peripubertal stage.

Fig 13. Plasma FSH profiles during growing period and peripubertal stage in female Black Bengal goats

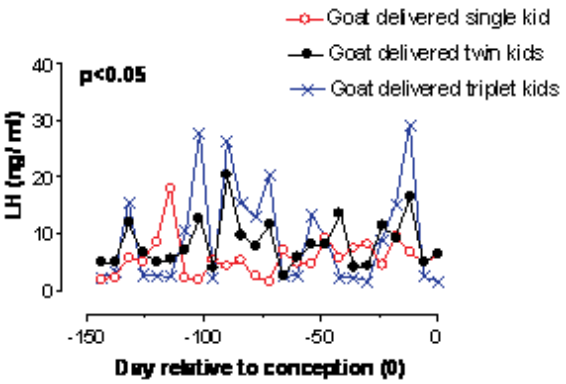


Fig 14. Plasma LH profiles during growing period and peripubertal stage in female Black Bengal goats

Similarly, plasma LH concentrations in goats under the twin kidding size group were higher ($p<0.05$) than the goats under single kidding size group. However, plasma FSH concentrations in goats among three different groups did not differ ($p>0.05$) during the growing stage and peripubertal period. The present investigation was further extended to more number of animals.

Plasma progesterone and estrone sulphate concentrations during pregnancy period and prediction of fetal number in Black Bengal goats

The investigation was made on 16 Black Bengal pregnant goats. Blood sampling was started from the day of breeding and collected at monthly interval during the pregnancy period and completed by collecting blood sample after one month of parturition. Pregnancy diagnosis was made using transabdominal USG scanning on day 60 of pregnancy. The numbers of single, twin and triplet pregnancies were seven, seven and two, respectively. The USG observation was also confirmed by recording the number of kid(s) after parturition. The blood samples were centrifuged ($2500\times g$ for 10min at 4^0C) and the plasma separated and utilized for the estimation of progesterone and estrone sulphate using enzyme immuno assay. Plasma progesterone values in goats with triplet pregnancies were significantly higher as compared to those with twin pregnancies (15.53 +/- 2.11 ng/ml vs. 26.16 +/- 4.33 ng/ml; $p < 0.05$) as well as single pregnancies (9.50 +/- 1.19 ng/ml vs. 26.16 +/- 4.33 ng/ml; $p < 0.01$). Plasma progesterone concentrations in goats carrying twin fetuses were also higher ($p < 0.05$) than that of carrying single fetus. Plasma estrone sulphate concentration, an indicator of endocrine activity of the fetoplacental unit which secretes significant amounts of progesterone (in addition to functional corpora lutea) for the maintenance of pregnancy, did not differ ($p > 0.05$) between does with single and multiple fetuses. Plasma estrone sulphate concentration started to increase to a level between 500- 1000 pg/ ml and the concentration reached at the level of 1500- 2000 pg/ ml between 2nd and 4th month of pregnancy. After parturition, plasma estrone sulphate concentration declined to a very low level. The results indicated that the determination of plasma estrone sulphate (Fig 15) might be useful for pregnancy diagnosis in goats. However, its concentration might not be helpful for the prediction of number of fetuses during pregnancy in goats. Plasma progesterone concentration (Fig 16 & 17) might be a predictive tool for the determination of

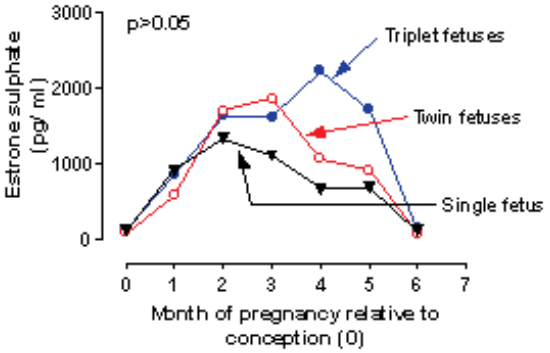


Fig 15. Plasma estrone sulphate concentrations in pregnant does carrying single, twin and triplet fetuses

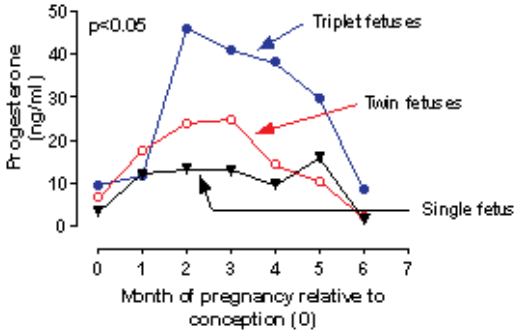


Fig 16. Plasma progesterone concentrations in pregnant does carrying single, twin and triplet fetuses

kidding size in goats during pregnancy. The present finding warranted further investigation on more number of animals.

Validation of timed and controlled breeding program in goats

The aim of the study was to validate the timed and controlled breeding program in goats for eliminating the unplanned breeding performed by the stray bucks within the flock of Black Bengal goats in the villages. Seven (7) female cyclic goats aged 18.29 ± 2.90 months with body weight of 11.77 ± 0.92 kg were selected randomly from the goat farm of ICAR, Tripura Centre and subjected to GnRH-PGF_2a-GnRH treatment (ovsynch) (Fig 17) on day 0, 7 and 9, respectively, irrespective of the stage of estrous cycle and thereafter, the goats were allowed for breeding by the buck (Fig 18) on day 10. Another fifteen (15) non-cyclic female goats aged 16.87 ± 2.20 months with body weight of 13.77 ± 0.88 kg were selected randomly and kept with buck in a separate paddock. The animals were served as control animals. The moment when the buck mounted on the female goat was considered as estrus. Daily blood samples were collected from the experimental goats. The plasma samples harvested from the collected blood samples were utilized for the estimation of progesterone. Plasma progesterone concentration was used as an indicator of ovulation. All 7 goats treated with ovsynch showed heat symptoms. Behaviorally, the does sought out the buck and displayed tail wagging, bleating, restlessness, frequent urination and clear thin discharge from the vagina. The time from the end of treatment protocol (ovsynch) till the occurrence of heat was 1.71 ± 0.47 day. In case of control goats, 11 out of 15 goats showed heat symptoms after 8.36 ± 1.63 days of introduction of buck in the flock. Synchronization of ovulation and timed breeding program following ovsynch resulted higher conception rate (85.71%) in treated goats when compared with standard reproductive management in control goats (73.3%). The plasma progesterone concentrations indicated the presence of the functional CL in pregnant goats. Synchronization of ovulation would allow more control in breeding program of goats and eliminate the dependence on estrus detection before breeding. The ovsynch program could provide an effective way to manage reproduction in goats and thus reduce the chance of conventional breeding practices.

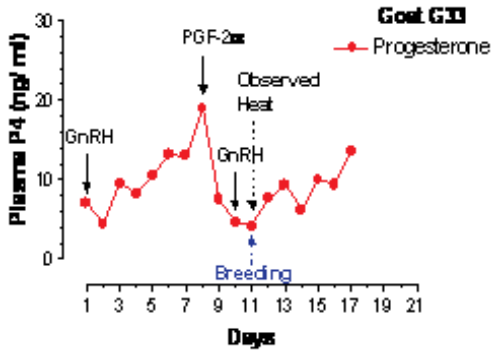


Fig 17. Plasma progesterone profiles in goat treated with ovsynch protocol

Fig 18. Buck in the Black Bengal goat flock for induction of estrus in she goats

POULTRY

Rural poultry production

A total of 6,200 nos. of healthy chicks of different varieties / lines of poultry were supplied to the farmers of different villages of Tripura under AICRP on Poultry Breeding Programme. Out of the 6,200 chicks, 2,749 chicks of Gramapriya were supplied to the farmers of Barjala (Bishalgarh), Mandavi (ARDD), NAIP (Dhalai dist.), Baghma, MogpusKurni, Jubutara, Bishramganj, Lembucherra, Sambhurampara, Khamparpara, Kobrapara and Holy Cross School, Agartala; 416

chicks of GD cross to the KVK Chebri , Kobrapara, Barkhatal and Bishalgarh; 678 chicks of DG cross to KVK Chebri and farmers of Kagamchikobra, Gandhigram, Khamparpara, Barjala, Bishramganj, Siphaipara, Damdamia, Agartala, Kamalghat, Jampai, Baganthakurpara and Lembucherra; 452 chicks of FG cross to the KVK Chebri and farmers of Baghma, Bishramganj and Matripally (Agartala). 1905 chicks of coloured broiler were also supplied to the farmers of Barjala, Baghma, Mogpuskurni and Holy Cross School, Agaratala.

Performance of Deshi black male (DM) × Gramapriya female (GF) cross

The mean performance of body weights of DG cross were measured from 2 to 20 weeks and then at 40 weeks of age in both the sexes at farm and field. The mean body weights at 20 weeks of age were: 1.635±0.011, 1.107±0.024 and 1.324±0.025 kg., respectively in male, female and overall mean at the ICAR Lembucherra farm and the corresponding body weights at KVK, Chebri farm were: 2100 g. and 1700 g., respectively in male and female and the overall mean at farmer's field was 1000 g. The mean body weights at the farm were quite high in comparison to field. The mean body weight of DG cross was similar to CARI Nirbheek and CARI Shyama variety tested at this centre. However, the higher mean body weights were observed in Gramapriya, Vanaraja and Giriraja at this centre being the cross of broiler line. The average feed consumption between 19-20 weeks of age was: 91.60 g., 93.30 g. and 92.50 g. per bird, respectively, in male, female and pooled mean. The feed consumption between 19-20 weeks of age was lowest than all the stocks evaluated at this centre being the lower body weight of the birds. The age at first egg was 145 days, 133 days and 160 days, respectively at the ICAR Lembucherra farm, KVK, Chebri farm and field level. The age at first egg is lower at the farm than field. The egg weight at 40 weeks of age was: 54.25±0.44g. The egg production upto 40 weeks of age was: 51.78 eggs at the ICAR Lembucherra farm, 42 eggs at KVK, Chebri farm and 37 eggs at field level. The egg production at 40 weeks of age was higher than other stocks evaluated at this centre except Gramapriya. The percent chick mortalitities were 0-8 wks (2.49 %), 9-20 wks (4.11 %) and 21-40 wks (3.68 %).

Performance of Gramapriya male (GM) × Deshi black female (DF) cross

The mean performance of different traits of GD cross was measured at different intervals in both the sexes. The mean body weights at 20 weeks of age were: 1.349±0.020, 1.089±0.018 and 1.214±0.017 kg., respectively in male, female and overall mean at the ICAR Lembucherra farm and the corresponding body weights at KVK, Chebri farm were: 2050 g. and 1700 g., respectively in male and female and the overall mean at farmer's field was 1100 g. The mean body weights of GD cross was comparable with CARI Nirbheek and CARI Shyama but lower than Gramapriya, Vanaraja and Giriraja. The average feed consumption between 19-20 weeks of age was: 92.50 g., 94.20 g. and 93.30 g. per bird, respectively, in male, female and pooled mean. The feed consumption between 19-20 weeks of age was lower than all the stocks evaluated at this centre being the lower body weight of the birds. The age at first egg was 152 days, 126 days and 160 days, respectively at the ICAR Lembucherra farm, KVK, Chebri farm and at farmer's field. The egg weight at 40 weeks of age was: 55.73±0.54 g. The egg production upto 40 weeks of age was: 57.11 eggs, 47 eggs and 40 eggs, respectively at the ICAR Lembucherra farm, KVK, Chebri farm and at farmer's field. The egg production at 40 weeks of age was higher than other stocks and cross evaluated at this centre except Gramapriya. The percent chick mortalitities were from 0-8 wks (3.33%), 9-20 wks (1.91 %) and 21-40 wks (2.25 %). The mortality was lower than other stocks tested at this centre.

Performance of Coloured broiler female line (FM) × Gramapriya (GF) cross

The mean performance of body weights of DG cross were measured from 2 to 20 weeks and then at 40 weeks of age in both the sexes at farm and field. The mean body weights at 20 weeks of age were: 1.748±0.062, 1.149±0.037 and 1.337±0.041 kg., respectively in male, female and overall mean at ICAR Lembucherra farm and the corresponding body weights at KVK, Chebri farm were: 3000 g. and 2100 g., respectively in male and female and the overall mean at farmer's field was 1900 g. The mean body weight of FG cross was higher than

GD Cross, DG cross, CARI Nirbheek and CARI Shyama but lower than Gramapriya, Vanaraja and Giriraja. The average feed consumption between 19-20 weeks of age was: 151.0 g., 106.0 g. and 128.0 g. per bird, respectively, in male, female and pooled mean. The feed consumption between 19-20 weeks of age was higher than the above said two crosses evaluated at this centre. The age at first egg was 167 days, 125 days and 155 days, respectively at the ICAR Lembucherra farm, KVK, Chebri farm and at farmer's field. The egg weight at 40 weeks of age was: 59.42±0.66 g. The egg production upto 40 weeks of age was: 32.73 eggs, 40 eggs and 30 eggs, at the ICAR Lembucherra farm, KVK, Chebri farm and at farmer's field. The egg production at 40 weeks of age was lower than the above said two crosses evaluated at this centre. The percent mortality from 0-8 wks, 9-20 and 21-40 weeks of age were 3.66 %, 7.60 % and 5.80%, respectively. Over all in terms of mortality and egg production, the performance of FG cross was poor than DG and GD cross. In terms of egg production, the GD cross performed better than other two crosses.

Performance of 1st generation of tripura local germplasm (Black)

Seven hundred eighty-three chicks of first generation were hatched out and brooded in the battery brooder at the farm. The average percent fertility was estimated 85.05 %. The observed percent hatchability on total egg set and fertile egg set were; 64.34 % and 75.65 %, respectively, in sire and dam lines. The mean performance of body weights from 4-20 weeks have been estimated in both the sexes. The mean body weight at 12 weeks of age were; 650.63 ± 15.06 g., 505.11 ± 8.93 g. and 546.64 ± 8.31 g., respectively in male female and pooled mean and at 20 weeks of age were; 1278.12 ± 23.31g, 1101.31± 18.47 g. and 1107.98 ± 17.81 g., respectively, in male female and pooled mean. The mean body weights at 20 weeks of age were slightly higher than the base generation. The age at first egg was 172 days, which is higher from base generation.

Performances of coloured broiler sire and dam lines

The mean body weights of coloured broiler sire and dam lines were measured at 4, 5, 6 and 8 weeks of age in both the sexes at farm. The mean body weights at 5 weeks of age were: 1029.00 ± 27.28, 962.97 ± 20.85 and 986.42 ± 16.28 g., respectively in case of male, female and pooled mean in sire line and the corresponding body weights at 5 weeks of age in case of dam line were: 853.43±24.83, 734.42 ± 16.68 and 792.16 ± 15.87 g., respectively. The mean body weights in sire line were higher in all the age groups in comparison to dam line, since the sire line was developed for higher body weights. The age at first egg was observed 146 and 147 days, respectively in sire and dam lines. The egg weight at 40 weeks of age was 64.78 ± 0.49 g. and 64.54 ± 0.57 g., respectively in sire and dam lines. The egg weight in sire and dam lines were not significantly different. The percent mortality during brooding and growing period was: 24.69 and 19.81 %, respectively in sire line and 20.41 and 10.39 %, respectively in dam line. The percent mortality was significantly higher than all the other stocks except Gramapriya Parent stock evaluated at this centre. The main cause of mortality was due to infection of lymphoid leukosis. The broiler parent lines were maintained to evolve new variety (ies) of poultry, by crossing these lines with local indigenous germplasm, which would be suitable for rural poultry production.

Genetic improvement of growth and production traits of Japanese quail in agro-climatic conditions of Tripura

Selective breeding was followed for the genetic improvement of two lines of Japanese quail viz. white and coloured quail line. The base populations were established after random mating in the parent populations. The evaluation of performance of second generation was continued. The overall mean performance of body weights of the progeny of coloured quail line at 3, 4 and 5 weeks of age were: 117.49±1.33, 153.35±1.46 and 186.38±1.62 g., respectively and the corresponding body weights in Control line were: 112.62±0.98, 144.61±1.08 and 171.27±1.39 g., respectively. Moreover, the overall mean performance of body weights of the progeny of white quail line at 3, 4 and 5 weeks of age were: 109.09±0.99, 145.84±1.14 and 177.44±1.24 g., respectively and the corresponding body weights in control line were: 102.98±1.97, 131.68±1.95 and 162.79±2.14 g., respectively. The weight gain in

coloured and white quail lines from 3-5 weeks of age were: 68.89±0.46 and 68.35±0.31 g., respectively and the corresponding weight gain in control lines were: 58.65±1.10 and 59.80±0.42 g., respectively.

NATIONAL AGRICULTURAL INNOVATION PROJECT (Component III, SRLS)

Food security through enhancement of productivity and production of rice in Dhalai of Tripura

Under this project, 378 farmers were covered under demonstrations on HYV and Package technology during 2009-10. The demonstrations recorded an average yield advantage of 31.3 per cent (732.5 kg / ha). Though the yield advantage was less in comparison to 2008-09 (which was mainly due to non availability of fertilizer), such advantage over the district average of rice productivity was highly significant and indicated the possibility of jump in rice production with adoption of proper HYV and package technology. Performance of the demonstrations is presented in Table 46 & 47.

Table 46. Performance of the demonstrations on rice in Dhalai

Variety introduced	Naveen, BPT 5204, Pusa – 44, TRC 2005-1 & TRC -87-251		
Cluster	**No. of farmers covered**	**Inputs provided**	**Area covered (ha)**
Maracherra	300 (0.16 ha each)	Seed and pesticides	48
Balaram	78 (0.16 ha each)		12.48

Mushroom cultivation

Mushroom cultivation at Balaram and Maracherra villages was introduced by giving training and demonstration. The spawn and other requisite materials were either supplied from this centre or supplied by purchasing from state Government laboratories. Eight low-cost mushroom houses were prepared in the houses of progressive

Table 47. Yield advantage of rice demonstrations at selected clusters over the district average

Cluster	Yield advanatge (%)	Yield advantage (kg/ ha)	Average over the clusters
Maracherra	39.1	915	31.3 %
Balaram	29.3	685	732.5 kg/ ha
Average productivity of rice in Dhalai :			2335 kg / ha

and interested farmers and 2 more progressive farmers were selected for shed construction. Many farmers learned the techniques and produced mushroom for the first time in their houses. The farmers earned money from selling of fresh mushroom @ Rs.80 per kg in the local markets. During the months of May and June (2008) mushroom cultivation was first introduced at Balaram and Maracherra areas of Dhalai district giving *in situ* training and demonstration at the farmers' houses. In all six SHGs (Abachanga, Khabaksha, Sharda, Pohor, Bokri Bodol and Loknath) and fifty beneficiaries were pertained training two times one each on mushroom cultivation with chemical disinfection and that with hot water treatment. The farmers successfully learned the techniques. The process of mushroom cultivation is still going on and several training programmes were organized to popularize the practice. In total 97 farmers of Balaram cultivated mushroom during the period starting from June, 2009 to January, 2010 (Table 48). They used 732 mushroom spawns (each 150g) and produced 495.8 kg of fresh mushroom. There expenditure was calculated as Rs. 8784 @ Rs. 12 for a poly bag filling. The farmers sold their produce @ Rs. 80 per kg fresh mushroom to the local markets and earned Rs. 36784, which resulted Rs. 28000 as net profit.

In Maracherra, 77 farmers cultivated mushroom during the period starting from June, 2009 to January, 2010 (Table 49). They used 710 mushroom spawns (each 150g) and produced 425 kg of fresh mushroom. There expenditure was calculated as Rs. 8520 @ Rs. 12 for a poly bag filling. The farmers sold their produce @ Rs. 80 per kg fresh mushroom to the local markets and earned Rs. 34000/-, which resulted Rs. 25480/- as net profit. Eight mushroom

Table 48. Mushroom production and profit observed in Balaram village, Dhalai

Period/Month	No. of Farmers	No. Spawn bag used (150g each)	Total expenditure (Rs.)	Production of mushroom (kg)	Amount received on selling (Rs.)	Profit (Rs.)
June-July,2009	10	80	960	52.7	4216	3256
August 2009	10	100	1200	60	4800	3600
September, 2009	8	80	960	51	5952	4080
October, 2009	20	100	1200	64	5120	3920
November, 2009	9	72	864	44.6	3568	2704
December, 2009	25	150	1800	93	7440	5640
January, 2010	15	150	1800	94.5	7560	5760
Total	97	732	8784	459.8	36784	28000

Table 49. Mushroom production and profit observed in Maracherra Village, Dhalai

Period/Month	No. of Farmers	No. Spawn bag used (150g each)	Total expenditure (Rs.)	Production of mushroom (kg)	Amount received on selling (Rs.)	Profit (Rs.)
June-July,2009	15	100	1200	60	4800	3600
August, 2009	12	120	1440	62	4960	3520
September-October, 2008	10	110	1320	64	5120	3800
November- December,08	25	200	2400	122	9760	7360
January	15	180	2160	117	9360	7200
Total	77	710	8520	425	34000	25480

sheds along with tank for substrate soaking, disinfection unit and racks for keeping mushroom beds were prepared at Balaram (Five) and Maracherra (Three). Training and demonstration on mushroom cultivation on four days at 8 locations were conducted.

Goat rearing

The aim of the study was to educate and support the farmers for better animal husbandry and management of local natural resources to improve rural livelihood and secure foods for few more days utilizing goat resource in resource limited area. The activities were undertaken on goat husbandry which was a common and traditional livelihood option in the locality. The actions included imparting trainings on state of art management, delivery of technical know-how on goat housing, making available of good female and male goats and organizing deworming-cum-treatment camps. Based on the land holdings, goat rearing patterns and other factors, 68 families in Balaram and 23 families in Murracherra were supported to construct a total of 91 goat houses using bamboo and other local materials. A total of 182 female Black Bengal goats were provided to 91 farmer men and women. The family based micro-survey indicated that a unit of two female goats could provide food security for about 45 days. Farmers showed keen interest for making goat house utilizing low-cost local materials and rearing goat with more care to fetch more income.

Eight deworming-cum-treatment camps were organized for treating 461goats including kids at different points of Balaram and Morracherra under NAIP program. A number of veterinary medicines were also given to the farmers for administering orally to the pregnant animals and weak growing animals. A total of 163 farmers participated in the program.

Backyard poultry

The day old chicks of Gramapriya procured at

the Centre were brooded upto 6 weeks of age. During the period, the chicks were fed prepared starter ration and vaccinated to control dreadly viral diseases (RD (F_1strain); IBD (MB strain); RD (R_2B). The beneficiaries were selected on 12th Nov, 2009 from Balram village of Dhalai Dist. On 13th Nov 2009, in the presence of Panchyat Samiti members, 455 chicks of Gramapriya of 6 weeks of age were distributed to 38 farmers of Balram village of Dhalai Dist. During the period, on 10th April, 2009 training on scientific poultry farming was imparted to 87 farmers of Maracherra village. Training was also imparted to 80 farmers of Balram village on 21st August, 2009. Along with training, an interaction was also held with the farmers of both the locations about their problems at field level and solutions were suggested.

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MEGHALAYA (H. Q.)

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6 कार्यकारी सारांश

मुख्यालय मेघालय और दूसरे छः केन्द्रो में वर्ष 2009–10 के दौरान हुए अनुसंधान कार्यो का संक्षिप विवरण निम्नलिखित है.

फसल उत्पादन के अन्तर्गत उपराऊँ परिस्थितियों में चावल की भौल्यूम–1 (1.86 टन/है॰) जीनोटाइपों की तुलना में आर सी पी एल 1–115 और आर सी पी एल 1–116 से क्रमशः 3.87 और 2.39 टन/है॰ पैदावार हुई जीनोटाइप आहा, एन–861, चंकी मासो , आई ओ आर ओ, मेगिलयी, कुलू फीरी, सीओ एल पी आदि जीनोटाइपों में बायोप्रोस्पेक्टिव के लिए अनुकूल हैं। पोषणिक पैरामीटरों के लिए मेघालय से चावल की 29 किस्मों का विश्लेषण किया गया जिनसे पता लगा कि इन किस्मों में क्रड प्रोटिन (सी पी) तत्व की श्रृंखला 5.24% से 13.85%तक रही और ऐमिलोज तत्व में 4.04 से 29.71% तक की विविधता पायी गई। फोस्फेट उपयोग क्षमता शाह सारंग और एनगोवा की तुलना में आर सी पी एल–1–160 में दुगनी पायी गई। फटन रोग की प्रतिरोधिता वाली एक सौ सत्ताईस प्रविष्टियां पाई गई। पाइकुलेरिया ओरिजी के वाइस्लेंस का फील्ड मौनिटरन किया गया। मक्के की सी एम एल–172 किस्म में ट्राइप्टोफान तत्व 0.76% पाया गया जो सबसे अधिक था। मक्के में अच्छी उत्पादकता अम्लीय मृदाओं में पी एम एल और चूने

(10% एल आर) के प्रयोग से ली जा सकती है। चूने के बिना जब जैविक सुधार (एफ वाई एम,) मुर्गी के मल की खाद और खरपतवार बायोमास) किए गए और उसका प्रयोग किया गया तो मृदा जल–भौतिक गुणों में काफी सुधार आया है। मक्के के जीनोटाइपों में 29 (बि एच–4062, बिस्को–111, बिस्को–555, बिस्को–855ए सि पी–838, कावेरी–25के60,एच एम–8,एच एम–9,एच एम–10,कोम पी आर–2006–1 कोम पी आर–2007–1,एफएच–3463,एफएच–3464,एफ एच–3473,एफ एच–3456,एफ एच–3458, एफ क्यू एच–38, विवेक क्यू पी एम–9 , विवेक हाइब्रिड–9, बि एच–417135, लक्ष्मी–9495, जी के–3059, पि ए सी–7745, के एम एच–3669, के एम एच सुपर–244,, बी एल –2801, एच टी सी एच–5401, एम सी एच738, बी एच– 406126 को प्रतिरोधी पाया गया। मक्के की विवेक संकर किस्म–15 में तना वेधक कीट का प्रकोप

(5.83%) सबसे कम रिकार्ड किया गया तथा स्थानीय पीले रंग की किस्म में जाला बुनने वाले कीट का प्रकोप न्यूनतम (4.13%) रहा। मटर की वी आर पी 373, वी आर पी 316,वी आर पी 281 और ई सी 881123 किस्मों के चने के रतुआ रोग और चूर्णक फफूंद की प्रतिरोधिता होती है।

थियामेथोक्सम 25% डब्लू जी 0.2 मि./ली. प्रयोग करने से मटर की फलियों में संक्रमण (10.47%) सबसे कम रिकार्ड किया गया और अरहर में फली छेदक कीट वीविल के मामले में सामान्य अवस्था की तुलना में 66.49% की कमी रिकार्ड की गई। तोरिया की आर सी टी–2 (चित्र 7) पहले की सर्वोत्तम किस्म एम–27 से बेहतर पायी गई। बिनी और एम–27 जीनोटाइपों में एफिड एवं अन्य हानिकारक कीटों का प्रकोप अपेक्षाकृत कम रहा। सोयाबीन और मूंगफली में उत्पादकता बढाने के लिए जैविक खाद व चूने के समान रूप से प्रयोग करने पर उर्वरक प्रयोग की संस्तुत मात्रा की तुलना में अधिक कारगर पाया गया। सोयाबीन के रतुवा रोग के कारण 17 से 73 % तक नुकसान हुआ। उपज क्षमता और नुकसान की दृष्टि से सोयाबीन के एम ए यू एस 417 और डी बी एम–2 जीनोटाइपों की क्रमशः अधिक उपज देने वाली और कम उपज वाले प्रतिरोधी जीनोटाइपों के रूप में पहचान की गई। चने के पौधे को परिवर्तित पौधों की विधि स्थापित करने हेतु एक ग्राफिटंग विधि का मानकीकरण किया गया। राइसबीन के लिए माइक्रोसेटेलाइट मार्कर विकसित किए गए। खासी नारंगी के मामले में सी. रेशनी के मूलवृन्त पर कलम बांधने से पौधे की लम्बाई (2.75 मी.) और मूलवृन्त का व्यास (5.73 से. मी.) अधिकतम पाया गया। स्कैब रोग के लिए बैविस्टीन के 2 ग्रा./लीटर में छिड़काव करने से 93% तक सफलता मिली है। स्कैब रोग को समाप्त करने के लिए एक व्यावसायिक दवा ट्रिचोडर्मा विरिड (निसर्ग) के प्रयोग से रोगों में 61.11 % कमी आयी है। मेघालय, असम के तिनसुकिया और अरूणाचल प्रदेश के लोहित जिलों में नींबू वर्गीय फलों में फाइटो फतोरा रोगों को देखने हेतु सरकारी और प्रगतिशील किसानों के बागों में एक सर्वेक्षण किया गया। नींबू वर्गीय फलों की पत्ती कुतरने वाले कीट के मामले में पौधे में मिडेक्लोपिड (0.075 %) का प्रयोग करने से लार्वाओं की संख्या सबसे कम रिकार्ड की गई।

बानस्पतिक विधियों में करंजिन (2%) के प्रयोग से सबसे कम लार्वा रिकार्ड किए गए।खुले और पोलिहाउस स्थितियों में कलमी पौधों में अधिकतम सफलता (80%) रिकार्ड की गई जब नेट हाउस में वेज ग्राफिटंग और प्रयोग में लिए जा रहे फल सोहिओंग फल में भौतिक और जैव रासायनिक अध्ययन किए गये। सुपारी की समस्याओं को देखने के लिए मेघालय के सात जिलों में सर्वेक्षण किया गया। सुपारी के तने का लाल वीविल कीट का प्रकोप पहली बार रिकार्ड किया गया। चेरी टमाटर में सर्वाधिक उपज प्रति पौधा (2.49 कि. ग्रा.) रिकार्ड की गई। नेट हाउस स्थिति में मेधा–10 टमाटर में प्रति पौधा (1.9 कि. ग्रा.) उपज रिकार्ड की गई। जल्दी फटन रोग की प्रतिरोधी किस्मों बी टी–1 और ढम टी–1 तथा टी ओ–017 व रॉकी किस्में उत्तम पायी गई। मेघालय से स्थानीय पत्ते वाली सब्जियॉ का संकलन किया गया । कोसो केसिया की सफेद गौरियो से सर्वाधिक उपज(52.00 टन/है॰) रिकार्ड की गई। शकरकन्दी की स्थानीय किस्म कोकराझार से कुलकन्द उपज (294.10 कि. ग्रा./है॰) रिकार्ड की गई।

बन्ध गोभी के मक्खी कीट के नियंत्रण के लिए करांजिन(0.2%) को सबसे कारगर पाया गया। बीज में थिमामेथोक्सम 25 प्रतिशत डब्लू जी का प्रयोग कारगर रहा जिससे अंकुरण के बाद 35 दिनों तक चूसक कीटों से पूरा संरक्षण किया जा सका। भिंडी के कीटों के नियंत्रण में बैक्टेरिया बैसिनिया को (68.63% कमी लाने में) सबसे कारगर पाया गया।

मसाला अनुसंधान में अदरक की नाडिया किस्म से सर्वाधिक उपज (28.50टन/है॰) रिकार्ड की गई। मेघाहल्दी–1 में सर्वाधिक उपज (25.33टन–है॰) प्राप्त की गई और उसके बाद लकाडौंग (20.00 टन/है॰) से प्राप्त हुई। गर्बेरा की लिओन किस्म से प्रति मी^{2} क्षेत्र (15.7 से.) में प्रति पौधा अधिकतम फूलों की उपज प्राप्त हुई।

अदरक को लम्बी दूरी तक ले जाने में सुरक्षित रखने हेतु पैकेजिंग विधि विकसित की गई। सोहिओंग और पैशन फल की मदिरा सोओंग जैम और चाचो से टूटी फूटी को प्रयोग में लाने के नयाचार बनाए गये।

फसल प्रणाली अनुसंधान में कुल प्रणाली उत्पादकता मूंगफली व शिमला मिर्च (159.42 कि./है॰) सर्वाधिक रही। अदरक में हरी खाद के प्रयोग से अच्छी उपज (11.1 टन/है॰) प्राप्त हुई और हल्दी (15.9 टन/है॰) की सामान्य अवस्था अर्थात बन की खेती प्रणाली की तुलना में अच्छी उपज रही।विभिन्न कृषि प्रणालियों के अन्तर्गत खाद्य व चारा फसलें उगाई गई और उनकी उत्पादकता एवं अर्थशास्त्र का अध्ययन किया गया। पूरे साल कृषि औजारों और उपकरणों को निर्मित करके उनकी बिक्री की गई। इस प्रकार बारह अलग–अलग तरह के औजार बनाए गए और उन्हे बेचा गया।

शूकर उत्पादन में लिंग सम्बंधी भी समस्या के लिए प्रद्योगिकी उपयोग और धारणा सम्बंधी अध्ययन किए गए। इसमे उपयोग की दर 50.5% रही । शूकर उत्पादन प्रोद्योगिकी की प्रयोग विधि तैयार की गई। खरीफ की फसल में नमी तत्वों का अध्ययन किया गया तो उनमे 31.08 और 32.85 % (डब्लू डब्लू) 31.45 से 34.25 प्रतिशत की विविधता पाइ गई और पारम्परिक व प्रचलित जुताई से फसल कटाई में 24.67% से 22.15% तथा 30.35% से 27.38% तक विविधता रही। रतनजोत की खेती के लिए तेरह क्षेत्रों का मूल्यांकन किया गया।पूर्वोत्तर भारत के सात राज्यों में मांस व मुर्गियों की आवश्यकता पर वर्ष 2010,2015,2020 तथा 2025 के आधार पर कार्य किया

गया तो पाया गया कि यह क्रमशः 505.75,560.89,623.21 तथा 693.89 हजार टन तक होगी।

पशु विज्ञान अनुसंधान में बोर वीर्य के परिरक्षण सम्बंधी अध्ययन से पता लगा कि 18^0से. पर रखने से उसमे ऐक्रोसोम प्रतिक्रिया हो जाती है और ऐक्रोसोमल समेकन में कमी आ जाती है। इसके अतिरिक्त 72 घन्टे तक 18^0से. पर बी टी सी में संरक्षित करने पर द्रव बोर वीर्य की उर्वरता में कमी आ जाती है। इसकी प्रौद्यौगिकी कई गावों में युवाओं को समझाई गई। मेघालय के डेरी पशुओं में प्रजनन सम्बंधी विकारो को रिकार्ड किया गया।

पशु स्वास्थ के मामले में इस क्षेत्र मे रोग प्रकोपों की निगरानी, मोनिटरन और जांच की गई। पशु परजीवी विज्ञान अनुसंधान में बकरियों के नमूनो मे स्ट्रौंगाइल प्रजाति (53.03%) आदि में जांच की गई। पशु पोषण में जुगाली वाले पशुओं और शूकरो के लिए घास का फलीचारा, पाचक कूड प्रोटीन और पाचक उर्जा के मामलो में सुधार किया गया।अरूणाचल प्रदेश केन्द्र में पडल स्थिति के अन्तर्गत वी एल–61 किस्म के धान की अधिकतम पैदावार रिकार्ड की गई। आर्द्र भूमि में चावल– मटर की अन्त: फसल पोषण तत्वों के जैविक स्रोत के अन्तर्गत चावल की खेती के लिए प्रयास किए गए । लुइट और टेफ्रोसिया (42.5 कि./है•)– मटर की हरी फलियों टी आर सी पी 8 (23.3 क्विं/है•) के हिसाब से अधिकतम अनाज उपज रिकार्ड की गई। खासी नारंगी की फसल में काले पोलिथिन से ढककर1.0 ई पैन पर ड्रिप सिचाई की गई तो बेहतर पैदावार रिकार्ड की गई।

मिजोरम में उपराऊं चावल की आर सी पी एल –1–101 2.33 टन/है. और आर सी पी एल 96 किस्मों से अच्छी उपज मिली है। निचली भूमि वाले चावल की यू पी एल 15 से सबसे अच्छी पैदावार हुई है। मक्के की विवके क्यू पी एम –9, विवेक एच वाई बी 31 में भी बहुत अच्छी उपज मिली। मूंगफली की आइ सी जी एस–76 में कोलेमैनाइट का 2 कि./है. के हिसाब से छिडकाव करने पर उपज बहुत अच्छी रही।

पादप संरक्षण अनुसंधान में चावल, मक्के, फलों और सब्जियों के कीटों की संख्या गतिकी सम्बंधी अध्ययन किए गए। अमरूद में फल मक्खी का प्रकोप अधिक मिला।

सिक्किम में मक्के की विवेक संकल मक्का–11 किस्म से **मृदा** अम्लीयता प्रबंधन के लिए डोलोमाइट के साथ जैविक पोषण देने से 1600 से 4,450 कि.ग्रा./है. तक उपज रिकार्ड की गई।सोयबीन– सरसों के चक्रण में सोयाबीन की पी के 10224 किस्म से 3240 कि. ग्रा./ है. उपज प्राप्त हुई यदि उसमे नीम खली और मिश्र कम्पोस्ट का समुचित उपयोग किया जाए। धान की पन्त धान–10, वी एल धान–61 और पूसा सुगध–2 एवं स्थानीय अद्रटे से जैविक स्थितियों के अन्तर्गत अच्छी उपज रिकार्ड की गई।

मणिपुर केन्द्र में चावल की एक नई किस्म आर सी एम–21 की पहचान की गई और उसे इस घाटी के लिए तथा मेघालय व मणिपुर के सीढ़ीनुमा खेती के लिए संस्तुत किया गया। आर सी एम– 21 से मुख्य उपज 5680 कि. ग्रा./है. रिकार्ड की गई। 6 नए संवर्धन भी विकसित किए गए। अरहर में अन्तर्विशिष्ट संकरण विधियों का मूल्यांकन व संवर्धन किया गया।

नागालैंड मे 12 वर्ष के मौसम के आंकड़े वार्षिक और मासिक वर्षा के वितरण को लेकर विश्लेषण किया गया तथा उसकी क्षमता सम्बंधी ई टी से पता लगा कि इन वर्षो में वर्षा का **रुझान** घटता रहा है। मौन जिले के लैम्पौंग शीघाह गांव में पानी की कमी का मानचित्रण धरेलू सर्वेक्षण के आधार पर तैयार किया गया जिसमे यह पता लगा कि सभी घरों में पानी की बहुत बड्डी समस्या है। पोषक तत्वों के जैविक और अजैविक स्रोतों के उचित समायोजन से आर सी एम–9 और मक्के की विजया कम्पोजिट किस्म से पैदावार बढ़ी है। सुगन्धित चावल की जिन किस्मो की जांच की गई, उनमे आई ई टी–16313 सर्वाधिक उपज रिकार्ड की गई है। मूंगफली में एम ई एस ई जी–10 से 3.04 टन/है. की अधिकतम पैदावार रिकार्ड की गई। तोरिया और सरसों की किस्म परीक्षण में पाया गया कि पी टी–303 से अधिकतम पैदावार मिली।

न्यूक्लियस/मूल बीज उत्पादन कार्यक्रम के अंतर्गत असम नीबु की दस हजार कटिंग, खासी नारंगी के 5000 पौधे , कच्चे नीबू के 1000 पौधे,, काली मिर्च की 5000 कटिंग तथा 50 कि. ग्रा. फ्रेंच बीन के बीजों का उत्पादन किया गया। रतनजोत की मौल्वम प्रोविनेंस में पौधे की सबसे अधिक लम्बाई 2.55 मी. रही । रतनजोत के प्लाटों मे मूंगफली, तिल, हरा चना और धान की अन्त: फसल अनुकूल नही पायी गई। 43.5 है. भूमि जो बंजर पडी हुई थी, उसे **कृषि** वानिकी की स्थापना करके फिर उपयोग में लाया गया। शूकरों के काले और धुंधरू नस्लों पर उनकी **वृद्धि** दर के लिए अध्ययन किया गया। सल्मोनेला कोलेरैसूट के प्रति ह्यूमोरल इम्यून प्रतिक्रिया पर इसका ज्यादा प्रभाव नही देखा गया। औखुनी के सूक्ष्मजीव विज्ञान सम्बंधी विश्लेषण भी किए गए।

त्रिपुरा केन्द्र में चावल की टी.आर. सी 2005–3 को ए.वी. टी 1 में प्रोन्नत किया गया। उपज सम्बंधी परीक्षणों में सिंचित स्थिति के अन्तर्गत आई. ई. टी. प्रविष्टि संख्या 21531 में सर्वाधिक अनाज उपज (8394कि.ग्रा./हैक्टर) रिकार्ड किया गया। आई.आर.आर. आई –इंडिया उपराऊं शटल प्रजनन नेटवर्क परियोजना की प्रविष्टि संख्या आर.आर. 509– 6– बी –2 से सर्वाधिक अन्न उपज (3988.5 कि.ग्रा./हैक्टर) रिकार्ड की गई। आई.आर 82589– बी– बी –2–2 से 2610कि.ग्रा./ हैक्टर की उपज ओ.वाई.टी (स्ट्रेस) परीक्षणो के अन्तर्गत रिकार्ड किया गया। सीथ ब्लाइट रोग के लिए अल्प संवेदनशील जीनोटाइपों की पहचान की गई। पीस्यूडोमोनास फ्लोरेसेन्स से सीथ ब्लाइट का नियंत्रण किया गया जिससे उपज में वृद्धि हुई। त्रिपुरा के महामहिम राज्यपाल डा. डी. वाई पाटिल के कर कमलों से मटर की क्षेत्र जीनोटाइप टी.आर. सी.पी 8 को जारी किया गया। मूंगफली की जी– जी –13 किस्मों से फलियों का उत्पादन सर्वाधिक –2.88 टन/है. रहा । एफ ई ई एस जी –10 और एफ ई ई–8 जैसी किस्मों में पत्ती के धब्बा रोग का प्रकोप अधिक दिखाई दिया (रोग की दर 6.33– 6.70) यद्यपि एफ ई ई एस जी –10 को रतुवा प्रतिरोधी पाया गया । टमाटर की त्रिशूल और ऑल राउन्डर किस्में पतमोड रोग का प्रतिरोधी पाया गया।

कृषि वानिकी में जंगली वृक्षों की प्रजातिया के अन्तर्गत बहुत सी फसलों को उगाया गया और उनकी उत्पादकता का अध्ययन किया गया ।

पशु विज्ञान अनुसंधान में ब्लैक बंगाल बकरियों में उनके बच्चों के आकार में विविधता संबंधी फेनोटाइपिक विशिष्टीकरण किया गया माली शूकरों में उत्पादक एवं प्रजनन संबंधी परीक्षणों पर विस्तृत अध्ययन किया गया। मुर्गी पालन में अ.भा.स. मुर्गी पालन कार्यक्रम अनुसंधान परियोजना के अर्न्तगत किसानों को 6200 चूजों की आपूर्ति की गई हैं। ग्रामप्रिया x देशी ब्लैक के संकरण संबंधी प्रगति एवं त्रिपुरा की स्थानीय मुर्गियों की प्रथम पीढ़ी संबंधी जननद्रव्य की प्रगति पर अध्ययन किये गये।

जापानी **'क्वैल'** की वृद्धि एवं उत्पादन संबंधी अनुवांशिक सुधार पर अध्ययन किये गये।

बलराम और मराचेरा गांव में खुम्भी उत्पादन पर किसानों को प्रशिक्षण दिया गया और प्रदर्शन किये गये। वौलवेरेला वौल्वैसिया प्रजातियों का मूल्यांकन किया गया।