वार्षिक प्रतिवेदन
ANNUAL REPORT 2012-13

भाकृअनुप
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पूर्वी क्षेत्र के लिए भा.कृ.अनु.प. का अनुसंधान परिसर
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ICAR Research Complex for Eastern Region
ICAR Parisar, P.O. : Bihar Veterinary College
Patna-800 014

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PREFACE

It gives me immense pleasure to bring out twelfth Annual Report of ICAR Research Complex for Eastern Region, Patna. The institute undertakes multi-commodity and multi-disciplinary research to enhance the productivity of agricultural production systems in diverse agro-climatic zones of Eastern States.

For achieving the goal of food and nutritional security along with water conservation, emphasis was given on conservation agriculture, rainwater harvesting, water productivity, ground water recharge, rehabilitation of waterlogged areas, restoration of degraded lands and cropping patterns. Models of integrated farming systems have been developed for rainfed, irrigated and waterlogged situations. These models have been found ecologically and economically viable. Development of climate resilient farming system models is yet another priority of the institute since simulation studies have indicated significant decline in yield of wheat and rice and an increase in *Rabi* maize in future time periods. Under climate change scenario, studies on host-pest interaction and its dynamics in mango have been studied in different states viz., Jharkhand, Karnataka, Uttar Pradesh, Gujarat, Maharashtra and Andhra Pradesh.

In the field of agro-diversity conservation, 13 underutilized beans, 9 leafy vegetables, 8 local germplasm lines of wild edible mushroom and 26 germplasm of makhana have been collected, evaluated and characterized.

During the period under report, promising genotypes of different fruits like mango, litchi, bael, sapota have been identified. Among vegetables, promising crosses/lines of chilli, cucumber, bottle gourd, capsicum, dolichus bean, vegetable soyabean, tomato, pea, brinjal, pumpkin, long melon, cowpea, rice bean, faba bean, yam bean, lima bean, mung bean have been identified for release as a variety in future. Rice genotypes for drought stress and advance breeding genotypes of wheat for rainfed lowland ecosystem have also been evaluated. Further, 30 kg of vegetable breeder seed, 3.32 t truthfully levelled seed, 74000 nos. of quality planting material of various fruits and vegetables, 5.5 q of mushroom spawn and 7.05 q of makhana have been produced. Makhana cultivation has also been introduced in Assam, Chhattisgarh, Odisha and Eastern UP during the period under report.

Breeding technique of ornamental fishes has been standardized. Different feeding experiments on pig, poultry, goat and cow have been conducted during this period. Murrah breed of buffalo is being reared at the Institute level so as to improve the local buffalo through artificial insemination. In case of post harvest and value addition, dry instant soup mix formulation of mushroom was developed besides drying of unripe jackfruit.

A total of 158 training programs, 25 Front Line Demonstrations, 6 On Farm Trials have been conducted for the farmers and the state government officials. The Institute also organized ICAR Zonal Sport Meet, XXI ICAR Regional Committee Meeting (Zone IV), Agri-Expo 2012, and Regional Farmers' Fair at Patna and Ranchi. During the period under report, the Institute published 81 nos. of research papers in the journal of national and international repute, 8 books, 18 book chapters, 2 training manuals, 8 technical bulletins and 1 extension bulletin.

I acknowledge the consistent support, keen interest and guidance received from Dr. S. Ayyappan, Secy. DARE and Director- General, ICAR in order to plan and implement various research and extension activities. The encouragement, valuable guidance and support rendered by Dr. A. K.Singh, Ex-DDG (NRM), Dr. M. M. Pandey, Ex-DDG Incharge (NRM) and Dr. A. K. Sikka, DDG (NRM) is duly acknowledged. Thanks are also due to Dr. B. Mohan Kumar, ADG (Agronomy & Agroforestry), ICAR for his support and cooperation from time to time. All Heads of the Divisions/Research Centres deserve appreciation for submitting their research findings in time. The editorial assistance rendered by R. D. Singh, A. Dey, Shivani, Ujjwal Kumar and A. Abdul Haris, and secretarial assistance by Sarfaraj Ahmad in bringing out the report is also appreciated.

(B.P.Bhatt)
Director, ICAR-RCER

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Executive Summary

- Simulation studies were conducted to assess climate change impact on streamflow in the Bhavani river basin. Under A2 emission scenarios, the changes in low flow (Q95) varied in the range of -17.70 to 7.00%, -28.40 to 36.40%, and -24.30 to 89.30% during 2020s, 2050s, and 2080s, respectively. For B2 emission scenarios, the changes in low flow (Q95) were lesser as compared to that of the A2 emission scenarios.
- Analysis of rainfall trend for different districts of Bihar showed decreasing trend in rainfall in most of the districts for the period 1950-2000.
- Fourteen rice genotypes were grown under stress (submergence) and non-stress (control) condition and agro-morphological and physiological characters related to submergence stress tolerance were recorded and analyzed. F_4 seeds were collected for further characterization for submergence and drought stress tolerance.
- Fifty one rice genotypes along with national and local check varieties were evaluated for drought stress at reproductive stage while twenty nine advance breeding genotypes of wheat were evaluated for rainfed lowland ecosystem.
- The potential rice straw loss due to field burning was estimated to be 5.2, 3.38 and 1.25 t/ha due to complete burning, harvesting at 35 and 25 cm, respectively.
- Studies on transplanted maize indicated that transplanting 5 week old maize seedlings on Broad Bed and Furrow (BBF) and fertilized at transplanting + early tasseling + silking, resulted in maximum grain yield and returns (₹ 48,346/ha) with saving of two irrigations.
- Among the 89 mango genotypes characterized, ICARRCERMS-1 was found to be most promising genotype based on fruit qualities. Among the 25 mango hybrids evaluated, Jawahar was found to be most promising for hill and plateau region.
- Slower growth of mango cultivar Langra was recorded in case of double grafted plants with Amrapali as interstock than that recorded in case of single grafted plants of cv. Langra.
- Studies on host-pest interactions and dynamics in mango under climate change scenarios exhibited shift in the date of incidence of powdery mildew, mango hopper and shift in species of mango hopper. RTPS data on insect pests and diseases of mango have been recorded from 120 mango orchards in Jharkhand, Karnataka, Lucknow, Gujarat, Maharastra and Andhra Pradesh.
- The performance of Rose scented in litchi, Pant Aparna in bael, ICAR-RCER RC 2/10 genotype in jackfruit, Murrabba genotype in sapota, lines HACAV-271-7-8-9 and HACAV-845-3-1-18 in capsicum, line HADB-119 in dolichus bean, basmatic line AGS-447, AGS-458 and AGS-456 in vegetable soyabean have been found promising. Among the other vegetables, promising crosses of chilli, cucumber, bottle gourd and promising lines of pumpkin, long melon, cowpea, rice bean, faba bean, yam bean, lima bean, mung bean have been identified.
- In pea, two early maturing, powdery mildew resistant progenies have been selected. In case of brinjal, an understanding of gene action of bacterial wilt has been developed. In tomato, crosses have been developed for resistance against bacterial wilt and root knot nematode.
- Under the study on biology and management of stink bug of litchi, four egg parasitoids of litchi stink bug have been isolated. Out of which only two were identified as *Anastatus bangalorensis* and *Anastatus acherontia.*
- Under varietal development of faba bean (*Vicia faba* L.), both the promising lines having yield potential (>5.0 t/ha) have been evaluated under multilocation trials at 8 locations covering Eastern Uttar Pradesh, Bihar and Jharkhand. Both the lines out yielded over National check viz., Pusa Sumeet and Vikrant. Under irrigated conditions, line 2011215 produced 5.38 t/ha seed whereas under rainfed condition it produced 3.94 t/ha.
- Germplasm of makhana were collected from 14 sites of Purnea and Kishanganj districts and 2 from Odisha. Through pure line selection first elite strain (Sel-6) of makhana was developed. On the basis of yield potential, strain (Sel-6) has been identified

most promising with seed yield of 3.09 t/ha against 1.68 t/ha local check at the farmer's fields.

- On the basis of available moisture content in the vegetative tissues of the makhana plant, it has been recorded that it adds biomass @ 6.4 to 8.9 t/ha (DW basis) along with N, P, and K in the range of 11.5-16.0, 9.6-13.44, and 12.0-17.0 kg/ha, respectively, to the soil mass.
- Among rice based diversified cropping systems, there was significant variation among cropping systems, levels of irrigation, nutrients and its interaction. Rice-tomato-bottle gourd, rice-coriander-lady's finger and rice-cabbage-cowpea have been found as the most promising cropping systems in Bihar.
- In rice-wheat based cropping system, zero tillage (ZT) was more productive, water use efficient and economical than conventional tillage. Intensification of rice-wheat system by rice-wheat-cowpea with CA practices (Zero tillage + 30 % residue retention + SSNM) and diversification by rice-maize+potato-cowpea with CA practices (ZT in rice & cowpea + residue retention + SSNM) have increased system productivity from 9.44 t/ha in rice-wheat to 13.32 and 21.47 t/ha, respectively.
- Integration of different components like Cereals + Horti. + Fish + Dairy + Duckery under 2 acre IFS model fetched a net return of ₹ 2,02,874/annum, i.e., ₹ 556/day.
- Under 1 acre IFS model Cereals + Horti. + Goat + Poultry + Mushroom integration fetched a net return of ₹ 1,42,708/annum, i.e., ₹ 391/day.
- In vegetable based integrated farming system, integration of Cereals + Vegetables+ Goat under one acre area fetched ₹ 96255/annum as net return in irrigated upland condition.
- Water use efficiency and water productivity (kg/m^3) of rice was studied following applications of different irrigation methods. Irrigation water use efficiency was observed higher in micro sprinkler irrigation system (1.05) followed by LEWA (1.01) and check basin irrigation (0.82). Similarly, water productivity was (kg/m^3) also observed higher in sprinkler (6.26) followed by LEWA (3.90) and check basin method (2.66).
- The water output of 170 m^3/day in April and 104 m^3/day in December on a cloud free day was recorded through solar energy ground water pumping unit at latitude of 25.65^{O}N (Patna)
- Rice polish can be fed up to 50 % in the mixed feed with supplementation of 20 g phytase (one lac unit) per 100 kg feed to finisher pig for maximum growth performance. However, resource poor farmers can feed rice polish up to 70% with supplementation of 20 g phytase enzyme per 100 kg feed for acceptable growth performance.
- Supplementation of phytase enzyme in the diets of backyard poultry can improve daily gain by 18.38% and feed efficiency by 15.12%.
- Cultivation of leguminous fodder like soybean (15.67 t/ha), rice bean (33.00 t/ha) and cowpea (37.33 t/ ha) in fodder production system was found beneficial in respect of biomass and nutrients yield for feeding of livestock.
- Compared to separate feeding system, Total Mixed Ration (TMR) was found beneficial in dairy cows in respect of milk production (4%), total feed intake (17.8%) and protein digestibility (10%).
- Compared to feeding of oat fodder alone, mixed feeding of oat and berseem improved dry matter intake (32.30%) and digestibility of dry matter (7.50%) and protein (19.50%) in goat.
- The average daily gain in New Zealand White and Soviet Chinchilla rabbits were recorded 17.55 ± 0.19 g and 17.87 ± 0.56 g, respectively.
- SSCP typing in Black Bengal goat revealed five genotypes AA, AB, AC, BB and BC and three alleles A, B and C of growth hormone gene.
- The fish productivity of 5.46 t/ha/yr was achieved in livestock-fish culture without supplementation of feed to fish.
- The dry instant mushroom soup mix was formulated by mixing mushroom powder (20%) tomato powder (20%), wheat flour (35%), milk powder (10%), corn starch (10%), onion and garlic powder (1%) and dried cabbage and carrot (4%).
- Pedal operated makhana seed grader was developed with 4 types of sieves.
- During the period under report, 30 kg of vegetable breeder seed, 3.32 t truthfully levelled seed, 5.5 q of mushroom spawn, 7.05 q of makhana and 74 thousand nos. of quality planting materials of various fruits and vegetables were produced.
- The cultivation of HYVs of tomato (S. Lalima) and brinjal (S. shyamali), and that of oyster mushroom with spawn from ICAR RCAR Ranchi Centre in villages of Ranchi was found to be farm income and employment augmenting. However, there were a few constraints to adoption of these technologies, the most prominent among them being lack of farm labour, irrigation water and capital.
- During the year under report, a total of 158 training programs, 25 Front Line Demonstrations, 6 On Farm Trials have been conducted for the farmers and the state government officials. The institute also organized ICAR Zonal Sport Meet, XXI ICAR Regional Committee Meeting (Zone IV), Agri-Expo 2012 and regional farmers' fair at Patna and Ranchi.

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INTRODUCTION

Historical Perspective

The eastern region comprises of plains of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha and West Bengal, representing 21.85% of the geographical area of the country and supporting 33.64% of country's population. Though the region is endowed with rich natural resources to support higher agricultural production including livestock and fisheries, the production levels have remained low due mainly to lack of location-specific production technologies, dissemination of scientific knowledge to farmers, fragmented land holdings, low seed replacement rate, large population of non-descript type of livestock, poverty, lack of infrastructure facilities, natural calamities e.g. frequent floods and droughts, water logging and social conflicts. Nevertheless, the region has vast untapped potential to enhance the production. Keeping this fact in view, planning priorities has also been set up to achieve the food self sufficiency at national level from eastern region under **Look East Policy** of Govt. of India.

ICAR Research Complex for Eastern Region (ICAR-RCER), Patna came into existence on the 22nd February 2001 so as to address diverse issues relating to land and water resources management, crop husbandry, horticulture, agroforestry, aquatic crops, fishery, livestock and poultry, agro-processing and socio-economic aspects in holistic manner for enhancing research capability and providing a backstopping for improvement in agricultural productivity and sustainability. Hence, the mandate of the institute is "to undertake strategic and adaptive research for efficient integrated management of natural resources so as to enhance productivity of agricultural production systems comprising of field, agricultural and horticultural crops, aquatic crops, agroforestry, livestock, avian, and fisheries in different agro-ecological zones of the eastern region". The modalities to achieve the mandate are:

- To facilitate and promote coordination and dissemination of appropriate agricultural technologies through network/consortia approach involving ICAR institutes, State Agricultural Universities, and other agencies for generating location-specific agricultural production technologies through sustainable use of natural resources.
- To provide scientific leadership and to act as a center for vocational as well as advanced training to promote agricultural production technologies.
- To act as repository of available information and its dissemination on all aspects of agricultural production systems.
- To collaborate with relevant national and international agencies in liaison with state and central government departments for technology dissemination.
- To provide need based consultancy and advisory support for promoting agriculture, horticulture and livestock in the region.
- Socio-economic evaluation and impact assessment of agricultural technologies.

The complex has four divisions besides two research centres and one KVK. The organizational setup of the complex is given in Fig. 1.

Finance

Summary of allocation and expenditure during the financial year 2012-2013 of the complex is presented below (Table 1).

Table 1. Financial allocation and expenditure during the year 2012-13 (₹ in Lakhs)

Head of accounts	Budget allocation		Actual expenditure	
	Plan	Non-plan	Plan	Non-plan
Establishment charges	0	1374.30	0	1374.10
T.A.	21.69	8.00	21.69	8.00
HRD	1.21	0	1.21	0
Works	202.89	752.70	202.87	726.80
Other charges	264.21	0	264.20	0
Total	490.00	2135.00	489.97	2108.90

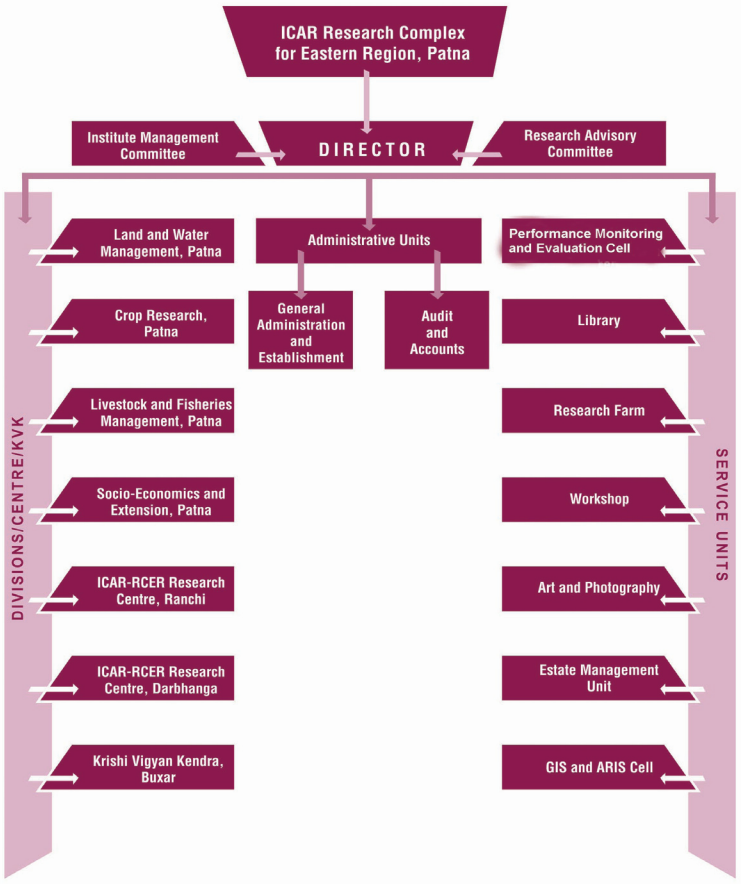

Fig. 1. Organogram of ICAR Research Complex for Eastern Region, Patna.

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WEATHER

Agro-meteorological Observation

Agro-meteorology observatory was established at Patna in June, 2012. Both manual as well as automatic data recording system is available in observatory. A state of art Automatic Weather Station (AWS) was established in observatory with different sensors like temperature, humidity, rainfall, wind speed, wind direction, solar radiation, soil temperature and leaf wetness. Weather parameters were recorded in hourly interval in AWS (Fig. 2).

Fig. 2. Agro-meteorology observatory

Manually different weather parameters were also recorded. Different instruments like thermometers for maximum, minimum, dry bulb & wet bulb temperatures, anemometer and wind vane for wind speed & direction, open pan evaporimeter for evaporation, rain gauge for rainfall, soil thermometer for soil temperature were also installed.

Table 2. Monthly meteorological data of Patna 2012

Month	Temperature (°C)				Average relative humidity (%)	Average sunshine (hrs / day)	Total rainfall (mm)		Rainy days
	Max.	Normal	Min.	Normal			Observed	Normal	
Jan	21.7	23.0	6.5	9.3	70.6	5.4	0.0	20.4	1
Feb.	25.3	26.1	11.3	11.6	61.3	7.2	12.2	11.1	1
Mar.	33.7	32.4	17.5	16.4	46.5	7.8	12.3	11.4	2
Apr	36.7	37.4	21.2	22.1	45.2	7.6	13.0	9.0	1
May	37.2	38.4	24.9	25.1	51.4	7.2	24.5	35.6	2
June	34.2	36.7	25.6	26.7	64.2	6.2	57.8	141.0	4
July	31.5	32.9	27.2	26.1	72.2	5.9	102.6	319.0	3
Aug	32.2	32.5	29.6	26.1	83.9	5.2	380.2	279.3	6
Sep.	31.6	32.2	26.5	25.3	82.7	5.1	345.8	212.6	5
Oct.	30.9	31.7	21.4	21.6	72.8	6.7	59.4	72.3	1
Nov.	27.5	28.9	14.6	14.8	67.1	7.1	0.0	8.2	0
Dec.	21.1	24.6	16.1	10.1	72.7	5.9	0.0	7.4	0
Annual	30.3	31.4	20.2	19.6	65.9	6.4	995.5	1127.3	26

Mean maximum temperature varied from 37.2°C in May to 21.1°C in December, and mean minimum temperature ranged from 29.6°C in August to 6.5°C in January (Table 2). Maximum sunshine hours was recorded in the month of March (7.8 hrs) whereas minimum was in the month of September (5.1 hrs). Lower maximum temparature was recorded in all the months except March, which recorded higher temparature than normal (Fig. 3). The trend was different for minimum temparature. Higher minimum temparature than normal

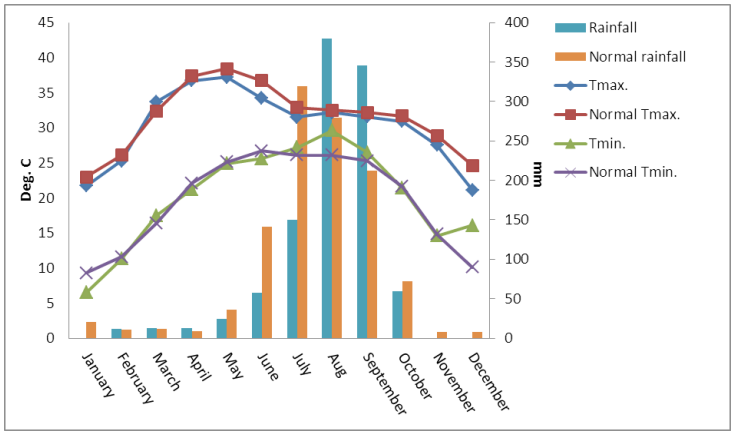


Fig. 3. Monthly variation of temperature and rainfall during 2012 at ICAR RCER, Patna

was recorded in Janauary, April, May, June, July, August and September and lower minimum temparature was recorded in February, March, October, November and December.

The total annual precipation recorded was 955.5 mm which is slightly below than normal rainfall for Patna. Precipitation recorded in the monsoon season was very irretic. May, June and July month received lower rainfall than normal. Whereas August (380.2 mm) and September 345.8 mm) received more rainfall than normal (279.3 and 212.6 mm), respectively.

Mean monthly maximum temperature varied from 38.1°C (in May) to 24.9.0°C (in December) at Ranchi (Table 3). Similarly, mean monthly minimum temperature ranged from 26.7°C (in June) to 9.4°C (in December). Relative humidity was maximum in July (91%) and minimum in December (83.8%). Total annual precipitation was recorded 1597.9 mm which is normal for the region. Ranchi also received almost 40% less rainfall in July, whereas June (442.0 mm) and August (504.4) had almost double rainfall than normal (Fig. 4).

Table 3. Monthly meteorological data recorded at ICAR RCER Research Centre, Ranchi

Month	Temperature (°C)				Average Relative Humidity (%)	Total Rainfall (mm)		Rain days
	Maximum	Normal	Minimum	Normal		Observed	Normal	
January	22.2	23.0	10.3	10.0	87.5	32.0	20.5	4
February	25.8	25.8	12.3	12.6	85.7	0.0	25.7	-
March	32.7	31.2	15.9	17	81.0	9.0	18.9	1
April	36.5	35.5	21.9	21.4	81.8	44.2	41.2	4
May	38.1	37.2	24	23.6	82.3	2.0	58.5	1
June	35.8	33.5	26.7	23.7	88.4	137.0	216.3	7
July	30.3	29.3	25.1	22.7	91.7	230.4	337.9	15
Aug	28.8	28.8	23.8	22.5	91.4	336.0	326.8	21
September	29.2	29.1	22.9	21.8	89.7	346.0	273.2	17
October	29.4	28.5	19.1	19.0	90.3	96.0	99.7	4
November	25.4	25.9	12.6	14.0	84.5	26.6	16.0	5
December	24.9	23.2	9.4	10.2	70.4	0.0	6.1	-
Annual	29.9	29.3	18.7	18.2	85.4	1259.2	1440.8	79

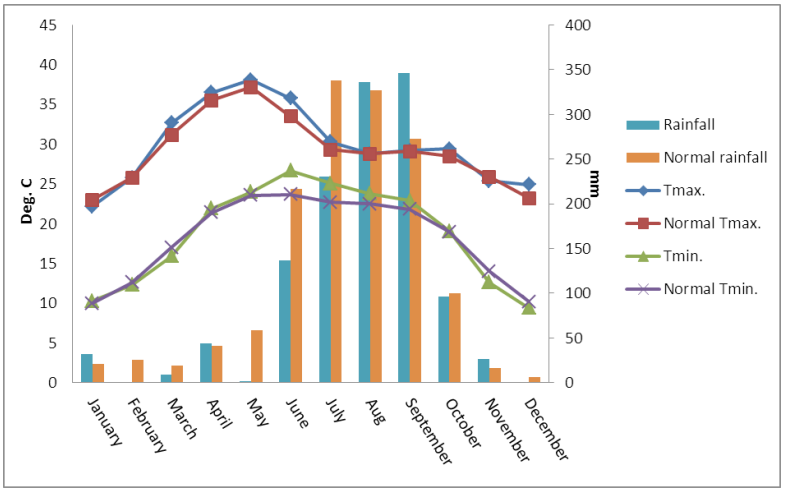


Fig. 4. Monthly variation of temperature and rainfall during 2012 in ICAR RCER Research Centre, Ranchi

4

Climate Change

Climate Change Impact on Crop Productivity and Water Resources

Study of rainfall and rice productivity trend in different districts of Bihar

Monthly mean rainfall data for different districts of Bihar was collected for the period 1950-2000. Trend test for rainfall was performed to find out significant variability in monsoon rainfall (June-September) in different districts by using Mann-Kendall test and the level of significance was tested at 5 and 1%. Rainfall during monsoon season showed a significant decreasing trend except four districts viz. Aurangabad, Gaya, Kishanganj and Lakhisarai (Fig. 5a). Linear trend of productivity for the period 1991-2000 (Fig. 5b) showed that all districts having increasing trend of productivity with time except Khagria and Nalanda districts. Significant positive regression coefficients were found for Bhojpur (0.66), Buxar (0.66), Madhepura (0.51), and Rohtas (0.50).

The regression relationship between Normalized Yield Index (NYI) and the Monsoon season Rainfall Indices (MRI) for the period 1991-2000 showed that Aurangabad, Nalanda, Nawada, Patna, Rohtas and Kishanganj district have higher R^2 values (0.77, 0.5, 0.5, 0.36, 0.43 and 0.57) as compared to other areas.

Refinement of simulation studies for wheat and maize crops

The simulated impact of climate change on three varieties of wheat, namely HD 2733, HUW 468 and RW 346 and one variety of maize, i.e., Ganga-11 under A2 scenario were fine tuned for Pusa, Madhepura, Patna and Sabour lying in three agro-ecological zones of Bihar based on available yield, soil and weather parameters. All the results were compared with the yields between A2 climate change scenario time slices, i.e., baseline (1961-1990), 2020, 2050 and 2080.

Simulated yield of wheat (HUW 468) decreased from the baseline in 2050 and 2080 to 3.6% and 14.1%, respectively, for Pusa. At Madhepura, decline in yield from the baseline was 5% during 2020, 13% in 2050 and 21% in 2080, respectively. Patna and Sabour showed decrease in simulated yield around 40% for 2080s (Fig. 6a). Number of grains increased marginally for Pusa and Patna during 2020; otherwise a decrease was noted for other time periods from the baseline. Zone I and II

D- Decreasing trend; I-Increasing trend;
*- sig level at 0.01 and **- sig level at 0.05

Fig. 5a. Map showing trend (Mann-kendall test) of rainfall in different districts of Bihar

D-Decreasing trend; I-Increasing trend; R^2 values

Fig. 5b. Map showing linear trend of rice productivity in different districts of Bihar

showed lesser decline in the number of grains and more or less constant weight of grains than zone III. However, zone III showed decrease in both number and weight of grains during different time-periods, thus indicating suitability of North Bihar (zones I and II) for wheat cultivation. Simulated yield of winter maize showed an increase from the baseline. This increase was in the range 8.4-18.2%, 14.1-25.4% and 23.6-76.7% for 2020, 2050 and 2080, respectively. Maximum increase was observed in Sabour for all the three time-periods (Fig. 6b). The decrease in duration is probably well compensated by increased growth rate with better temperature regimes resulting in increased number of grains and grain weight leading to overall increase in biomass.

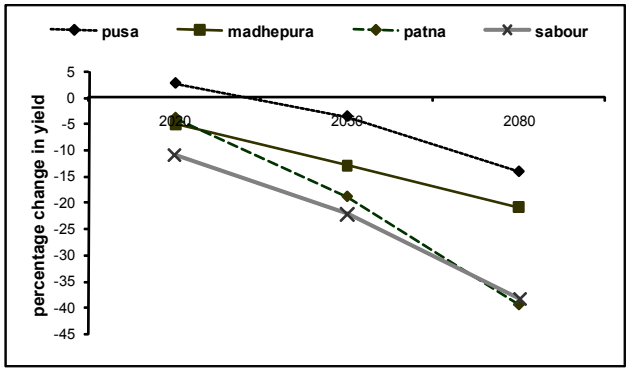


Fig. 6a. Percentage change in simulated yield of wheat

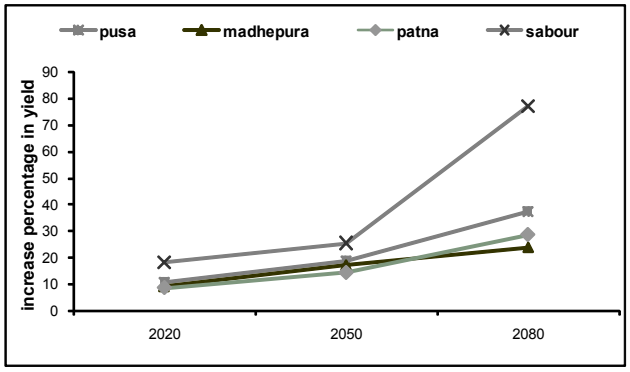
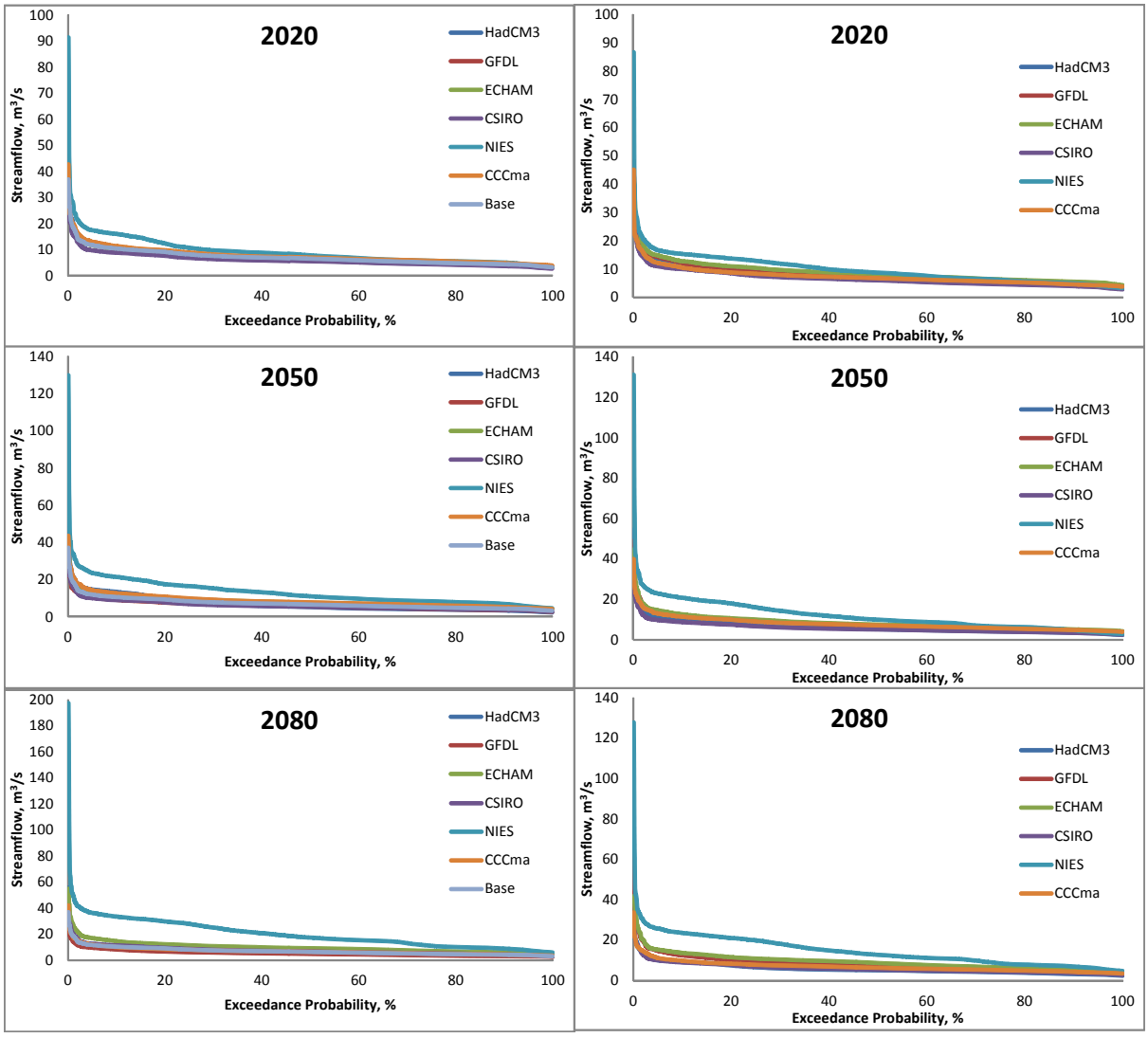


Fig. 6b. Percentage change in simulated yield of winter maize

Hydrological Modeling for Assessment of Climate Change Impact in the Bhavani River Basin

For assessing climate change impact on streamflow in the Bhavnai river basin, daily stream flow of Moyar sub-basin (catchment area 1362.74 km^2) was simulated and impact of climate change on extreme flows (high and low flows) were analysed. Climate change scenario data from six different GCMs (HadCM3, GFDL, CSIRO, NIES, ECHAM, CCCMA), two emission scenarios (A2 and B2) and three different time-slice 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2099) were considered. Mean monthly rainfall (mm/day), minimum and maximum temperature generated using different GCMs for the period 1980s, 2020s, 2050s, and 2080s were extracted from four/six grid points covering the entire Bhavani basin and interpolated using Inverse Distance method. Mean monthly rainfall for 16 rain gauge stations (considered for hydrological modeling) was extracted from the generated rainfall surface and monthly rainfall factor for each station was calculated. Similarly, minimum and maximum temperature change factors were calculated. Computed monthly rainfall and temperature factor were then applied to the observed data series for input to the hydrological model. From the simulated daily stream flow data, flow duration curves (FDC) representing the relationship between the magnitude and frequency of stream flow were developed. The effects of the climate change on three flow indicators were then analysed: the Q95 low-flow quantile (the discharge exceeded 95% of the time), the Q50 median flow, and the Q5 high-flow quantile that is exceeded 5% of the time. In this study, Q5 was used instead of peak discharges as it can be more robustly estimated from the shorter data records.

The flow duration curves under different GCMs scenarios showed the uncertainty associated with GCM projected scenarios and the range in which flow varies at different exceedance probability levels. The low (Q95), medium (Q50) and high (Q5) flows estimated from the FDCs, and the projected relative change in low, medium and high flows throughout the year compared with the baseline period are presented in Table 4. Under A2 emission scenarios, the changes in low flow (Q95) varied in the range of -17.70 to 7.00%, -28.40 to 36.40%, and -24.30 to 89.30% during 2020s, 2050s, and 2080s, respectively (Fig. 7). The HadCM3, GFDL and CSIRO projected scenarios resulted in the decrease in low flows, whereas ECHAM, NIES and CCCMA projected scenarios resulted in increase in low flows. Under B2 emission scenarios, the changes in low flow (Q95) is lesser as compared to that of the A2 emission scenarios, and it varied in the range of -11.30 to 28.60, 22.50 to 19.20 and 25.80 to 48.60 % during 2020s, 2050s, and 2080s, respectively. While comparing changes in low (Q95) and high flows (Q5), it was observed that the decrease in high flow (Q5) is lesser as compared to low flows (Q95) whereas increase in high flow is greater as compared to low flows. The changes in high flows varied in the range of -17.20 to 48.00%, -16.00 to 97.80%, -18.00 to 208.30% under A2 emission scenarios, whereas under B2 emission scenarios it varied in the range of -7.40 to 41.30%, -17.40



(a) A2 emission scenario (b) B2 emission scenario

Fig. 7. Flow duration curves for the Moyar river sub-basin under different climate change scenarios during 2020s, 2050s and 2080s

Table 4. Relative changes in low (Q95), medium (Q50) and high (Q5) flows during 2020s, 2050s, and 2080s under different climate change scenarios

Period	Flow Indicators	A2 emission scenario						B2 emission scenario					
		HadCM3	GFDL	ECHAM	CSIRO	NIES	CCCMA	HadCM3	GFDL	ECHAM	CSIRO	NIES	CCCMA
2020	Q5	3.43	4.92	-0.33	-17.23	48.02	10.29	8.77	20.51	24.98	-7.44	41.29	2.98
	Q50	-2.94	-3.87	-0.73	-15.53	19.82	6.56	0.62	7.83	25.66	-7.33	34.79	4.40
	Q95	-0.33	-2.84	1.44	-17.70	2.18	7.00	-0.06	5.79	28.61	-11.31	1.81	4.86
2050	Q5	23.25	-13.79	16.05	-16.04	97.81	19.63	-3.93	21.26	24.03	-17.42	93.46	9.75
	Q50	-20.24	-14.46	15.14	-18.25	68.30	18.14	-18.24	7.16	16.89	-20.75	54.01	10.60
	Q95	-28.40	-18.51	14.00	-18.61	36.43	14.14	-22.51	7.52	19.16	-22.27	-8.59	10.08
2080	Q5	6.42	-18.05	44.60	7.44	208.31	1.35	-14.84	24.61	29.70	-14.45	118.37	-4.97
	Q50	-8.23	-23.09	43.58	6.46	170.20	2.94	-20.64	15.68	34.49	-15.87	97.11	-1.42
	Q95	-3.74	-24.32	37.95	0.57	89.31	0.05	-25.80	4.33	32.98	-16.44	48.57	-1.28

Q95 (Low flow): Flow exceeded 95% of the time; Q5 (High flow): Flow exceeded 5% of the time; Q50 (Medium flow).

to 93.50%, and -14.80 to 118.40% during 2020s, 2080s, and 2080s, respectively. Low flow changes are particularly important in summer months when low absolute flows are more evident, and increase in high flows are more evident during rainy season. The variation in the low and high flows indicates the need for developing suitable adaptation options to mitigate the effect of flood as well as minimum flow requirements.

Modelling the Performance of Few Major Cropping Systems in Eastern India in the Light of Projected Climate Change (NAIP Comp-4)

Open Top Chamber(OTC) experiment

A study was undertaken in rice- wheat cropping system inside four OTCs (Fig. 8). Four varieties of rice namely Rajshree, Rajendra Bhagawati, Swarna sub1 and MTU 7029 and wheat namely C306, HD297, PBW550 and HD2733 were grown in different OTCs during *rabi* 2011-12 and *kharif* 2012 seasons. Response of these wheat and rice varieties was observed in 25% higher CO_2 concentration (475 ppm) than ambient (380 ppm) in one OTC and 25% higher CO_2 concentration (475 ppm) + 1^0C higher temperature than ambient condition in another OTC (Fig. 9 & 10). Performance of Swarna sub 1 (Promising HYV of eastern region) and HD2733 (ruling variety of Bihar) were evaluated under different nutrient management practices along with 25% higher CO_2 concentration (475 ppm) with 1^oC more temperature.

All varieties of wheat and rice showed positive response with CO_2 but with increase in temperature, there was decrease in yield. In nutrient management practices, split application of fertilizer showed better yield in comparison to other nutrient practices which are 125% chemical, INM and conservation technology.

Fig. 8. Open Top Chambers with control room

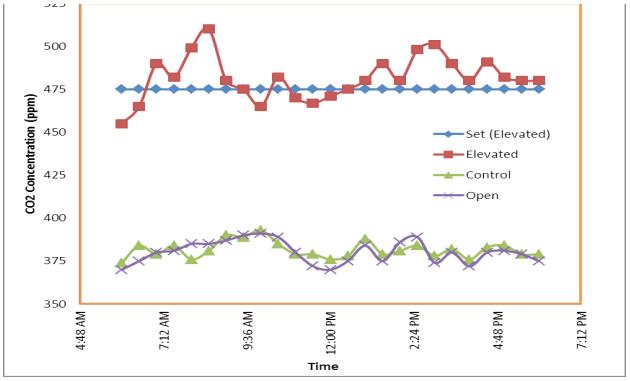


Fig. 9. Diurnal variation of CO_2 (concentration in ppm) inside and outside of different OTCs

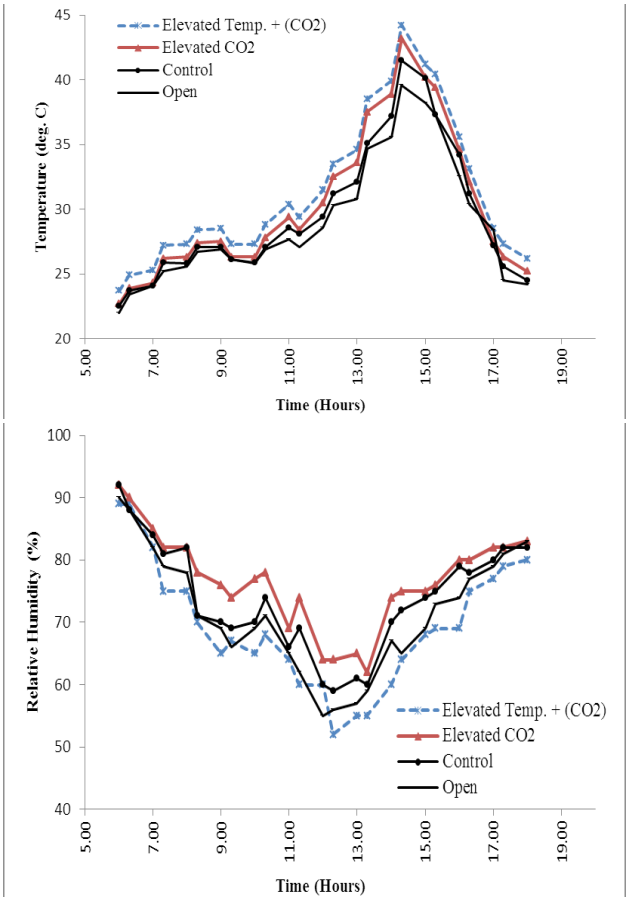


Fig. 10. Diurnal variation of temperature and relative humidity inside and outside of different OTCs

In case of rice, Rajshree and Swarna sub 1 produced higher yield in 25% higher CO_2 concentration (475 ppm) than other treatments. Yield was decreased in OTC where temperature is 1^0C more and control. Yield of variety Rajendra Bhagwati and MTU7029 was increased in 25% higher CO_2. In case of both the varieties, yield decreased with 1^oC rise of temperature. Least variability of yield was noticed in Rajendra Bhagwati and MTU 7029. In case of nutrient management, split application of fertilizer showed higher yield followed by integrated nutrient management and conservation technology.

Understanding Changes in Host-pest Interactions and Dynamics in Mango under Climate Change Scenarios

For assessing the impact of climate change on incidence of insect pest and diseases and their natural enemies along with phenological parameters in mango, RTPS data were collected at six centres from major mango growing regions of India. The data collected from 20 mango orchards distributed in four districts of Jharkhand showed that mango hoppers, shoot gall psylla, leaf webber, powdery mildew and anthracnose were serious problem in this area. The Population dynamics of mango hoppers (Fig. 11) increased from month of January to March in selected orchards but the population variation among orchards was due to their age difference (orchards/ tree age), canopy structure (tree) and management practices followed by farmers. Old plants of mango (25-30 years old) were found heavily infested by leaf webber in the month of September in the whole area of Jharkhand. The incidence of powdery mildew was severe (up to 85% PDI) in this region which may be due to early increase of temperature in Jan 2012. It was also recorded that midge infestation on new leaves increased the intensity of anthracnose disease on mango plants in the end of September month (Fig. 12).

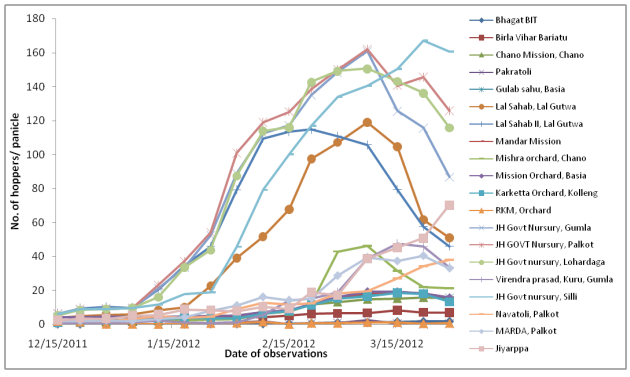


Fig. 11. Population dynamics of mango hoppers in selected mango orchards in Jharkhand

Fig. 12. Anthracnose with midges infestation on new leaves

Under Karnataka conditions, due to unusual cold temperature (minimum), the occurrence of *Idioscopus nagpurensis* was more compared to *Idioscopus nitidulus*. The increased infestation of leaf miner and leaf weevil was mainly due to increased minimum temperature. Intensity of minor diseases like leaf bight, mango malformation and black banded (Fig. 13) were recorded to be increasing gradually which may be attributed to increase in temperature.

In Konkan region of Maharastra, overall activity of mango hopper, *Idioscopus neveosparsus* extended up to March 2012 with the peak activity in the month of January due to prevalence of low temperature till 15th March (Fig. 14). A new disease called branch dying was found increasing in entire Konan region during monsoon and post monsoon period.

Fig. 13. Black banded disease infested mango plants in Bangalore region of Karnataka

Fig. 14. Mango hopper

Under Uttar Pradesh conditions, severe incidence (95%) of shoulder browning of mango fruits (Fig. 15) with moderate severity (60-65%) was recorded on late maturing cultivars (*Lucknow Safeda, Amrapali, Langra, Chausa, Mallika*, etc.) in the end of July when relative humidity was constantly recorded above 80% and temperature ranged between 25 to 35°C.

Fig. 15. Shoulder browning infected mango

In Gujarat state a new disease in mango by a gram positive bacterium, *Staphylococcus xylosus* causing havoc was noted.

For reducing impact of insect pest and diseases in mango under changing weather scenario, screening of 100 mango genotypes for resistance against different insect pests and diseases is under progress. The effectiveness of centre opening on incidence of insect pests and diseases in 10 mango genotypes is under progress. So far, observation showed that early increase in maximum and minimum temperature in January, 2012 resulted in increase in the incidence of mango hopper and powdery mildew. Early initiation of panicle was found to be a contributing factor for high incidence of powdery mildew whereas early occurrence of 75% flowering (10-11th standard meteorological week) was found to be contributing factor for high population of mango hopper. Centre opening of mango trees in the month of August in order to increase sunlight penetration and ventilation inside the plant canopy was found to be an effective adaptation strategy for minimization of infestation of mango hopper in large canopy cultivars.

Research Achievements

5

CEREALS

RICE

Management of Submergence Stress through Biotechnological Approaches in Rice Grown in Lowland Ecosystem

Rice varieties viz. IR64 and FR13A were cultivated and crossing was done for generation of F_3 breeding materials towards submergence tolerance. Stress was imposed on vegetative stage (25 days old seedling) for two weeks (Fig. 16). The generated F3 materials were thereafter reared along with parents and analysed for agro-morphological and physiological characters viz. days to attain 50% flowering (DFF), growth duration, panicle number, tiller number, plant height, total biomass, panicle weight and grain yield. Among the F_3 breeding materials, tiller number ranged from 11 to 27 days to attain 50% flowering (DFF) ranged from 91 to 118 days whereas total biomass ranged from 138.8 to 275.1 g/hill, plant height from 115 to 142 cm among breeding populations (Table 5). Molecular profiling of parents and F_2 materials were carried out with 22 SSR markers for submergence stress tolerance. Out of 22, six polymorphic primers (RM 257, RM 444, RM 444A, RM 219, RM 23381 and RM 23906) were identified, which showed differences between parents and among breeding population (Fig. 17).

Fig. 16. F_3 breeding population under water stress (submergence) field condition

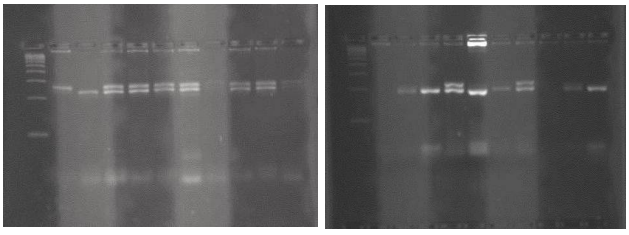


Fig. 17. Molecular profile of parents and F2 breeding population for submergence tolerance with SSR markers

Genetic variability analysis and development of mapping population for drought tolerance in rice

F_3 generation rice breeding materials of drought along with parents IR64 and IR 55419-04 were evaluated under water stress condition. Stress was imposed on reproductive stage (55 days old plants) for 20 days by withholding irrigation (Fig. 18). Agro-morphological and physiological parameters viz.days to 50% flowering (DFF), panicle length, tiller number, plant height, total biomass, panicle weight, leaf rolling, tip drying and grain yield were recorded. Drought related data such as leaf rolling, tip drying, relative water content and total dry matter were also recorded. The F_4 seeds were collected for further study. Molecular profiling of parents and F_2 materials were carried out with 28 SSR markers for submergence stress tolerance. Out of twenty eight, some polymorphic primers (RM 263, RM 3825, RM 164, RM 201, RM22, RM 302 and RM 5) were identified, which showed differences between parents and among breeding population (Fig. 19).

Table 5. Range in different agro-morphological traits among F_3 materials generated for submergence and drought tolerance in rice

F_1-Trait	Days to 50% flowering (days)	Days to Maturity (days)	Panicle length (cm)	Tiller No.	Plant height (cm)	Total biomass (g)	Leaf weight (g)	Leaf area (cm^2)	Grain Yield (g)
F_3-Submergence	91-98	125-148	21-28	11-27	115-142	138.8-275.1	35.6-75.6	975.15-2250.12	14.21-25.52
F_3-Drought	84-92	112-127	23-26	9-16	100-135	78.2-160.7	33.20 -50.48	580-75-795.3	16.76-28.39

Fig. 18. F_3 breeding population under water stress (drought) field condition

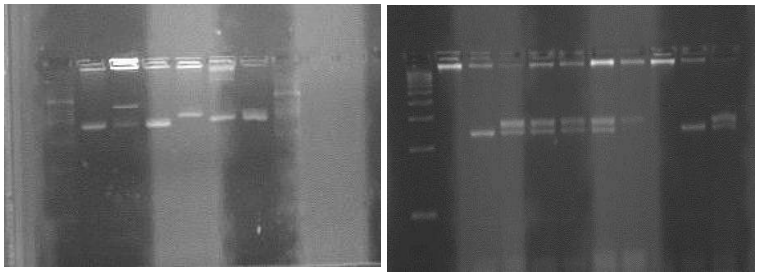


Fig. 19. Molecular profile of parents and F_2 breeding population for drought tolerance with SSR Markers

Characterization and evaluation of elite genotypes and high yielding varieties of rice for aerobic condition

Twenty four rice entries of early duration and forty eight entries of late duration were evaluated during kharif season, 2012 under aerobic (water stress) condition. Agro-morphological as well as physiological parameters viz. days to 50% flowering (DFF), panicle length, tiller number, plant height, total biomass, panicle weight and grain yield were recorded. Soil moisture status of the experimental field was also recorded at different stages. In the aerobic field, surface irrigation of about 5 cm was applied twice a week at the vegetative stage and an interval of 2-3 days at the reproductive stage. Surface Irrigation was applied only when the soil moisture tension at 15 cm depth reached -30 kPa. At the time of flowering, the threshold for irrigation was reduced to -10 kPa to prevent spikelet sterility. Twelve entries were identified which showed better performance under aerobic condition as compared to check varieties. Grain yield of different genotypes were varied from 1.84 to 5.58 t/ha in aerobic condition. The early vegetative vigor, relative water content and leaf area index during water scarcity condition were recorded. Promising lines performing better under water limited/ scarcity conditions include IR 83931-B-B-304-5-1-1-3, IR 84887-B-157-38-1-1-3, IR 83750-B-B-126-3-172-1, IR 82639-B-B-140-1-163-4, IR 84899-B-183-20-1-1-1, IR 83929-B-B-291-4-1-1-3, IR 82635-B-B-75-2-219-2, IR 83752-B-B-12-3-134-1, IR 84898-B-168-24-1-1-1, IR 84899-B-179-16-1-1 and IR 84882-B-120-46-1-1 (Table 6). These lines performed significantly better than check varieties IR 36, IR64 and Sahbhagi (Fig. 20). Hence these lines can be better utilized for water limited areas. Compared with traditional lowland rice, water inputs in cultivation of aerobic rice was also less. These promising lines may be further evaluated for water limited conditions.

Fig. 20. Evaluation of advanced breeding population under aerobic field condition

Table 6. Performance of advanced breeding rice genotypes under aerobic condition

Name of entries	Days to 50% flowering (days)	Plant height (cm)	Yield (t/ha)	No. of tiller/ hill	Panicle length (cm)	Biomass under aerobic condition (g)	Harvest index
IR 83931-B-B-304-5-1-1-3	94	119	5.58	11.8	24.8	476	0.48
IR 84887-B-157-38-1-1-3	82	109	5.21	9.6	25.3	429	0.51
IR 83750-B-B-126-3-172-1	92	104	5.09	13.7	23.6	443	0.45
IR 82639-B-B-140-1-163-4	88	118	4.92	11.2	26.6	379	0.47
IR 84899-B-183-20-1-1-1	80	128	4.87	10.2	27	345	0.48
IR 83929-B-B-291- 4-1-1-3	88	128	4.74	12.6	25.1	382	0.43
IR 82635-B-B-75-2-219-2	89	125	5.47	11.4	26	439	0.48
IR 83752-B-B-12-3-134-1	83	99	5.23	12	23	397	0.42
IR 84898-B-168-24-1-1-1	79	128	4.88	8.9	26.9	402	0.43
IR 84899-B-179-1-1-1-1	84	135	4.71	9.4	25.8	356	0.41
IR 84899-B-179-16-1-1	80	132	4.56	8.8	25.9	385	0.44
IR 84882-B-120-46-1-1	84	124	4.37	7.8	24.6	352	0.41
IR 64	88	116	2.67	11.6	26.0	311	0.36
IR 36	90	109	2.08	10.4	23.8	273	0.31
Sahbhagi	93	115	2.87	11.8	25.9	306	0.37

Evaluation of high yielding variety with Sub 1 and their intolerant parents under submergence stress and control condition

A field experiments were conducted at the research farm of ICAR-RCER, Patna during *kharif* 2012, to evaluate the yield response of fourteen rice genotypes contrasting in their tolerance of submergence, comprising of landraces, high yielding variety (HYVs) carring Sub 1 as well as without Sub 1 of the lowland ecosystem of eastern India. Grain yield and yield contributing traits were recorded for comparing the performance of rice genotypes between submergence stress and non-stress field condition. Yield decline was observed almost in all rice genotypes grown under stress condition as compared to non-stress. Under flash floods or short term submergence, rice genotypes carring Sub 1 survived complete submergence stress up to 14 days, whereas genotypes without Sub 1 did not survive significantly and gave very low yield (Fig. 21). In non-submerged experiments, both Sub 1 and without Sub 1 HYVs, showed no significant differences in grain yield. But under submerged experiment results suggested that rice genotypes with Sub 1 gave higher grain yield than genotypes without Sub 1 (Table 7). High yielding varieties carring Sub 1 and landraces showed higher survival percentage than the intolerant parent and check variety IR42 (Fig. 22).

Fig. 21. Performance of rice genotypes under submergence stress condition

Table 7. Days to 50% flowering, tiller number, grain yield and shoot elongation of fourteen rice genotypes grown under stress (S-submergence) and non-stress (NS-control) field condition

Genotypes	DFF (Days)		No. of tiller /m^2		Grain yield (t/ha)		Elongation stress (%)
	NS	S	NS	S	NS	S	
Swarna	123	131	428	157	5.97	1.07	37.44
Swarna Sub 1	117	129	441	248	5.64	3.18	40.28
Sambha Mahsuri	119	127	476	117	6.14	1.23	38.91
Sambha Mahsuri Sub 1	125	134	462	265	5.88	2.73	35.26
IR 64	84	91	357	78	4.92	0.78	57.23
IR 64 Sub 1	87	89	329	287	5.11	2.46	48.67
Savitri Sub 1	108	111	403	322	5.76	3.13	41.13
Sita	96	103	321	56	4.34	0.32	62.53
FR 13A	126	137	356	292	3.12	2.79	45.27
Atiranga	123	132	289	257	3.28	2.94	79.73
Gangasuili	121	129	288	245	2.98	2.44	89.57
Kusuma	121	130	308	291	2.65	2.61	87.31
Kalaputia	124	133	317	303	2.81	2.42	78.54
IR 42	103	108	355	47	4.47	0.13	54.82
Mean	112.6	120	366.4	211.79	4.51	2.02	56.91

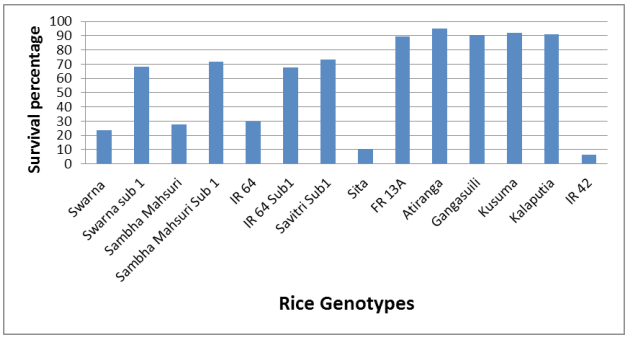


Fig. 22. Survival percentage of rice genotypes after 14 days submergence stress

Performance of near iso-genic lines of IR64 under reproductive stage drought stress condition

Six near iso-genic lines (NILs) of IR 64 along with three check varieties (Shanti, Sushk Samrat and IR 64) were evaluated under drought stress field condition during *kharif* 2012, to evaluate the yield performance of DRT introgression lines under drought at reproductive stage. The NILs was taken up in field under two situations, i.e., rainfed drought and normal irrigated conditions. Fifty five days old seedlings were subject to drought by withholding irrigation and withdrawing water from the field. Thereafter, crop was left rainfed and there was no standing water up to maturity. IR 64, NIL 3603 & 3604 showed uniformity, good grain

quality and proper maturity without any off-type and varietal mixture. IR 64 NIL 3603 showed 48.84%, 95.16% and 27.67% higher yield over IR64, Shanti and Susk Samrat, respectively. Whereas, NIL 3604 showed 33.87%, 75.52% and 12.90% higher yield over IR64, 3602 Shanti and Sushk Samrat, respectively (Table 8). IR64 NILs IET 22835, IET 22836 & IET 22837 showed 22.51%, 36.56% and 26.67% yield advantage over IR64, respectively.

Table 8. Performance of drought introgression lines under drought stress condition

Entries	DFF (days)	Plant height (cm)	No. of tillers / m^2	Grain yield (t/ha)
3603	80	110	315	7.18
3604	80	107	303	6.52
3605	80	102	339	5.45
IET 22835	80	99	234	5.63
IET 22836	80	107	272	6.27
IET 22837	80	103	261	5.85
IR 64	79	92	256	4.82
Shanti	90	99	289	3.68
Sushk Samrat	79	118	324	5.64

Evaluation and development of drought tolerance rice for eastern region (STRASA Phase-2)

The frequent occurrence of abiotic stresses such as drought has been identified as the key to the low productivity in rainfed ecosystems. Out of the total 20.7 million ha of rainfed rice area reported in India, approximately 16.2 million ha lies in eastern India, of which 6.3 million ha of upland area and 7.3 million ha of lowland area are highly drought-prone. Despite the importance of drought as a constraint, little effort has been devoted to developing drought-tolerant rice cultivars. Most of the high-yielding varieties- IR36, IR64, Swarna, and Sambha Mahsuri grown in rainfed areas are the varieties bred for irrigated ecosystems. These varieties are drought susceptible. Keeping this fact in view, under STRASA project phase-2, a field drought- screening was done during *kharif* season 2012 at ICAR Research Complex for Eastern Region, Patna with aim to identify drought donor lines. Fifty one rice entries received from IRRI and CRRI, Cuttack alongwith some local varieties were evaluated under two treatment, i.e., rainfed and irrigated in alpha lattice design. Fifty five days old seedlings were subject to drought by withholding irrigation and withdrawing water from the field. Thereafter, crop was left rainfed and there was no standing water up to maturity. Agro-morphological and physiological data related to drought tolerance were recorded. Some breeding lines showed better drought tolerance under field stress as compared to check varieties (Fig. 23). Grain yield varied from 3.4-8.7 t/ha and 0.9-4.4 t/ha under non stress (irrigated) and stress (rainfed) conditions, respectively. The relative water content (RWC), chlorophyll content, and leaf area index were also recorded. Rice genotypes IR 87651-26-1-1-3, IR 84900-B-149-CRA-2-1, IR 83377-B-B-42-3, CB-09-510, IR 87746-26-2-1-1, IR 83376-B-B-24-2, IR 83373-B-B-24-3, IR 84895-B-127-CRA-5-1-1, IR 87753-11-2-1-2 and IR 87751-20-3-2-1 performed better and showed tolerance under water stress (drought) as compared to check varieties - Lalat, IR64, IR 36, Abhishek, Swarna, BPT 5204 and MTU 1010 (Table 9 & 10). These lines may be further investigated for their stress tolerance capability.

Development of management practices for drought tolerant genotypes in rainfed agricultural system in Bihar (IRRAS)

Seven drought tolerant rice genotypes were evaluated under rainfed ecosystem during *kharif* season 2012 (Fig. 24). The main objective of this experiment was to develop, validate, refine and demonstration best agronomic technologies for improved rice varieties along with complementary crops to increase the productivity and reduce the risk of rainfed rice based systems. All the rice genotypes were evaluated under different management practices such as SRI vs. best management

Fig. 23. Screening of rice genotypes under drought stress condition

Table 9. Performance of promising genotypes of AYT 100-120 days under water stress condition

Name of entries	DFF (days)	PHT	Grain yield (t/ha)	Harvest index	Biomass (dry wt. in kg)
IR 87651-26-1-1-3	78	118	4.34	0.52	259
IR 84900-B-149-CRA-2-1	73	128	3.98	0.51	245
CB-09-510	80	111	3.95	0.48	237
IR 87746-26-2-1-1	80	116	3.92	0.49	230
CR 2732-2-2-1-2-1	77	107	4.08	0.52	255
CR 2732-2-2-1-2-1	79	112	3.94	0.5	226
IR 87638-10-1-1-3	84	115	3.45	0.42	238
CB-05-753	82	108	3.38	0.46	204
IR 83381-B-B-18-3	80	123	3.46	0.45	216
IR 83383-B-B-129-3	80	113	2.93	0.35	199
IR 87759-2-2-1-1	85	118	3.18	0.42	181
IR 64	77	102	1.97	0.31	112
IR 36	84	106	2.18	0.35	137
Lalat	85	110	2.09	0.38	147
Abhishek	86	99	2.28	0.32	125
CV (%)	1.84	2.97	.007	5.01	6.25
LSD (5%)	2.39	5.46	0.27	0.03	49.60

Table 10. Performance of promising genotypes of AYTGT 120 days under water stress condition

Name of entries	DFF	PHT	Grain yield (t/ha)	Harvest index	Biomass (dry wt. in kg)
IR 83376-B-B-24-2	86	125	3.97	0.39	217
IR 83373-B-B-24-3	88	122	3.91	0.35	222
IR 84895-B-127-CRA-5-1-1	90	114	3.39	0.38	197
IR 87753-11-2-1-2	89	119	3.54	0.39	230
IR 87751-20-3-2-1	78	121	3.43	0.38	181
MTU 7029	109	87	2.22	0.31	141
BPT 5204	111	95	1.97	0.34	127
Sushk Samrat	85	118	2.77	0.36	155
R. Sweta	104	98	2.05	0.32	118
CV (%)	2.67	2.91	.006	4.88	8.48
LSD (5%)	3.14	5.24	0.352	0.03	36.44

practices (BMP), puddle vs. un-puddled transplanting field, laser leveler vs. non-laser leveled field. Sahbhagi, a drought tolerant variety, was also evaluated under different microbial treatment. Rice breeding line IR83387-B-B-40-1 has been identified as drought tolerant and yield was recorded to be 6.67 and 6.64 t/ha in SRI and BMP as compared to Swarna (6.06 t/ha in SRI and 5.83 t/ha in BMP) (Table 11). On average, rice genotypes grown in laser leveled field has 26.93 % grain yield (5.54 t/ha) advantage over non-laser leveled field ((4.05 t/ha). In general, treatment of Sahbhagi seed with Trichoderma strains (S1, S2, S3 & S4) increased 25.89 % (5.33 t/ha) grain yield as compared to non-treated seed (3.95 t/ha) under rainfed lowland ecosystem (Table 12). Seed treatment with FYM + S3, FYM + S4, S2 & S4 has helped in vigorous root growth of seedling, which reflects in grain yield of the variety.

Table 11. Performance of drought tolerant genotypes under different agronomic management practices.

Rice genotypes	Grain yield (t/ha)				
	SRI	BMP	Puddled	Un-puddled	Non-laser leveled field
Sushk Samrat	5.46	5.84	5.24	4.90	4.87
IR 84899-B-183-CRA-19-1	4.25	5.93	5.76	4.10	4.28
kasturi	4.74	4.42	4.59	4.29	3.19
Abhishek	5.40	6.30	5.71	5.03	5.17
IR 82870-11	5.28	5.37	5.09	5.54	4.26
IR 83387-B-B-40-1	6.67	6.64	6.27	6.33	4.72
Swarna	6.06	5.83	5.96	5.72	3.48
CR Dhan	4.82	4.18	4.51	4.17	3.44
Sahbhagi	4.89	5.74	5.18	5.09	3.04
Mean	5.282	5.588	5.368	5.019	4.050

Table 12. Performance of Sahbhagi variety under different microbial tratments

Treatments	DFF (days)	Plant height (cm)	Effective tiller /m^2	Grain yield (t/ha)	Harvest index (%)
FYM+S1	85	106	182	5.96	52.71
FYM+S2	85	118	214	6.03	53.01
FYM+S3	84	111	200	6.48	52.57
FYM+S4	86	112	280	6.17	54.28
S1	84	109	224	6.12	52.70
S2	83	122	226	6.32	48.07
S3	86	122	193	5.46	52.13
S4	85	116	259	5.93	53.20
FYM	84	110	205	5.75	56.92
Control	84	120	221	4.88	43.47

Fig. 24. Evaluation and screening of drought tolerant genotypes under different agronomic management practices

WHEAT

Screening and Evaluation of Advanced Breeding Lines of Wheat under Rainfed Lowland Ecosystem

Twenty nine advanced breeding lines of wheat comprising of timely sown and late sown genotypes were evaluated under rainfed ecosystem at ICAR-RCER, Patna with aim to identify suitable genotypes for this ecosystem (Fig. 25). The recommended farming practices like seed rate, fertilizers, irrigation etc. were adopted. The climatic parameters like temperature, relative humidity and sunshine hours were also recorded.Yield and yielding attributes of the different genotypes were regularly monitored and recorded (Table 13). Wheat genotypes viz. NE-TS-01, NE-TS-03, NE-TS-05, NE-TS-08, NE-LS-02, NE-LS-07, NE-LS-09 and NE-LS-11 were identified promising as compared to check varieties PBW 343 & PBW 371.

Fig. 25. Screening of wheat genotypes under rainfed condition

Table 13. Yield and yielding attributes of promising wheat genotypes

Genotypes	Early Vegetative Vigor (EVV)	Grain yield (t/ha)	DFF (days)	Plant height (cm)	Test weight (g)
NE-TS-01	1	5.71	80	92	45.36
NE-TS-03	3	5.16	73	93	42.89
NE-TS-04	3	5.13	83	110	37.93
NE-TS-05	1	5.19	82	100	35.69
NE-TS-08	1	5.39	80	105	42.34
NE-TS-11	3	5.12	88	93	44.61
NE-TS-13	1	5.10	86	96	40.89
NE-LS-02	1	6.30	73	96	37.85
NE-LS-07	3	6.27	69	101	38.72
NE-LS-11	3	6.05	67	94	45.65
NE-LS-09	1	5.91	66	89	40.53
PBW 343	5	4.29	88	95	44.60
PBW 373	5	5.31	80	96	40.98
Mean	---	5.46	78.08	96.92	41.39

Integrated Weed Management in Aerobic Rice

A trial under All India Coordinated Rice Improvement project (AICRP) was undertaken during *kharif* 2012 at main research farm of ICAR Research Complex for Eastern Region, Patna to find the most economical method of weed control under aerobic unpuddled condition. Rice variety Rajendra Bhagwati was sown on 15th July, 2012 in RBD with eleven treatments. The treatments consisted of Pendimethalin (30 EC) or Butachlor (50 EC) as pre emergence and Bispyribac-sodium, 2,4-D Na salt, Ethoxysulfuron or a mixture of Chlorimuron+MS methyl as post emergence herbicides. The crop received 680.4 mm rainfall during the crop period. Five irrigations were also given during the whole crop duration.

Effect of herbicide on planting density was non-significant. Weeds were counted five days before and ten days after herbicide application. Results revealed that maximum weeds were controlled by application of Pendimethalin (30EC) + Bispyribac-sodium, which was at par with that of need based hand weeding (Table 14). Grain yield and yield attributes like panicle number per unit area, panicle weight and 1000-grain weight were higher in the treatments treated with Pendimethalin (30 EC) + Bispyribac-sodium (W1) followed by Pendimethalin (30 EC) + 2, 4-D Na salt (W2). Based on economics, application of pendimethalin + Bispyribac-sodium was found as the most economical method of weed management. Weed control rating was calculated on the basis of weed control efficiency and it was found that W1 and W10 treatments controlled the weeds efficiently and thereby showed maximum weed control rating (Fig. 26).

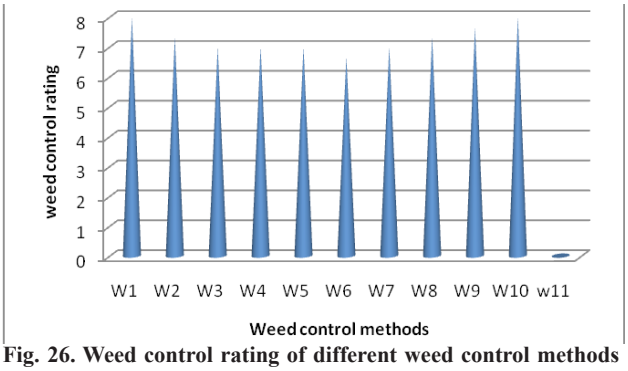


Fig. 26. Weed control rating of different weed control methods

Table 14. Effect of different weed control methods on number of weeds, yield attributes and yield of aerobic rice

Treatments	No. of Plants/m^2	No. of weeds/ m^2 (before application)	No. of weeds/ m^2 (after application)	No. of panicle/m^2	Panicle weight (g)	Grain yield (t/ha)
W1: Pendimethalin (30EC) @ 1.00 kg a.i./ha (3-4 DAS)+ Bispyribac-sodium (10%SC) @ 35 g a.i./ ha (15-20 DAS)	26	56	11	353	2.59	3.29
W2: Pendimethalin (30EC) @ 1.00 kg a.i./ha (3-4 DAS) + 2, 4 D Na salt (80WP) @ 0.06 kg a.i./ha (20-25 DAS)	26	54	20	337	2.27	3.10
W3: Pendimethalin (30EC) @ 1.00 kg a.i./ha (3-4 DAS)+ Ethoxysulfuron (15 WSG) @ 5 g a.i./ha (25-30 DAS)	25	66	22	314	2.12	2.85
W4: Pendimethalin (30EC) @ 1.00 kg a.i./ha (3-4 DAS) + Chlorimuron+MS methyl (20 WP) @ 4 g a.i./ha (25-30 DAS)	24	65	24	299	2.26	2.79
W5: Butachlor (50EC) @1.50 kg a.i./ha (3-4 DAS)+ Bispyribac-sodium (10%SC) @ 35 g a.i./ha (15-20 DAS)	27	65	18	322	2.07	2.83
W6: Butachlor (50EC) @ 1.50 kg a.i./ha(3-4 DAS) + 2,4 D Na salt (80WP) @ 0.06 kg a.i./ha (20-25 DAS)	25	69	23	288	2.02	3.04
W7: Butachlor (30EC) @ 1.00 kg a.i./ha (3-4 DAS)+ Ethoxysulfuron (15 WSG) @15 g a.i./ha (25-30 DAS)	27	60	22	311	2.03	2.52
W8: Butachlor (30EC) @ 1.00 kg a.i./ha (3-4 DAS)+ Chlorimuron+ metsulfuron methyl (20 WP) @ 4 g a.i./ha (25-30 DAS)	26	65	19	302	1.96	2.58
W9: Mechanical weeding/weeders at 20 & 45 DAS	27	55	17	320	2.26	2.77
W10: Need based hand weeding	27	57	12	312	2.20	2.85
W11: Unweeded control	24	91	91	231	1.34	1.33

Screening of Rice Germplasm for Diseases

Total no. of 435 entries of 5 accession viz., NSN-1(195), NHSN(112), DSN(79), BL(26) and IRBB(25) were evaluated against blast, bacterial leaf blight (BLB), sheath blight, sheath rot, brown spot and rice tungro diseases. The data revealed that most of the lines were affected by sheath blight (Fig. 27), followed by blast (Fig. 28). Field monitoring of virulences of *Pyricularia grisea* were observed in entries BL13 Zenith, BL4 C105, TTP-4-L23 in mean 4.5 of (0-9 scales). Special lines of virulence's of *Xanthomonas oryzae* pv. *oryzae* were found in lines IRBB4,IRBB53, IRBB4, IRBB7, IRBB53 in 3-4 mean of (0-9 scales).

Fig. 27. Sheath blight of rice

Fig. 28. Blast affected entries

Optimization of Method of Transplanting and Fertilizer Application in Maize

The experiment on transplanted maize was started since 2008. Five week old seedlings have been found best for transplanting in the fields as *rabi* crop in Bihar. A new experiment was conducted at the same farm from 2011 with five method of maize raising as direct seeding, transplanting (T/p) of seedlings on flat bed after tillage, T/p of seedlings on narrow beds (ridge/furrow), T/p of seedlings on broad beds, planting of seedlings in the moist field without tillage and fertilizer application at four different growth stages viz. T/p + knee height + silking, T/p + silking + grain filling, T/p + pre tasseling + silking, T/p + tasseling + grain filling stages where recommended dose of nitrogenous fertilizer was applied into three splits (½ + ¼ + ¼) as per the treatments. Five weeks older seedlings were transplanted in the main field on 20th December, 2011 under all the treatments (Fig. 29). It was observed that low seedling mortality after transplanting, more plant height, maximum leaf length, dry matter, root volume, leaf area index were recorded with maize grown on broad beds and furrows (BBF) and were found at par with the crop transplanted on ridge and furrows.

Further, maize crop grown on broad bed and furrow method also performed better than other method of maize raising in respect of yield and yield attributes (Table 15). Highest yield (6.6 t/ha) was recorded with sand cultured seedlings which were found at par with the crop grown on ridge and furrow method (6.4 t/ha) and was found also at par with direct sown maize which

Fig. 29. Maize seedlings transplanted on broad beds and nursery uprooting

was sown on 21st October (6.7 t/ha) with a B : C ratio of 2.6 and 2.5 and 2.6, respectively. The crop fertilized by nitrogen before transplanting + pre tasseling + silking stage resulted significantly higher grain yield (6.6 t/ha) over all other treatments. Water use efficiency (WUE) was recorded highest with broad bed and furrow method of maize cultivation (370.3 kg/ha cm^{-1}) in combination with N-fertilizer applied before transplanting + pre tasseling and silking stages over all other methods of maize cultivation.

At the end of first year experiment, it was observed that five weeks older seedlings could be easily transplanted as winter maize in the region provided seedlings should be healthy and lesser damage to the roots while uprooting and transplanting . For this nursery soil should be mixed with sand (2:1). Transplanted maize crop with 5 week old seedlings on BBF and fertilized at transplanting + early tasseling + silking, resulted in maximum grain yield and returns (₹ 48,346/ha) with 14-21 days early maturity over direct sown maize with almost same yield level. Transplanted maize crop also saved 2 irrigations (12 cm) over direct seeded maize sown in the last month of October. By using this technique of maize cultivation, *rabi* maize can be grown profitably after harvest of rice.

Table 15. Growth, yield and B:C ratio of transplanted maize under different seedling raising method and age

Treatments	Mortality 15 DAT (%)	Plant height at 90 DAT (cm.)	Root volume at 90 DAS (cm^3)	Dry matter/plant at maturity (g)	Days to 50 % flowering (days)	Maturity days (Seed to seed)	Grain yield (t/ha)	B: C ratio
Nursery Raised								
Direct sown	6.5	111.8	5.4	381.6	94.5	179	67.0	2.6
Flat bed	9.5	101.5	54.2	342.6	71.8	161	58.6	2.3
Raised bed	8.7	1.3.0	66.6	354.3	68.0	163	64.1	2.5
Sand culture	7.6	105.0	72.8	373.1	68.7	165	66.6	2.6
Plastic culture	10.6	100.7	52.2	300.7	64.4	157	50.9	2.1
C.D.±0.05	2.02	3.6	3.9	25.6	4.8	-	3.5	0.03
S. Em.	0.62	1.11	1.21	7.86	1.46	-	1.06	0.01
Fertilizer Scheduling								
4 week	7.1	103.9	50.2	340.6	70.4	161	57.8	2.3
5 week	7.3	104.6	60.8	353.8	74.8	167	62.1	2.5
6 week	8.7	106.1	72.6	357.8	75.0	169	66.6	2.6
7 week	8.6	103.0	53.4	350.4	73.6	164	59.6	2.4
C.D.±0.05	2.1	4.68	6.1	20.2	2.3	-	2.0	0.03
S. Em.	NS	1.62	2.10	6.99	0.82	-	1.02	0.01

6

PULSES

FABA BEAN

Crop Diversification with Faba Bean to Improve Land and Water Productivity

A field experiment was conducted in RBD to evaluate suitable faba bean cropping system for eastern region. Five cropping systems *viz.*, (CS_1) rice-faba bean-ladies finger, (CS_2) rice-faba bean- green gram, (CS_3) rice-faba bean + potato-cowpea (green fodder), (CS_4) rice-faba bean + maize-green gram and (CS_5) rice-faba bean + lentil- green gram (green fodder) were tested under rainfed (I_1) and irrigated (I_2) condition especially during *rabi* season. The texture of soil of experimental plot was silty clay loam with mean pH value of 6.9, electrical conductivity 0.18 ds/m in 1:2 soils : water solution, organic carbon 0.68 per cent, available nitrogen 258.2 kg/ha, available phosphorus 32.3 kg/ha, available potash 198.1 kg/ha, sulphur 9.4 kg/ha and zinc 1.1 kg/ha.

Rice performance under cropping system

Rice was taken during *kharif*, 2012 under irrigated conditions. Data presented (Table 16) for rice crop revealed that plant height ranged between 125.1 to 126.7 cm. Maximum (126.7 cm) plant height was recorded with the cropping system (CS_5) in which rice-faba bean + lentil - green gram were taken (Fig. 30). LAI varied from 5.69 to 6.12. Number of panicle/m^2 ranged between 275.7 to 281.1. Likewise, numbers of grains/ panicle ranged from 197.7 to 203.2. Grain yield ranged from 6.67 to 6.74 t/ha. Similarly, irrigation water productivity (kg/m^3) ranged from 2.14 to 2.17.

During *rabi* season 2011-12, (Table 17) experiment was initiated as per treatment. Under sole cropping system, faba bean seed yield ranged between 4.15 to 4.19 t/ha in irrigated situation whereas under rainfed condition it varied from 1.25 to 1.27 t/ha. Performance of faba bean under intercropping system ranged between 1.39 t/ha (faba bean + maize) to 2.12 t/ha (faba bean

Table 16. Rice growth and development, yield attributes and yields during 2012

Cropping System	Plant height (cm)	LAI	Panicle /m^2	Grains/ panicle	Grain (t/ha)	Irg. WP (kg/ m^3)	HI (%)	1000 seed weight (g)
Rice-faba bean - ladies finger (CS_1)	125.1	5.71	276.5	201.3	6.72	2.16	0.41	16.1
Rice-faba bean- green gram (CS_2)	126.3	5.78	278.3	199.8	6.68	2.14	0.42	16.0
Rice-faba bean+ potato -cowpea (GP) (CS_3)	125.4	5.69	277.3	199.2	6.67	2.14	0.42	16.0
Rice-faba bean + maize (cob) - green gram (CS_4)	125.9	5.71	275.7	197.7	6.69	2.15	0.41	16.0
Rice-faba bean + lentil- green gram (CS_5)	126.7	6.12	281.1	203.2	6.74	2.17	0.42	16.0
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Fig. 30. Rice crop in *kharif* 2012 under faba bean based crop diversification

Table 17. Faba bean performances under sole cropping system

Cropping System	Faba bean seed yield (t/ha)		Irrigation WP (kg/m^3)
	Irrigated	Rainfed	
Sole cropping			
Rice-faba bean-ladies finger(CS_1)	4.15	2.11	1.25
Rice-faba bean- green gram(CS_2)	4.19	2.14	1.27
Intercropping			
Rice-faba bean+potato-cowpea (GP) (CS_3)	1.82	1.37	716.7
Rice-faba bean+maize (cob)-green gram (CS4)	1.39	0.94	26.35
Rice-faba bean+lentil-green gram (CS_5)	2.12	1.37	3.06

+ lentil). Irrigation water productivity ranged between 1.25 to1.27 kg/m^3.

Performances of intercrops with faba bean are presented in Table 18 and Fig. 31. Tuber yield of potato was 21.4 and 11.9 t/h under irrigated and rainfed conditions, respectively. Similarly maize green cob yield was recorded 64.5 and 31.8 t/ha under irrigated and rainfed conditions, respectively. However, lentil performance was recorded to be 0.95 and 0.45 t/ha in case of irrigated and rainfed conditions, respectively.

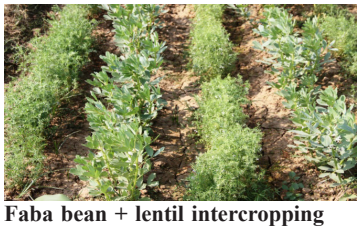
Table 18. Performances of intercrops during *rabi* season under faba bean based cropping system

Cropping System	Faba bean seed yield (t/ha)	
	Irrigated	Rainfed
Rice-faba bean+ potato -cowpea (GP) (CS_3)	21.4	11.9
Rice-faba bean + maize (cob) - green gram (CS_4)	64.5	31.8
Rice-faba bean + lentil - green gram (CS_5)	0.95	0.45

The summer crops were also raised on recommended levels of irrigation (Fig. 32). Lady's finger yield was recorded to be 8.15 t/ha (Table 19). Similarly yield of cowpea green pods was estimated 7.93 t/ha. Green gram seed yield was recorded in between 1.78 and 1.8.4 t/ha under different cropping systems.

Faba bean as a sole cropping

Faba bean+maize intercropping



Faba bean + lentil intercropping

Faba bean+potato intercropping

Fig. 31. Faba bean and other intercrops crops in *rabi* 2012 under faba bean based crop diversification

Table 19. Performance of summer crops under faba bean based cropping system

Cropping System	Name of intercrops	Yield (t/ha)
Rice-faba bean - ladies finger (CS_1)	Ladies finger	8.15
Rice-faba bean - green gram (CS_2)	Green gram	1.84
Rice-faba bean+ potato -cowpea (GP) (CS3)	Cowpea (GP)	7.93
Rice-faba bean + maize (cob) - green gram (CS_4)	Green gram	1.78
Rice-faba bean + lentil- green gram (CS_5)	Green gram	1.81

Ladies finger under CS1 cropping system

Green gram under CS2 cropping system

Cowpea under CS3 cropping system

Fig. 32. Ladies finger, green gram and cowpea in *summer* 2012 under faba bean based crop diversification

Varietal Development of Faba bean (*Vicia faba* L.) for Nutritional Security in Eastern Region

Multilocation evaluation trial has been conducted at 8 centers covering Eastern Uttar Pradesh, Bihar and Jharkhand (Fig. 33 & 34). In respect of water management only one irrigation was supplemented at pre flowering stage in rainfed condition, whereas in case of irrigated condition, 2-4 irrigations were suggested as per need during critical period conceding with at pre-flowering and post podding. Entry no 2011215 which was developed for irrigated and rainfed conditions, yielded 4.76 to 6.13 t/ha under irrigated condition and 2.43 to 4.53 t/ha under rainfed condition. Similarly, for 2011410, which was developed for assured irrigation condition, the average seed yield was recorded at 5.05

At early stage of growth

At peack growth stage

Fig. 33. Multilocation evaluation of faba bean varieties developed by institute

Fig. 34. Faba bean being evaluated at KVK, Sitamarhi and Bihta, Patna by the progressive farmers

t/ha (range - 3.18 to 5.88 t/ha). None of the national check varieties has performed closed to both the entry (Table 20).

Table 20. Multi location evaluation of developed lines of faba bean

Location of evaluation	Performance of faba bean (Seed yield t/ha)				
	Developed lines			Check variety	
	2011215 (Irrigated)	2011215 (Rainfed)	2011410 (Irrigated)	Pusa Sumeet (Irrigated)	Vikrant (Irrigated)
ICAR, Patna	5.53	3.16	5.38	2.91	2.36
ICAR, Ranchi	4.76	2.43	3.18	2.26	2.19
IARI, Pusa	6.13	2.29	5.88	2.86	2.51
WALMI, Patna	6.03	4.53	5.18	28.1	2.74
CPRS, Patna	5.23	2.43	4.58	2.91	2.57
KVK, Auraiya (UP)	5.39	3.34	4.23	2.96	2.28
KVK, Sitamarhi	4.84	2.69	3.82	2.52	1.96
KVK, Buxar	5.11	2.67	3.89	2.17	2.34
Average	5.38	3.94	5.05	2.68	2.37

Development of Guidelines for Distinctiveness, Uniformity and Stability (DUS) Test for Faba Bean

The work was initiated to develop guidelines for DUS in case of faba bean. Varieties/lines have been evaluated with the guidelines provided by Protection of Plant Variety and Farmers Right Authority, New Delhi. All the entries were sown on 04.12.2012 and replicated thrice. Plot size was 5 x 2 m to accommodate five row of 5 meter for individual entry. The planting distance was kept 30 x 10cm (Fig. 35).

Fig. 35. Close up and over view of faba bean grown for conduction of Distinctiveness, Uniformity and Stability Test

Deposition of Faba Bean Germplasm to National Gene Bank

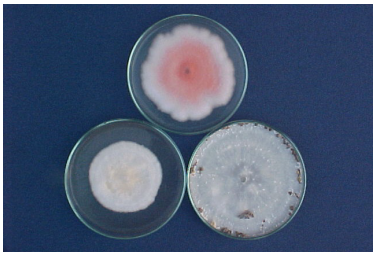
All the faba bean germplasm which was collected explored and were carefully evaluated. After three years of evaluation, entries were deposited to NBPGR, New Delhi along with Passport datasheet and evaluation report for its national accessioning and long term storage in National Gene Bank and National Identification Number knows as Indigenous Collection Numbers (IC Numbers) has been received from NBPGR, New Delhi.

LENTIL

Management of Wilt Complex of Lentil (*Lens culinaris* Medikus) through Bio-agents Coupled with Host Resistance

A survey of lentil fields was conducted in ten district's of Bihar. On an average, 5 fields of lentil in each village were visited and the per cent wilt incidence was recorded (Fig. 36 & 37). The data revealed heavy disease incidence in the fields of Pandarak (38.68%) followed by Gaya (36.91%) and moderate in Maranchi (35.58%). The lowest disease incidence was, however, recorded in the fields of Daniyawaha (16.47%) and Nagarnausa (17.08%).

Fig. 36. Patches to patches of wilted lentil plants in fields



1. *Fusarium oxysporum f.* sp. lentis (Tal) 2. *F. oxysporum f.* sp. lentis (Digha) 3. *Sclerotium rolfsii* (Maranchi)

Fig. 37. Cultures features of pathogen on PDA

Cultural variability of *Trichoderma* spp.

Morphological characteristic of 30 *Trichoderma* spp. isolated from soil samples of different places were studied. On the basis of cultural characteristics all the 30 isolates of *Trichoderma* spp. were grouped into I to X Groups. On the basis of mycelial growth as fluffy mycelial and suppressed mycelial growth. These groups were further characterized on the basis of sporulation (good, moderate and abundant), ring formation and presence or absence of pigmentation. Under fluffy mycelial growth, five groups *viz.*, I, II, III, IV and V were categorized.

Development of Bio-insecticide Modules for Management of Gram Pod Borer *Helicoverpa armigera* (Hubner) in Chickpea Crop

The disease infested larvae of entomopathogenic fungus was assessed by undertaking an intensive field study. Naturally infested larvae of entomopathogenic fungus were found occasionally in the month of August in soybean crop, October in rice and January in cabbage, respectively. During survey, different crops naturally infected with typical symptons of the fungus were collected from farmers' fields and brought to the laboratory. All the samples, collected from different locations, were subjected to isolation on selective medium in the isolation condition and maintain in pure culture in laboratory (Fig. 38-40).

Five microbial bio insecticides of fungal, bacterial and viral origin in different doses have been used against one of the most serious pest *H. armigera* that alone shares a major portion of damage to the crops. The 1.5 % concentration of bioinsecticide caused 86.7% mortality in 3rd larval instar of *H. armigera* (Table 21).

Fig. 38. *Beauveria bassiana* infested larvae in rice crop

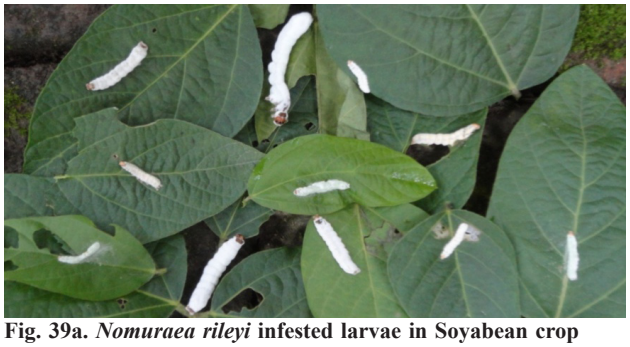


Fig. 39a. *Nomuraea rileyi* infested larvae in Soyabean crop

Fig. 39b. Sporulation stage of *Nomuraea rileyi* (green muscardine fungus)

Fig. 40. *Nomuraea rileyi* infested larvae in cabbage field

Table 21. Efficacy of different bioinsecticides on 3rd Instar larvae *Helicoverpa armigera* (Hubner)

Bioinsecticides	Doses (per cent)	% mortality
Nuclear polyhedrosis viruses (NPV) 100LE	0.1	16.7
	0.25	16.7
	0.5	20.0
	1.0	63.3
	1.5	70.0
Beauveria bassiana	0.1	20.0
	0.25	26.7
	0.5	26.7
	1.0	36.7
	1.5	56.7
Metarrhizium anisopliae	0.1	10.0
	0.25	6.7
	0.5	16.7
	1.0	30.0
	1.5	36.7
Nomuraea rileyi	0.1	23.3
	0.25	23.3
	0.5	30.0
	1.0	73.3
	1.5	86.7
Bacillus thuringiensis (B.t.)	0.1	20.7
	0.25	26.7
	0.5	46.7
	1.0	76.7
	1.5	80.00
Control	Nil	6.66

7

FRUITS

MANGO

Plant Genetic Resource Management

Under the trial on germplasm evaluation, 89 mango genotypes were evaluated for fruit quality and yield. The average fruit weight ranged between 33.6 g (Ratnagiri Alphanso) to 545.0 g (Hamlet). The genotype Zarda recorded the minimum peel content (6.94%) whereas the minimum seed content (10.56%) was recorded in the genotype Sahabale. The maximum pulp content (79.04%) was recorded in case of the genotype *Bastara*. Other genotypes *viz.,* Yogada Selection-1, Zarda, Alphanso, Barbelia, ICARRCERMS-1 (Fig 41) were found promising for high pulp content (>70%). The maximum TSS (25.0^{O}B) was recorded in case of *Dashehari* and other genotypes *viz.,* Bombaiya, Lucknow Safeda, Rani Pasand, Krisha Bhog, Safeda Mallihabadi, Makkhan, Mithua Bihar, Khasul Khas, Husn-e-Ara, Alphanso, Nayab, Prabhasankar, Chinnarasam, Swarnarekha, Rataul, Mundappa Black, Hyder Saheb and ICARRCERMS-1 were found promising for high TSS (>19^{O}B). With respect to yield, among the genotypes of age more than 25 years, Rajapuri recorded the maximum yield (30.0 kg/plant) whereas among the genotypes of age between 15-18 years, the maximum yield was recorded in case of *Hyder Saheb* (22.8 kg/plant). Keeping in view the fruit quality, the genotype ICARRCERMS-1 (5 years age) was found to be most promising (round shaped fruit with red blush at shoulder of fruit, average fruit weight 266.5g, pulp content-70.32%, TSS- 19.2^{O}B).

Under the trial on performance evaluation of mango hybrids, 25 hybrids released from different parts of the country were evaluated for fruit quality and yield. The hybrids, Jawahar, Sundar Langra, A.U. Rumani, Mahmood Bahar, PKM-1, Swarna Jahangir, Alfazli, Arka Aruna, Manjeera, Neelgoa, Arka Neelkiran and Pusa Arunima were found promising for fruit weight (>200 g). With respect to pulp content, the hybrids Jawahar (Fig 42), Neeleshan, Alfazli and Arka Aruna recorded higher values (pulp content >70%). High TSS of pulp (>19^{O}B) was recorded in case of hybrids Sabri, Jawahar, Sundar Langra, Neeluddin, Ratna and Sindhu. The hybrids, Jawahar, Prabhasankar, Mahmood Bahar and Amrapali were high yielders (> 15 kg/plant in 12 years old plants). Hence, keeping in view the fruit quality and yield, the mango hybrid Jawahar exhibited its consistency in superiority over other hybrids under eastern plateau and hill conditions.

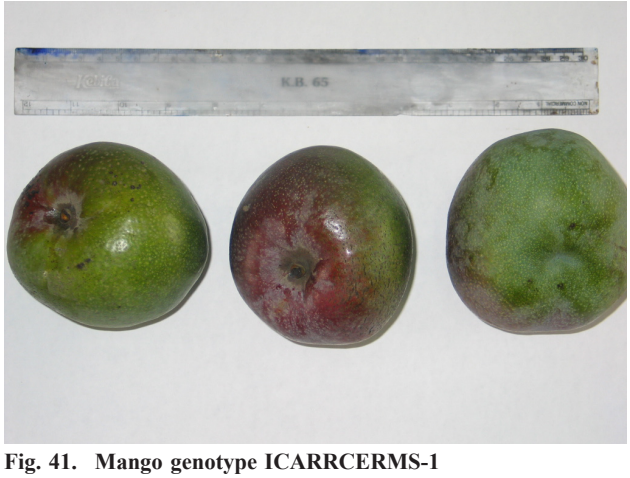


Fig. 41. Mango genotype ICARRCERMS-1

Fig. 42. Mango hybrid Jawahar

Standardization of Interstock for Induction of Dwarfing in Vigorous Mango Cultivars Growing Under Eastern Plateau and Hill Conditions

The trial is being conducted with the objectives to test the efficacy of use of mango cultivars Amrapali and Latra as interstocks for inducing dwarfness in vigorous mango cultivars. During the second year of experimentation, the plant height of single grafted plants of Langra was significantly higher than double grafted plants of Langra with both types of interstocks. However, in case of other cultivars like Himsagar and Bombay Green, the height of single grafted plants did not differ significantly from double grafted plants with mango cultivar Amrapali as intrerstock. The significantly lower values of double grafted plants with Latra as interstock can be attributed to initial delay in establishment of the plants in the field. Similar trend was recorded in case of girth of rootstock and girth of scion. With respect to girth of interstock, significantly lower values of both the interstock (Latra and Amrapali) were recorded in case of mango cultivar Langra. Hence, during the second year of orchard establishment, slower growth of double grafted plants of mango cultivar Langra with interstock of cultivar Amrapali could be recorded whereas no such trend could be recorded with mango cultivars Himsagar and Bombay Green (Fig. 43).

LITCHI

Evaluation of Germplasm

The trial was undertaken to identify suitable genotype of litchi for cultivation under eastern plateau and hill conditions. Forty one litchi genotypes were evaluated for fruit quality and yield. The genotypes Rose Scented and Trikolia were found promising for average fruit weight (fruit wt > 20 g). With respect to pulp content, the genotypes Late Bedana, Bedana, Shahi, D.Rose, Surguja Selection-1 were found promising (>70%). The maximum TSS (21.4^{o}B) was recorded in case of Rose Scented (Fig. 44). The genotypes China, Bedana, Rose Scented, Swarna Roopa and Yogada selection were found promising for high TSS/acidity ratio. The minimum fruit cracking (0%) was recorded in case of Purbi. Among the genotypes with plant age more than 30 years, the maximum yield (36.8 kg/plant) was recorded in case of Rose Scented. Hence, keeping in view the fruit quality and yield, the performance of litchi genotype Rose Scented was found to be the most promising during the year.

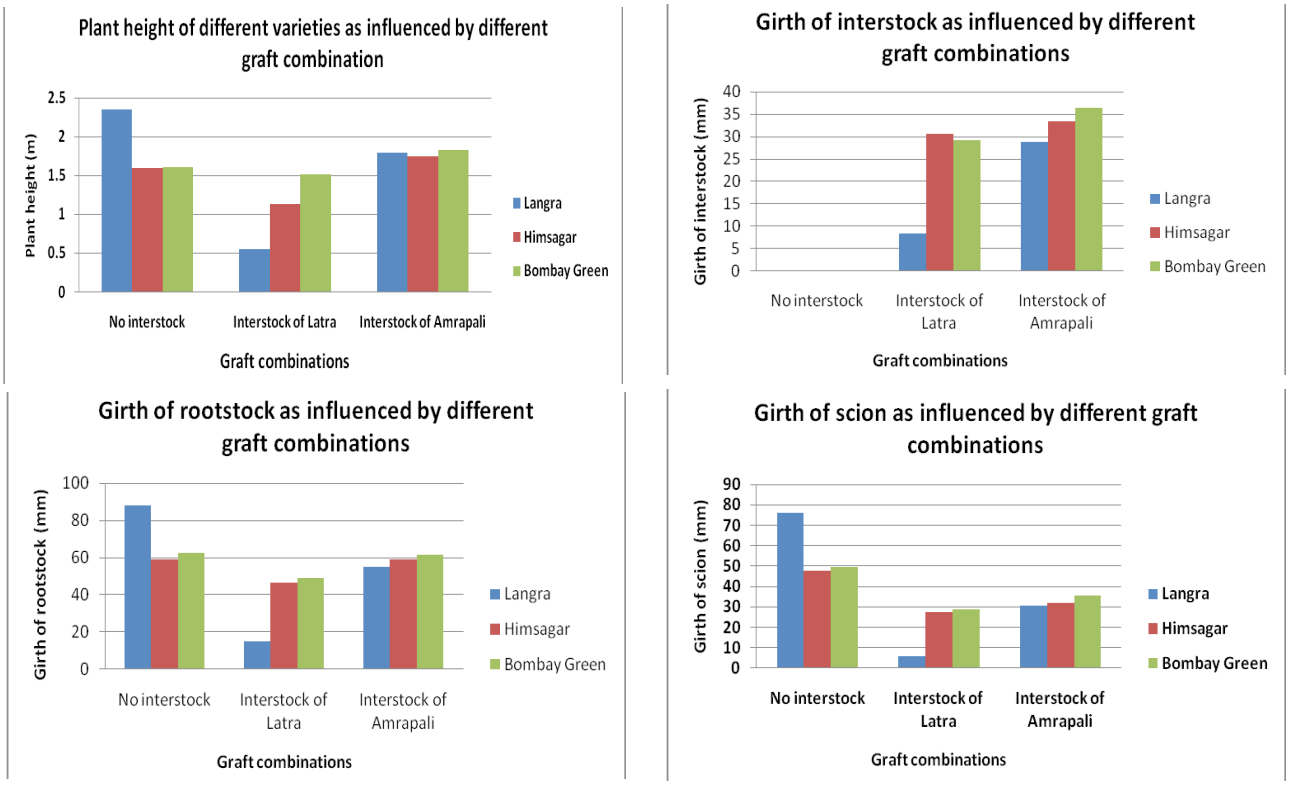
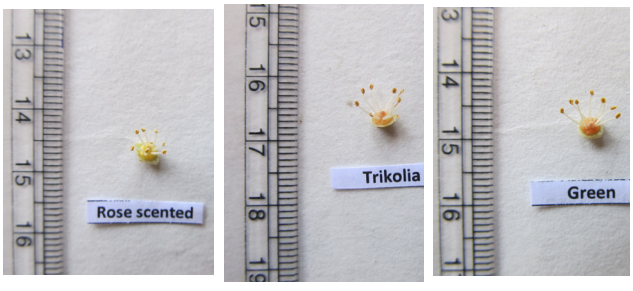


Fig. 43. Efficacy test by using mango cultivars Amrapali and Latra as inter stocks for inducing dwarfness in vigorous mango cultivars

Fig. 44. Litchi genotype Rose Scented

Developing National Repository and Creating Facilities for DUS Testing in Litchi (*Litchi chinensis*)

The project was undertaken to validate litchi descriptors for their utility for developing DUS guidelines and to develop characteristic database of litchi varieties from DUS point of view. Based on the 32 characters identified for DUS characterization of litchi, 41 genotypes were characterized. As recorded during the first year of characterization, genotypes could be successfully differentiated based on characters like young leaf colour, leaflet blade shape, leaf margin curvature, leaflet apex shape, leaf shape index and fruit shape. Apart from this, floral morphology was recorded to be a consistent character for distinguishing the litchi genotypes. Based on flower disc colour of male flower, the genotypes could be grouped as Light cream (Ajhouli, Desi, Rose Scented, Longia, Shahi, Surguja Selection 2, CHES 3, CHES 4,CHES 5, Late Large, VKG 8/6, *Nafarpal*), light yellow (Late Bedana, China, Bedana, Kasba, Dehradun, Dehra Rose, Rose scented (Fig. 45a), CHES 2, Bombaiya 1, Bombaiya 2, Swarna Roopa, Yogda Selection, Surguja Selection 1, CHES 2-1, Lal Bombaiya, CHL 7, VKG 8/1, CHL 8, VKG 8/5, Illaichi, Rukka Collection), dark yellow (Green, Srikolia Green) and pink (Trikolia (Fig. 45b), *Purbi,* Green (Fig. 45c). Based on the characters identified, a draft document on "Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability of Litchi (*Litchi chinensis* Sonn.)" has been prepared.



a. Rose scented **b. Trikolia** **c. Green**

Fig. 45a-c. Diversity of flower disc colour in litchi

Biology, Seasonal Incidence and Management of Stink Bug (*Tessaratoma* sp.) on Litchi in Eastern Plateau and Hill Region

The trial is being conducted to develop a better understanding of biology of stink bug of litchi in order to develop effective control measures. Observations on seasonal incidence of litchi stink bug indicated that the hibernating adults aggregated only on four out of 100 monitored Shahi variety plants (6-8 adults per shoot on particular plants but average population of bug were 0.47 to 0.87 bug/shoot) from October 2011 to January 2012. After hibernation, the activation and dispersion of adults to other litchi plants coincided with emergence of panicles on the Shahi variety of litchi. Mating of the adults started from the first week of February 2012. The colonization of adults started on litchi plants during the first week of February 2012, and during the second week of February 2012 the first egg mass was observed on the lower surface of tender leaves. The mean density of egg masses was 11.66 egg clusters/m^2 plant canopies (range 8-15 egg clusters) from the first week of March 2012 to the third week of April 2012. The population of immature stages of stink bug increased drastically from the second week of March and the highest population (159 nymphs/30 cm shoot length) (Fig. 46) was recorded during the first week of April (Fig. 47). Frequent movement of the adults and nymphs of the litchi stink bug from one plant to another was recorded throughout the study period. This can be attributed to resource shortage due to exhaustive feeding by the insects.

Data on varietal susceptibility of litchi plants against bug showed less population of litchi bug on genotypes Purbi, Dehradun, L4/36 and CHES-5. Exploration of natural enemies of litchi stink bug resulted in recording of four egg parasitoids of litchi stink bug. Three were from the family Eupelmidae and one from the family Encyrtidae of order Hymenoptera. Among parasitoids recorded, only two were identified namely Anastatus bangalorensis (Fig. 47) and Anastatus acherontia (Fig. 48). Among these, *A. bangalorensis* (59.19%) was most abundant species, infesting eggs of bug followed by unidentified eupelmid (22.42%), *A. acherontia* (15.69%) and unidentified encyrtid (2.69%).

Observation on biological parameters of bug showed that a single egg cluster consisted mostly of 14 eggs (ranged between 10 and 16 eggs per cluster). The newly laid eggs were globular in shape, pink in color (sometimes white also) but their color became slightly blackish before hatching. Under the field cages,

Fig. 46. Large number of litchi stink bug nymphs on twig of litchi plant

Fig. 47. Adult female of *Anastatus bangalorensis*

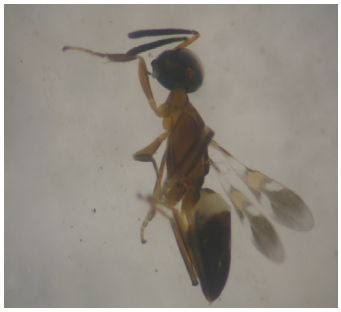


Fig. 48. Adult female of *Anastatus acherotiae*

a maximum of 16 egg batches (mean 13.40 egg batches, range10-16, n=10) were laid by the single gravid female. The eggs were hatched in 12.80±1.40 days (range 9–18 days, n=70). Five instars of the insect were observed in the field cages. The mean developmental period of first, second, third, fourth and fifth instar nymphs was 11.69±0.58 (range 10–13 days, n=61), 7.23±0.20 (range 7–8 days, n=61), 8.63±0.55 days (range 8–10 days, n=42), 13.04±0.55 and 26.31+0.97 days (11–14 days, n=50), respectively.

Testing of efficacy of insecticides against litchi stink bug in laboratory conditions indicated that chlorpyriphos, DDVP, quinolphos and acephate showed maximum efficacy against litchi stink bug with 95 to 100 percent mortality.

BAEL

Evaluation of Bael Germplasm

Ten bael genotypes conserved at the field gene bank of the institute were evaluated for their performance under eastern plateau and hill conditions based on yield and fruit quality characters like average fruit weight, pulp per cent, seed number, TSS, total sugar, reducing sugar, non-reducing sugar, value of TSS:acidity. Average fruit weight ranged between 0.94 kg (Godda Collection) to 2.20 kg (Pant Shibani). Pulp content ranged between 72.02% (Pant Sujata) to 76.62% (Pant Aparna). The genotype Deoria recorded the minimum number of seeds per fruit (61.0) whereas the maximum number of seeds per fruit (164.7) was recorded in case of Pant Shibani. The maximum TSS (48.6^{O}B) was recorded in case of Pant Urvashi. Other genotypes like Pant Aparna, Begusarai Collection and Deoria Collection also had high TSS (>35^{O}B). The cultivar Pant Aparna (Fig. 50) recorded the maximum fruit yield (39.6 kg per plant). Hence, based on overall performance (average fruit weight-1.33 kg, pulp content-76.62%, TSS-36^{O}B), the cultivar Pant Aparna was found to be the most promising during the year.

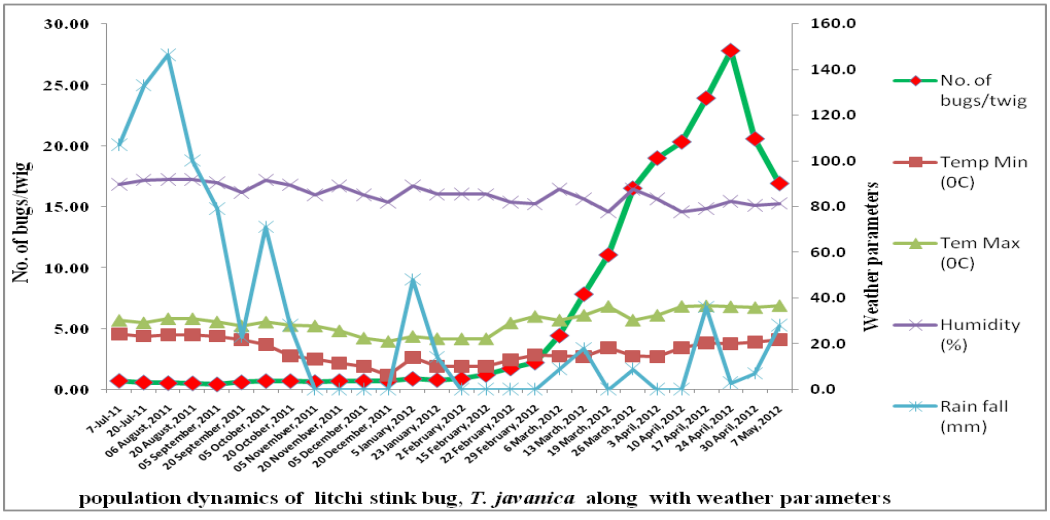


Fig. 49. Seasonal incidence of litchi stink bug (*T. javanica)* along with weather parameters

Fig. 50. Bael genotype Pant Aparna found most promising

JACKFRUIT

Evaluation of Jackfruit Germplasm

In Jackfruit, 55 genotypes were evaluated for fruit quality of ripe fruits based on 33 parameters. The average fruit weight ranged from 3.53 (ICAR-RCER RC 1/10) to 14.57 kg (ICAR-RCER RC 10/2). The rind content ranged between 33.13% (ICAR-RCER RC 1/9) to 72.24% (ICAR-RCER RC 5/13). The number of flakes per fruit ranged between 41 (ICAR-RCER RC 1/9) to 758 (ICAR-RCER RC 1/10). Maximum weight of flake (44.25 g) was recorded in case of the genotype ICAR-RCER RC 1/9. With respect to seed content, the genotypes ICAR-RCER RC 12/8, 1/10, 10/2, 16/3, 5/4, 5/11, 6/13, 11/10, 2/10, 3/13, 2/15, 1/13, 1/14 and 3/15 were found promising for high seed content (>20.0% of total fruit weight). The maximum pulp content per flake (88.31%) was recorded in case of the genotype ICAR-RCER RC 1/9. The genotypes ICAR-RCER RC 7/2, 1/6, 6/12, 12/8, 2/10, 16/3, 5/4, 5/11, 6/13, 2/1, 3/13, 2/15, 1/14 and 3/15 were found promising for higher value of contents suitable for human consumption (>70%). Vivipary was not recorded in genotypes ICAR-RCER RC 4/5, 3/7, 3/8, 6/12, 5/13, 5/14, 6/9, 14/12, 4/14, 2/10, 16/3 and 2/6. The TSS of flakes ranged between 16.9 ^{0}B (ICAR-RCER RC 7/2) to 28.9^{O}B (ICAR-RCER RC 1/10). Based on overall performance the jackfruit genotype ICAR-RCER RC 2/10 was found to be most promising for fruit quality (Medium sized and cylindrical shaped fruit having >70% pulp content per flake, more than 80% of total fruit biomass suitable for human consumption with 0% vivipary, TSS >25^{O}B and fibreless flakes with pleasant flavour (Fig. 51)

a. Fruit

b. Flakes

Fig. 51. Fruit and flakes of jackfruit genotype ICAR-RCER RC 2/10

SAPOTA

Evaluation of Sapota Germplasm

Performance of 12 sapota genotypes were evaluated for fruit quality and yield under eastern plateau and hill conditions. The average fruit weight ranged between 86.0 g (Kirthibathi) to 191.85 g (Mahayothi). The genotype Murrabba recorded the highest pulp content (93.86%) whereas the minimum number of seeds per fruit (2) was recorded in case of Cricket Ball. The genotypes Kalipatti, Murrabba and Mahayothi were found promising for high TSS (>30^{O}B). With respect to plant vigour, the genotypes DHS-1 and DHS-2 were found to be vigorous, PKM-1 was found to be dwarf whereas other genotypes were found to be semi-vigorous. The maximum yield (29.58 kg/plant) was recorded in case of the genotype Murrabba. Hence, keeping in view the fruit quality and yield the sapota genotype Murrabba exhibited consistency in its superiority among the genotypes evaluated (Fig. 53).

Fig. 52. Sapota genotype Murrabba

8

VEGETABLES

BRINJAL

Evaluation of Bacterial Wilt Resistant Lines

Out of the twelve promising lines of brinjal that were tested in bacterial wilt sick plot with artificial inoculation, two lines were found resistant at 90 days after transplanting *viz.*, HAB-905 (Fig. 53) and HAB-906 (Fig. 54). These lines have been entered under multi-location evaluation trial of AICRP.

Fig. 53. HAB - 905

Fig. 54. HAB - 906

Varietal evaluation

Under AICRP, in brinjal long variety AVT-I, highest yield was recorded in 2010/BRLVAR-3 (15.16 t/ha) followed by 2010/BRLVAR-1 (13.07 t/ ha), which performed better than the national check cv. Kashi Tarou (8.91 t/ha). In brinjal round AVT-I, highest yield was recorded in 2010/BRRVAR-6 (29.67 t/ha), followed by 2010/BRRVAR-5 (26.47 t/ha), which performed better then the best check Swarna Mani (24.49 t/ha). In brinjal round hybrid IET, highest yield was recorded in 2011/BRRHYB-I (50.37 t/ha), followed by 2011/BRRHYB-2(47.92 t/ha) which performed better then the best check hybrid EPH-178 (28.27 t/ha). In brinjal round hybrid AVT-II, highest yield was recorded in 09/BRRHYB-5 (61.65 t/ha), followed by 09/BRRHYB-2 (51.98 t/ha) which performed better than the best check variety Swarna Mani (40.98 t/ha). In brinjal long hybrid IET, highest yield was recorded in 2011/BRLHYB-6 (37.28 t/ha), followed by 2011/BRLHYB-1 (34.33 t/ha) which performed better than the best check hybrid ARBH-201 (27.03 t/ha). In brinjal long hybrid AVT-II highest yield was recorded in 09/BRLHYB-2 (21.99 t/ha), followed by 09/BRLHYB-3(19.82 q/ha) which performed better than the best check variety Punjab Sadabahar (18.22 t/ha).

Screening for bacterial wilt resistance

Under AICRP AVT-I, all the six enteries tested viz; BRBRES-1, BRBRES-2, BRBRES-3, BRBRES-4, BRBRES-5 and BRBRES-6 exhibited susceptible reaction. The check (SM-6-6) showed resistant reaction whereas the other resistant check Arka Nidhi showed susceptible reaction during the year under report. In AVT-II, out of five enteries *viz.*; BRBRES-1, BRBRES-2, BRBRES-3, BRBRES-4 and BRBRES-5 tested in bacterial wilt sick plot, BRBRES-4 recorded as resistant.

Characterisation of bacterial wilt resistance gene(s) in brinjal using conventional and molecular approaches

Evaluation of F_2s and parents for bacterial wilt resistance and segregation studies

Evaluation of all the 36 F_2s those were developed from 36 F_1s among the parents *viz.,* Swarna Shree (P_1), Swarna Sobha (P_2), Swarna Mani (P_3), HAB-381 (P_4), HAB-792 (P_5), HAB-900 (P_6), HAB-901 (P_7), Swarna Shyamali (P_8) and Swarna Pratibha (P_9) was carried out under artificially inoculated and wilt sick plot conditions during the rainy season. Preliminary segregation studies using chi-square analysis indicated 3:1 ratio of inheritance for per cent survival and per cent wilted plants in eight crosses and 1:3 ratio in seven crosses (Table 22). Complementary, duplicate and inhibitory gene action was recorded in some crosses indicating presence of interaction among two resistance genes (Fig. 55 & 56).

Table 22. Survival of F_2s against bacterial wilt under artificial wilt sick plot conditions

Designation of F_2s/ parents	Survival (%) at 90 DAT	Designation of F_2 s / parents	Survival (%) at 90 DAT	Designation of F_2 s / parents	Survival (%) at 90 DAT
1x2	44	3x5	5	6x9	81
1x3	22	3x6	18	7x8	90
1x4	59	3x7	31	7x9	52
1x5	86	3x8	2	8x9	59
1x6	79	3x9	13	p1	10
1x7	68	4x5	46	p2	20
1x8	74	4x6	72	p3	0
1x9	30	4x7	76	p4	75
2x3	4	4x8	30	p5	55
2x4	55	4x9	53	p6	50
2x5	80	5x6	89	p7	80
2x6	26	5x7	49	p8	30
2x7	44	5x8	68	p9	30
2x8	26	5x9	99	PPL (check)	0.0
2x9	15	6x7	87		
3x4	21	6x8	58		

Fig. 55. Swarna Mani X HAB-381 F_2(susceptible)

Fig. 56. HAB-901 x Swarna Shyamli F_2(resistant)

Combining ability in F_1s for wilt resistance and yield under wilt sick plot

Combining ability studies in F_1 for wilt resistance and yield under wilt sick plot was carried out using SPAR3. Per cent survival at 90 days after transplanting (DAT) showed positive significant GCA effects indicating additive gene action. Yield per plant showed positive significant GCA and SCA (Table 23) effects indicating both additive and non additive gene action. HAB 381, HAB 792, HAB 900 and HAB 901 showed significant positive GCA effects for percent plant survival. Significant positive GCA effects for yield per plant under wilt sick plot by HAB 792, HAB 900 and HAB 901. None of the crosses showed positive significant SCA effects for percent plant survival. HAB 792 X HAB 900, HAB 792 X HAB 901 and HAB 900 X HAB 901 are showing significant positive SCA effects for yield per plant under wilt sick plot.

Table 23. Analysis of variance for GCA and SCA

Source of variance	Percent survival at 90 DAT	Yield/plant
GCA	3505.3**	47105.9**
SCA	192.2	3078.8**
GCA/SCA ratio	4.63	2.33

* Significant at 5%, ** significant at 1% level

Combining ability of F_1s for yield and yield characters

Combining ability study in F_1 for yield and yield characters was carried out using SPAR3 package. Positive significant GCA effects were recorded in all the characters under study indicating additive gene action. Positive significant SCA effects were recorded in all the characters except for yield per plant and branches per plant indicating both additive and non additive gene action (Table 24).

Evaluation of F_2s for yield and yield components

All the 36 F_2s were transplanted in field with 100 plants per cross and data on per cent survival at 90 DAT, days to first flowering, fruit colour, fruit shape, leaf

Table 24. Analysis of variance for GCA and SCA for 8 characters

Source of variance	Yield/plant	Fruits/plant	Plant height	Branches/ plant	Fruit weight	Fruit length	Fruit breadth	Days to 50% flowering
GCA	0.19**	244.10**	341.26**	0.26*	13563.44**	13.48**	8.04**	49.37**
SCA	0.06	15.27*	100.36**	0.11	2029.34**	2.62**	1.28**	21.31**
GCA/SCA ratio	3.93	2.83	0.37	1.38	0.66	0.49	0.59	0.24

spine-ness, plant pigmentation, plant height, number of fruits per plant and yield per plant were collected. Preliminary data analysis showed higher yield per plant for plant no.12 from the cross 8 x 9 (6.78 kg per plant).

Development of F_1 hybrids through full dialled fashion using bacterial wilt resistant lines

Full diallel crosses have been developed among the ten parents *viz.,* HAB-905, HAB-906, HAB-901, HAB-913, IC-261793, IC-545931, IC-545941, IC-112993, IC-545901 and IC-261786 (Fig. 57) which include bacterial wilt resistant screened germplasm of advance breeding lines and germplasm collections.

IC - 545931 HAB-906

HAB 905 IC 545941

IC 261786 IC 545901

Fig. 57. Parents development of F_1 hybrids through full dialled fashion using bacterial wilt resistant lines

TOMATO

Evaluation of F_1 Hybrids of High Yielding Bacterial Wilt and Root-Knot Nematode Resistant Parents in Half Diallel Mating Design

Evaluation of 36 half diallel crosses having root knot and bacterial wilt resistance along with 9 parents *viz.,* P_1 (Swarna Lalima), P_2 (HADT-294), P_3 (HADT-295), P_4 (HADT-296), P_5, (HADT-297), P_6 (HADT-306 BWR), P_7 (HADT-310 BWR and root knot resistance), P_8 (HADT-312-BWR) and P_9 (EC-596742) (Fig. 58) was carried out. Half diallel analysis was done using ICARSTAT package. Combining ability revealed significant GCA effects for yield per plant or per ha basis (Table 25).

Combining ability analysis indicated that fruit breadth had positive significant GCA for HADT -294, and positive significant SCA effects for the following crosses 1x7, 1x8, 2x3, 2x4, 2x6, 2x7, 2x8, 3x9, 5x6, 5x8, 5x9, 6x7and 6x9; Fruit length had positive significant GCA for EC-596742; Fruit weight had positive significant GCA for *S*warna Lalima, HADT-294, HAT

HADT-306 X HADT-312 HADT-306 X HADT-310

HADT 294 HADT-297 x EC-596742

Fig 58. Evaluation of F_1 hybrids of high yielding bacterial wilt and root-knot nematode resistant parents in half diallel mating design

Table 25. Combining ability analysis

Source of variation	Yield per plant (kg)	Yield per ha	No. of fruits/ Plant	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	TSS (^{0} brix)	No. of locules	Placental thickness (cm)
GCA	1.43**	907.79**	231.34*	1128.08**	3.72	1.09**	0.81**	0.48	0.004
SCA	0.38**	232.02**	93.99**	413.46**	2.44	0.35**	0.19**	0.62	0.003**

*P = 0.05, **P = 0.01

306, positive significant SCA effects for the crosses 1x3, 1x4, 1x7, 2x3, 2x4, 5x6, 5x8, 5x9,6x7 and 6x9; No. of fruits per plant had positive significant GCA for Swarna Lalima and HADT–295 and positive significant SCA effects for 1x7, 2x7, 2x8, 3x6, 4x6, 4x8, 6x8; Yield per plant (kg) had positive GCA effects for Swarna Lalima, HADT 294, HADT-295, positive SCA effects for the crosses, 1x4, 1x7, 2x4, 5x9, 6x7, 6x8, 8x9; Yield (q/ha) had positive GCA effects for Swarna Lalima, HADT 294, HADT- 295, positive SCA effects for the crosses, 1x4, 2x7, 5x6, 5x9, 6x7, 6x8. Among the parents Swarna Lalima, HADT-294 and HADT 295 were the best and among the crosses 5x9, 6x7 and 6x8 were the best.

Varietal evaluation

Under AICRP, in tomato determinate hybrid IET, 2011/TODHYB-3 (66.75 t/ha) followed by 2011/TODHYB-8 (52.01 t/ha) performed better than the best check ARTH-3 (35.8 t/ha). In tomato Determinate hybrid AVT-I, 10/TODHYB-2 (62.3 t/ha) followed by 10/TODHYB-8 (52.8 t/ha) performed better than the best check variety DVRT-2 (26.6 t/ha). Similarly, determinate hybrid AVT-II, 09/TODHYB-4 (59.6 t/ha) followed by 09/TODHYB-2 (51.7 t/ha) performed better than the best check variety DVRT-2 (26.6 t/ha). In tomato determinate varietals IET, highest yield was recorded in 2011/TODVAR-3 (47.5 t/ha) followed by 2011/TODVAR-1 (38.1 t/ha) and performed better than the best check variety H- 86 (29.4 t/ha). In tomato determinate varietals AVT-II, highest yield was recorded in 2009/TODVAR-3(49.3 t/ha) followed by 2009/TODVAR-5 (42.4 t/ha) and performed better than the best check variety H-86 (29.4 t/ha). In tomato, indeterminate varietals IET, highest yield was recorded in 2011/TOINDVAR-5 (52.2 t/ha) which performed better than the best check variety Arka vikash (43.8 t/ha).

CHILLI

Varietal evaluation

Nine advance breeding lines were evaluated for their performance, out of which 4 individual plant progeny selected for further study in F_7 generation (**Table 26**). Highest yield was recorded in HC-51 x HC-62-1-2-6 (1.6 kg/plant, no. of fruits per plant 671) and HC-62 X HC-34-1-4-1 (1.55 kg/plant, No. of fruits per plant 456) followed by HC-62 x HC-34-2-1-1 (1.51 kg/plant, No. of fruits per plant 606). Under AICRP in chilli AVT-II, highest yield was recorded in 2009/CHIVAR-5 (15.6 t/ha) followed by 2009/CHIVAR-4 (14.4 t/ha) which performed better than the check variety LCA-334 (8.0 t/ha) (Fig. 59-61).

Table 26. Performance of chilli advance breeding lines (F_7)

Designation of cross	No. of fruits per plant	Yield per plant (kg)	Yield (t/ha)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)
HC-7 X HC-23-1-9-3	448.0	1.02	13.8	2.80	6.30	0.80
HC-62 X HC-34-2-1-1 (Fig. 61)	606.0	1.51	21.8	2.60	5.92	0.70
HC-8 X HC-5-4-4-1	468.0	0.95	18.3	2.60	8.10	0.68
HC-8 X HC-51-2-2-8	347.0	1.10	18.4	3.20	7.60	0.82
HC-33 X HC-5-1-1-2	525.0	1.30	12.0	2.60	6.84	0.74
HC-51 X HC-62-1-2-6 (Fig. 59)	671.0	1.60	20.0	2.20	5.48	0.70
HC-51 X HC-62-1-4-1	628.0	1.15	15.6	2.20	6.78	0.68
HC-62 X HC-34-1-4-1 (Fig. 60)	456.0	1.55	20.4	3.0	7.36	0.68
HC-8 X HC-34-2-2-16	661.0	1.38	19.3	2.20	5.52	0.64

Fig. 59. HC-51xHC-62-1-2-6

Fig. 60. HC-62xHC-34-1-4-1

Fig. 61. HC-62xHC-34-2-1-1

CAPSICUM

Development of Improved Variety Suitable for Open Field Condition

Five capsicum lines were evaluated for their suitability of cultivation under open field condition (Table 27). Out of them HACAV-271-7-8-9 (yield/plant 1.05 kg, no. of fruits/plant 12) and HACAV-845-3-1-18 (yield/plant 0.80kg, no. of fruits / plant 10) recorded higher yield than others (Fig. 62).

Table 27. Evaluation of promising lines of capsicum

Designation of progeny	No. of fruits per plant	Yield per plant (kg)	Yield (t/ha)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)
HACAV-271-15-2-3	5.0	0.45	18.0	134.0	8.0	7.5
HACAV-271-7-8-9 (Fig. 62)	12.0	1.05	42.3	107.0	9.3	6.2
HACAV-845-3-1-18	10.0	0.80	32.2	118.0	9.0	6.4
HACAV-271-5-10	6.0	0.49	19.8	104.0	8.0	6.0
HACAV-845-20-5-2	5.0	0.45	18.1	95.0	5.0	7.0

HACAV 271-7-8-9

HACAV 271-7-8-9

Fig. 62. No. of fruits/plant of capsicum

Varietal evaluation

Under AICRP, in capsicum hybrid AVT-I, highest yield was recorded in 2010/CAPHYB-2 (17.1 t/ha) followed by 2010/CAPHYB-4 (16.7 t/ha) which performed better than the best check variety Nishat (9.0 t/ha). In capsicum hybrid AVT-II, highest yield was recorded in 2009/CAPHYB-2 (17.5 t/ha) followed by 2009/CAPHYB-5(16.0 t/ha) which performed better than the best check Nishat (12.9 t/ha). In capsicum varietal IET, highest yield was recorded in 2011/CAPVAR-1-(24.0 t/ha) followed by 2011/CAPVAR-5 (18.7 t/ha) which performed better than the best check Nishat (17.5 t/ha). In capsicum varietal AVT-II, highest yield was recorded in 2009/CAPVAR-4 (16.6 t/ha) followed by 2009/CAPVAR-6(16.2 t/ha) which performed better than the check Nishat (10.2 t/ha).

CUCUMBER

Development and Evaluation of F_1 Hybrid

Twenty eight F_1s were developed from eight parents *viz.,* HACGM-2 (P_1), HACGM-3(P_2), HACGM-4 (P_3), HACGM-5 (P_4), HAC-158(P_5), HAC-159 (P_6), HAC-160(P_7), and HAC-163 (P_8) (collected from NEH region, fruiting only in rainy season) using gynomonecious and developed lines from *C. hardwiicki* in half diallele fashion. Evaluation of all the half diallel crosses alongwith parents were carried out with two replications in RBD. Half diallel analysis was done using ICARSTAT.

Combining ability revealed significant SCA effects for no. of fruits per plant, yield per plant, node at which first female flower appears and days to 50% flowering and significant GCA effects for fruit length, placental thickness (Table 28).

Combining ability analysis indicated that number of fruits per plant had positive significant GCA for HACGM-3, HAC-158 and positive significant SCA effects for the crosses, 2*x*8 and 7*x*8; fruit length had positive significant GCA for HACGM-2 and positive significant SCA effects for 2*x*5; fruit weight had positive significant SCA effects for the crosses 2*x*5; yield per plant (kg) had positive GCA effects for HAC-159, positive SCA effects for the crosses, 4*x*6 and 7*x*8; flesh thickness had significant positive SCA for 1*x*8, 5*x*7; placental thickness had significant positive GCA for HACGM-3, node at which first female flower appears had significant negative GCA for HACGM-4 and HAC-159 and negative significant SCA for 1*x*7, 5*x*8 : days to 50% flowering had negative GCA for HACGM-2 and negative SCA for 6*x*7. Among the parents HACGM-3, HACGM-5, HAC-159 (Fig. 63) were the best and among the crosses 2x8,7x8 (Fig. 64) and 4*x*6 were the best.

Table 28. Combining ability analysis

Source of Variation	No. of fruits per plant	Yield per plant	Yield per ha	Fruit weight	Fruit length	Fruit breadth	Flesh thickness	Placental thickness	Node at which first female flower appears	Days to 50 % flowering
GCA	6.28	1.7	1099.15	770.2	4.88*	0.25	0.011	0.032*	4.87	16.86
SCA	3.57**	0.14*	1563.97	1897.3	1.92	0.17	0.012	0.012	3.54*	9.99*

*P = 0.05, **P = 0.01

Fig. 63. HAC-159

Fig. 64. HAC-160 X HAC-163

Varietal evaluation

Under AICRP, in cucumber varietal IET, highest yield was recorded in 2011/CUCUVAR-5 (1.7 t/ha) followed by 2011/CUCUVAR-1 (1.4 t/ha).

BITTER GOURD

Evaluation of F_1s

Twenty one F_1s those developed from seven parents *viz.,* HABG-23 (P_1), HABG-24 (P_2), HABG-28 (P_3), HABG-29 (P_4), HABG-30 (P_5), HABG-31 (P_6), and HABG-34 (P_7) in half diallele fashion were evaluated for yield and growth characters with two replications. Half diallel analysis was done using ICARSTAT package.

Combining ability revealed significant SCA effect for no. of fruits per plant, yield/plant, yield in q/ha, fruit weight and vine length and both GCA and SCA effects significant for fruit breadth (Table 29).

Combining ability analysis indicated that number of fruits per plant had positive significant SCA effects for the crosses 1x7, 2x5 and 3x6; fruit breadth had positive significant GCA for HABG-30 and positive significant SCA effects for 3x4 and 5x7; fruit weight had positive significant GCA for HABG-30, positive significant SCA effects for the crosses 2x5, 3x4 and 6x7; yield per plant (kg) had positive GCA effects for HABG-30, positive SCA effects for the crosses, 1x7 and 2x5; yield in t/ha had significant GCA for HABG-30 and significant positive SCA for 1x5, 1x7 and 2x5; Vine length had significant GCA for HABG-23 and HABG- 30, significant positive SCA for 1x7, 2x5,3x4 and 3x6; days to 50% flowering had negative SCA for 2x5 and 4x5. Among the parents HABG- 30 was the best and among the crosses 2x5 (Fig. 65) was the best.

Fig. 65. HABG-24 X HABG-30

Varietal evaluation

Under AICRP, in bitter gourd hybrid IET, highest yield was recorded in 2011/ BIGHYB-2 (8.7 t/ha) followed by 2011/ BIGHYB-4 (5.7 t/ha).These hybrids performed better than the check cv. Vivek (4.0 t/ha).

BOTTLE GOURD

Advancement of segregating generation (F_5)

On the basis of evaluation under natural field conditions, four segregating population *viz.*, HABOG-16xHABOG-13-2-1, HABOG-9xHABOG-13-2-1, HABOG-17xHABOG-10-6-5 and HABOG-10-xHABOG-26-3-2 were found resistant against fusarium wilt. Selfed seeds were harvested for further study in F_6 generation

Table 29. Combining ability analysis

Source of Variation	No. of fruits per plant	Yield per plant	Yield per ha	Fruit weight	Fruit length	Fruit breadth	Days to 50 % flowering	VL
GCA	3.99	0.03	1134.43	650.38	10825.38	0.25*	4.45	0.22
SCA	6.27*	0.03**	1048.02**	312.59**	15799.31	0.08*	4.32	0.11**

*P = 0.05, **P = 0.01

PUMPKIN

Varietal evaluation

In Pumpkin varietal AVT-I, highest yield was recorded in 10/PUMVAR-2 (8.5 t/ha) followed by 10/PUMVAR-1 (7.6 t/ha) which performed better than the check variety CM-350 (5.0 t/ha)

LONG MELON

Varietal evaluation

Under AICRP, in varietal IET on long melon, highest yield, was recorded in 2011/LGMVAR-3 (19.2 t/ha) followed by 2011/LGMVAR-1 (16.5 t/ha). These entries performed better than the check Punjab long melon (13.8 t/ha.)

PEA

Development of powdery mildew resistant cultivars

To develop powdery mildew resistant early garden pea lines for testing under AICRP, 8 powdery mildew resistant and early maturing F_5 progenies of the crosses VRR-16 x IPS-1(6 progenies) and JP-585 x VRP-16 (2 progenies) were selected and advanced to exercise selection pressure in next generation. Under AICRP screening trial, all the five entries viz; PMPM-1, PMPM-2, PMPM-3, PMPM-4, and PMPM-5 were resistant to powdery mildew under natural condition whereas the susceptible check showed susceptible reaction during the year under report.

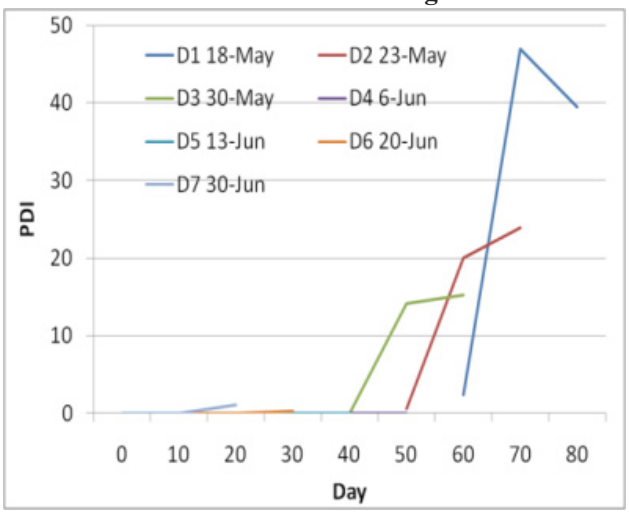
COWPEA

Varietal evaluation

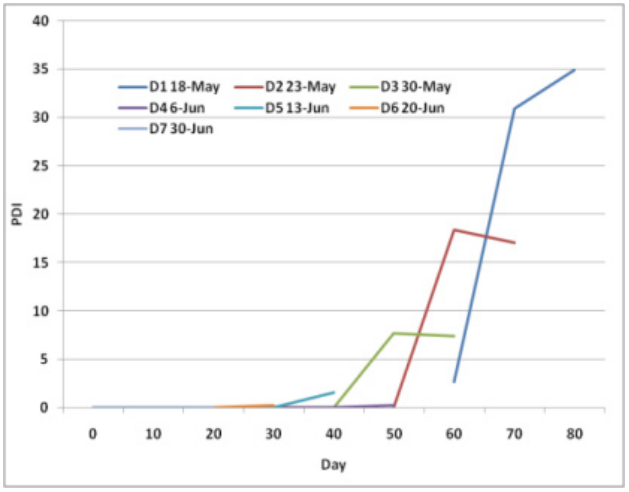
Under AICRP, in cowpea (bush) IET, the entries 2012/COPBVAR-1 (14.13 t/ha), 2012/COPBVAR-5 (11.52 t/ha) and 2012/COPBVAR-3 (10.11 t/ha) performed better than the check variety Kashi Kanchan (8.67 t/ha). In cowpea (bush) AVT-I, the entries 2011/COPBVAR-6 (12.25 t/ha) and 2011/COPBVAR-7 (9.71 t/ha) performed better than the check variety Kashi Kanchan (8.67 t/ha).

Epidemiology of most important diseases

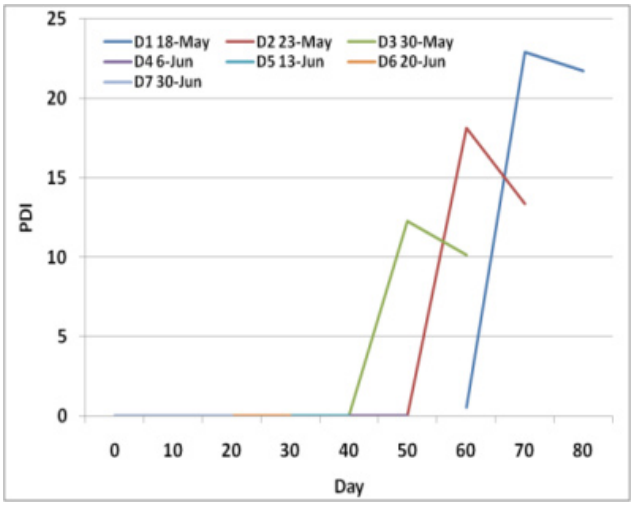
The experiment was conducted with seven dates of sowing with three varieties viz; HAC44, HAC43 and *Pusa Komal*. The rust caused by *Uromyces appendiculatus* disease was not seen during the year but anthracnose was seen on early sown plants at 60 day of sowing , progressed at 70 day old and later on its progress was declined. The variety wise progress of anthracnose incidence is shown in **Fig. 66a-c.**



a) HACP-44



(b) HACP-43



(c) Pusa Komal

Fig. 66a-c. Progress of anthracnose in cowpea on different days on different cultivars

LEAFY VEGETABLES

Leaf Amaranth

Out of 12 multi-cut type germplasm lines evaluated for three years along with 2 checks *viz.*, Pusa Lal Chaulai and Pusa Kirti, the red leaved line HAMTH-15 (19.38 t/ha) and the green leaved line HAMTH-13 (17.43 t/ha) were found promising and stable. HAMTH-15 also recorded the maximum content of vitamin C (40 mg/100 g), carbohydrate (7.87%) and potassium (199 mg/100 g) (Table 30 & 31).

Table 30. Nutrient composition of leafy amaranth lines (per 100 g edible portion)

Lines	Carbo-hydrate (g)	Protein (g)	Vitamin C (mg)	Fibre (g)	Phos-phorus (mg)	Potas-sium (mg)	Calcium (mg)
HAMTH-15	7.87	2.24	40.83	10.83	50.02	199	216
HAMTH-13	5.69	2.02	7.70	7.33	45.36	164	187
HAMTH-21	4.12	1.91	12.08	6.00	39.48	128	198
HAMTH-43	4.45	2.49	26.87	7.00	46.52	156	258
Pusa Lal Chaulai	5.82	2.53	32.70	8.00	54.65	167	271
Pusa Kirti	3.61	2.34	25.00	7.50	43.57	137	267
Pusa Kiran	6.40	2.56	19.37	5.33	39.34	150	256
CD at 5%	1.80	0.45	2.01	2.46	NS	30	27.5

Table 31. Nutrient composition of leafy amaranth lines (per 100 g edible portion)

Lines	Mag-nesium (mg)	Sul-phur (mg)	Iron (mg)	Manganese (mg)	Copper (mg)	Zinc (mg)
HAMTH-15	115	65	4.08	6.67	0.018	1.13
HAMTH-13	113	38	6.30	5.00	0.090	0.89
HAMTH-21	151	78	4.58	3.43	0.082	0.72
HAMTH-43	112	76	5.68	6.28	0.139	0.94
Pusa Lal Chaulai	140	89	6.93	5.56	0.143	1.06
Pusa Kirti	129	87	4.68	5.18	0.018	1.17
Pusa Kiran	114	78	4.00	6.83	0.038	1.10
CD at 5%	23.3	30	1.64	0.90	0.031	0.13

Grain Amaranth

Fourteen germplasm lines of grain amaranth species (**Fig. 67**) *viz.*, *Amaranthus cruentus* (5), *A. caudatus* (4) and *A. hypochondriacus* (5), received from NBPGR Regional Station, Phagli, Shimla, Himachal Pradesh, were evaluated and maintained through fresh seed multiplication for further evaluation. Among these lines, EC-150199 (109.3 g/plant) performed best in respect of grain yield.

Other Leafy Vegetables

The germplasm lines of palak (2), methi (2), coriander (2), Malabar night shade/poi (2), Lai sag (7), Kang kong (1), Chinese cabbage (1) and *bathua* (*Chenopodium* spp.) (3) were maintained. Among these

Fig. 67. Promising line of grain amaranth at flowering stage

leafy vegetables, the maximum content of vitamin C (208.33 mg/100 g) was found in local collection of fenugreek. The local collection of coriander recorded the maximum content of protein (3.62 g/100 g), potassium (728 mg/100 g) and iron (11.92 mg/100 g). The maximum content of calcium (178 mg/100 g) was found in Chinese cabbage and Kang Kong. Kang Kong (*Ipomoea aquatica*) line also contained the maximum content of manganese (5.37 mg/100 g) and zinc (1.12 mg/100 g). The radish variety Japanese White contained the maximum amount of sulfur (42 mg/100 g).

DRUMSTICK

Twenty six germplasm lines are being maintained in the field gene bank. Among four promising vegetative propagated perennial lines, the fruits of HADS-4 recorded the maximum content of vitamin C (21.88 mg/100g) whereas those of HADS-6 recorded the maximum content of protein (2.69 g/100g), calcium (50.89 mg/100 g), copper (0.36 mg/100g) and zinc (0.44 mg/100g) (**Table 32 & 33**).

Table 32. Nutrient composition of drumstick lines (per 100g fruits)

Lines	Carbo-hydrate (g)	Protein (g)	Vitamin C (mg)	Fibre (g)	Phospho-rus (mg)	Potassium (mg)	Calcium (mg)
HADS-4	12.26	2.57	21.88	5.91	78.81	143	21.90
HADS-6	16.34	2.69	17.92	7.13	62.48	168	50.89
HADS-26	10.90	1.88	17.50	6.21	61.39	145	49.29
HADS-38	11.74	1.88	15.00	11.00	66.39	161	36.52
CD at 5%	NS	0.27	4.20	NS	NS	NS	8.55

Table 33. Nutrient composition of drumstick lines (per 100 g fruits)

Lines	Magnesium (mg)	Sulfur (mg)	Iron (mg)	Copper (mg)	Zinc (mg)
HADS-4	38.32	64.04	0.86	0.22	0.40
HADS-6	50.79	99.78	1.54	0.36	0.44
HADS-26	44.41	57.82	0.80	0.13	0.31
HADS-38	33.76	80.22	0.84	0.22	0.33
CD at 5%	NS	NS	NS	0.125	0.073

UNDERUTILIZED BEANS

Lablab/Dolichos Bean

A total of 51 germplasm lines including 11 photo-insensitive lines were maintained through fresh seed multiplication. The promising photo-insensitive lines/variety HADB-32, HADB-119 and Swarna Rituvar were tested in 28 farmers' field conditions/KVKs. The maximum yield of the fleshy and flat green pod HADB-119 (2.68 kg/plant; 44.66 t/ha) was recorded at Divyayan KVK, Morabadi, Ranchi whereas that of the round and green podded HADB-32 (1.56 kg/plant; 26.0 t/ha) was recorded in Anidih, Bundu, Ranchi. The flat and creamy podded Swarna Rituvar recorded the maximum yield of 1.43 kg/plant (23.83 t/ha) in Karambu, Bundu, Ranchi. During the harvest period in August-September, the off-season produce (fresh pods) of these lines/variety fetched market price of ₹ 40-50/- per kg. Under AICRP, in Dolichos bean (bush type) AVT-I, the entry 10/DOLVAR-5 (21.94 t/ha) performed better than the check variety Arka Jay (19.23 t/ha). In Dolichos bean (pole type) AVT-I, the check variety Swarna Utkrisht (37.68 t/ha) out yielded all the entries.

Vegetable Soybean

A total of 31 germplasm lines of vegetable soybean including 8 basmatic lines were maintained through seed multiplication. Out of 7 basmatic vegetable soybean lines evaluated, the lines AGS-447 (7.7 t/ha), AGS-458 (7.5 t/ha) and AGS-456 (7.2 t/ha) were found promising in respect of graded (2 & 3-seeded) green pod yield and earliness. These lines became ready for 1st green pod harvest in 65 days after sowing, i.e., 14 days earlier over non-basmatic vegetable soybean variety Swarna Vasundhara. The lines also recorded >50% recovery of fresh shelled green grains which were having characteristic basmatic (scented rice) after boiling flavour. On the basis of nutritional composition per 100 g edible portion, the high yielding line AGS-458 recorded the maximum content of protein (11.28 g), carbohydrate (12.25 g), phosphorus (230 mg), potassium (682 mg), iron (5.224mg) and higher amount of calcium (91.9 mg), magnesium (97.7 mg) and manganese (0.5 mg) (Table 34 & 35). AGS-461 recorded the maximum content of vitamin C (26.46 mg), calcium (161.25 mg), copper (0.245 mg) and zinc (1.768 mg). The maximum content of magnesium, sulfur and manganese was recorded in AGS-459 (118.56 mg), AGS-456 (99.921 mg) and AGS-457 (0.668 mg), respectively.

Table 34. Nutrient composition of *Basmatic* vegetable soybean lines (per 100 g edible portion)

Lines	Carbohydrate (g)	Protein (g)	Vitamin C (mg)	Phosphorus (mg)	Potassium (mg)	Calcium (mg)
AGS-447	8.42	8.98	14.79	213	553	97.91
AGS-456	10.97	10.47	13.33	175	627	122.09
AGS-457	9.89	9.02	16.46	172	590	123.18
AGS-458	12.25	11.28	13.54	233	682	91.92
AGS-459	8.43	9.26	22.92	207	641	88.34
AGS-460	8.11	10.26	20.83	196	588	63.15
AGS-461	10.06	10.37	26.46	212	558	161.25
Swarna Vasundhara	10.28	8.84	26.04	186	636	111.45
CD at 5%	NS	1.61	6.32	NS	209	NS

Table 35. Nutrient composition of *Basmatic* vegetable soybean lines (per 100g edible portion)

Lines	Magnesium (mg)	Sulfur (mg)	Iron (mg)	Manganese (mg)	Copper (mg)	Zinc (mg)
AGS-447	93.66	74.747	4.394	0.524	0.219	1.410
AGS-456	82.50	99.921	4.615	0.599	0.180	1.576
AGS-457	65.32	94.119	4.391	0.668	0.220	1.503
AGS-458	97.43	92.300	5.224	0.578	0.228	1.706
AGS-459	118.56	58.074	4.414	0.550	0.189	1.645
AGS-460	103.41	80.629	3.952	0.469	0.172	1.397
AGS-461	58.73	83.759	4.553	0.595	0.245	1.768
Swarna Vasundhara	57.07	65.384	4.394	0.510	0.098	1.426
CD at 5%	NS	22.63	0.587	NS	NS	0.216

Nineteen lines/varieties of vegetable soybean were received from AVRDC Regional Centre for South Asia, Hyderabad for evaluation. Out of these, AGS-380 recorded the maximum green pod yield (15.57 t/ha) and green seed yield (7.58 t/ha) followed by Swarna Vasundhara which recorded green pod yield and green seed yield of 13.29 t/ha and 6.89 t/ha, respectively. AGS-380 (73 days) was also one week earlier to Swarna Vasundhara (80 days) in respect of days to 50% green pod maturity.

Under Multi-location trial initiated by the Directorate of Soybean Research, Indore, five lines/varieties of vegetable soybean were evaluated. Out of these, Swarna

Vasundhara recorded the maximum graded green pod yield (9.62 t/ha) with 52.52% recovery of fresh shelled green beans (grains).

Rice Bean

One new germplasm line of rice bean was collected from Mokokchung district of Nagaland. Totally, two lines including one dull yellow seeded and another maroon seeded were maintained for use in rice-legume production system.

Faba Bean

Twenty germplasm lines were maintained and evaluated for 3 years. The lines HAVFB-41 (35.72 t/ha) and HAVFB-37 (34.69 t/ha) were found stable and high yielding in respect of green pod yield.

Yam Bean

Two germplasm lines were maintained. The line HAYB-1(tuber yield 59.9 t/ha) performed better than Rajendra Mishri Kand-1 (tuber yield 44.4 t/ha).

Lima Bean

Two germplasm lines were maintained. The nucleus seed (77.5 kg) of the identified promising white seeded lima bean line HALB-1 was produced for demonstration trial.

Other Beans

The germplasm lines of winged bean (11), sword bean (2), velvet bean (3), Jack bean (1) and cluster bean (1) were maintained through fresh seed multiplication.

MUNG BEAN

Eight germplasm of mungbean received from AVRDC RCSA, Hyderabad were evaluated along with K-851 (check) both in summer and kharif seasons. The lines/varieties *viz.*, CN-9-5 (2.27 t/ha) and VC-3890 A (2.26 t/ha) performed better than the check K-851 (1.74 t/ha) in respect of dry grain yield and were found very promising for summer season cultivation. CN-9-5 (7.4 g) was also very promising in respect of 100 dry seed weight. Among the same lines when tested during kharif season, NM-92 (3.22 t/ha), Harsha (3.16 t/ha) and CN-9-5 (3.10 t/ha) were found promising for grain yield.

VEGETABLE PIGEON PEA

Seven diverse germplasm lines were evaluated and maintained. The nucleus seed (15.3 kg) of the identified promising purple podded and purple mosaic seeded line HAVPP-1 was produced for demonstration/trial.

9

MUSHROOM

Evaluation of Substrates and Assessment of Water Requirement for Commercial Production of Oyster Mushroom

The trial was conducted to assess the performance of oyster mushroom on different substrates and estimate the water requirement for commercial production of oyster mushroom. Analysis of nutrient content of different substrates indicated significant difference in the content (Table 36). Soybean substrate content had maximum nitrogen followed by maize.

Table 36. Nutrient analysis of different substrates during 2012

Substrate	Nitrogen (%)	Phosphorus (%)	Potash (%)	Sodium (%)	Copper (ppm)	Iron (ppm)	Zinc (ppm)	Manganese (ppm)
Wheat	0.46	0.14	1.07	0.21	10.10	488.2	33.67	44.10
Paddy	0.34	0.03	1.50	0.26	10.30	561.1	67.30	805.10
Maize	0.69	0.11	1.22	0.36	13.20	424.8	138.45	890.60
Soybean	1.21	0.22	1.31	0.40	15.70	231.8	33.03	95.80
Ragi	0.58	0.10	1.24	0.36	11.53	668.7	73.50	882.93
CD (P0.05)	0.17	0.02	0.05	0.04	2.22	N/A	31.33	14.95
CV (%)	14.36	10.82	2.11	6.96	9.89	46.85	24.58	1.49

Biological efficiency (BE) of different mushrooms on different substrates

Estimation of biological efficiency revealed that the maximum efficiency of oyster species was on paddy straw for *P. florida* (118.1%) followed by ragi (60.15%) and maize straw (56.7%), and minimum was on soybean straw (51.85%). Soybean substrate was, however, found to be the best substrate for blue oyster (*H. ulmarius*) production with a BE of 107.9% followed by paddy straw (100.3%).

Water use efficiency in mushroom production

Estimation of water use efficiency of oyster species on different substrates indicated that *Pleurotus florida* need 19.1 litres of water to produce 1 kg of mushroom on paddy straw substrate. Similarly, the water requirement was recorded to be 21.9, 22.9 and 34.5 litres to produce 1 kg of mushroom on maize, soyabean, and ragi straw substrates, respectively (Fig. 68).

In case of Blue oyster (*H. ulmarius*), amount of water required for production of 1 kg of mushroom was estimated to be 16.5, 17.1, 30.2 and 38.2 litres, respectively, when soyabean, paddy, maize stalk and ragi straw substrate was used.

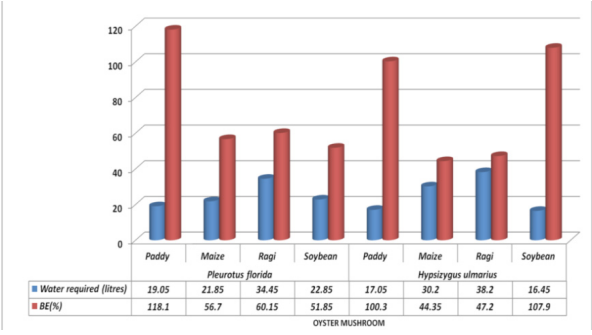


Fig. 68. Water use efficiency and Biological efficiency of oyster mushroom on four substrates

Biochemical constituents of fruiting bodies of mushroom

The nutrient contents (Table 37) and biochemical constituents viz; protein, soluble protein, carbohydrate and ascorbic acid (Table 38) of four oyster mushroom viz; *P. sajor caju, P. ostreatus, P. florida* and *Hypsizygus ulmarius* were determined. There was a significant difference in the content of all the above biochemical parameters. The maximum protein content was recorded in *P. ostreatus* (25.62%) and the maximum ascorbic acid (30.47 mg/100 g) was found in *P. sajor caju.*

Table 37. Nutrient content of fruiting bodies of oyster mushroom

Kind of Mushroom	Primary (%)			Secondary (%)				Minor (ppm)		
	N	P	K	Ca	Mg	S	Na	Fe	Cu	Zn
P. sajor caju (Str.P7)	3.19	0.82	1.38	0.25	0.33	0.14	0.26	150.20	17.83	48.43
P. ostreatus	4.10	0.81	1.55	0.26	0.13	0.24	0.26	172.33	42.53	58.17
P. florida	2.61	0.61	1.49	0.16	0.32	0.19	0.28	191.30	30.68	59.18
Hypsizygus ulmarius	2.73	0.62	1.39	0.18	0.43	0.18	0.26	192.67	30.83	59.70
CD (P0.05)	0.01	0.02	0.06	NA	0.09	0.03	0.01	NA	2.41	3.05
CV (%)	1.55	1.75	2.09	21.46	15.19	9.29	1.55	13.58	4.14	2.83

Table 38. Biochemical constituents of fruiting bodies of oyster mushroom

Kind of Mushroom	Protein (%)	Soluble protein (%)	Carbohydrate (%)	Ascorbic acid (mg/100g)
P. sajor caju (Str.P7)	19.95	0.28	4.11	30.47
P. ostreatus	25.62	0.68	3.00	18.83
P. florida	16.30	0.53	3.16	19.80
Hypsizygus ulmarius	15.50	0.30	3.60	17.27
CD (P0.05)	1.36	0.07	0.38	5.08
CV (%)	3.68	7.65	5.67	12.31

Cellulose utilization pattern of oyster mushroom on different substrates

The cellulose utilization pattern of oyster mushroom on different substrates was estimated and has been presented in Table 39 and Fig. 69 (a,b,c & d). It was noticed that there was no significant change in the content of cellulose in the substrate till 20 days of spawning. Later on, there was a significant change in the content of cellulose during 30 to 60 days of spawning in all the substrates.

Table 39. Cellulose utilization (%) by different oyster mushroom on different substrates

Substrate	Kind of oyster	Initial (day)	Incubation period (day)		Production period (day)		
		0	20	30	40	50	60
Paddy	*Pleurotus florida*	34.8	6.5	39.7	14.4	7.7	18.5
	Hypsizygus ulmarius		9.4	57.2	16.4	8.7	17.4
Maize	*Pleurotus florida*	34.5	4.9	20.3	10.5	14.2	16.8
	Hypsizygus ulmarius		7.5	68.3	12.4	15.2	16.7
Ragi	*Pleurotus florida*	20.2	11.4	32.3	15.0	3.7	26.7
	Hypsizygus ulmarius		10.1	42.4	22.9	8.3	26.7
Soybean	*Pleurotus florida*	24.1	17.0	6.5	20.1	15.4	NT
	Hypsizygus ulmarius		16.5	6.9	28.3	15.6	NT

NT= Not Tested

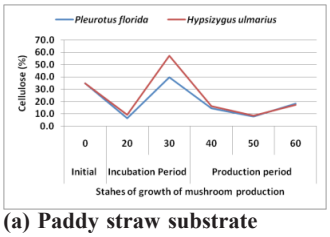
Collection, Identification and Conservation of Wild Edible Mushrooms

The following local germplasms lines were collected and preserved. The sample of *Polypore* sp., found on ber (*Ziziphus mauritiana*), has been deposited to Directorate of Mushroom Research, Solan (Table 40 & Fig. 70).

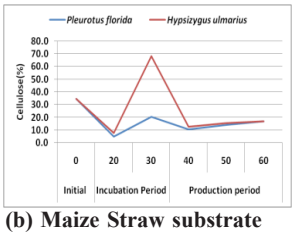
Table 40. Particulars of mushroom collections from local market

Local name	Scientific name	Name/ market/ district	Date of collection	Sale price (₹/Kg)	Mode of consumption (fresh/ dried/ both/raw/ Cooked as vegetable/ with rice etc.)	Any association with tree(s) / soil type etc.	Temperature range
Rugra	*Sclerodermasp.* sp.	Sec-2 Ranchi	17.07	200-250	Fresh	Sal tree	20-25°C
Bada Khukhri	*Termitomycetes* sp.	Ranchi	24.07	300-600	Fresh	TN	30-35°C
Muchu Khukhri	*Termitomycetes* sp.	Ranchi	24.07	-	Fresh	TN	30-35°C
Muchu Khukhri	*Termitomycetes* sp.	Ranchi	24.07	-	Fresh	TN	30-35°C
Namak Khukhri	*Termitomycetes* sp.	Plandu	24.07	-	Fresh	TN	30-35°C
	Polypores sp.	Sarai-toli	24.07		Fresh	Ber	30-35°C
Patra	*Russula* sp.	Sec-2 Ranchi	30.07	100	Fresh	DL	30-35°C
Tecnas	*Cococybe cyanopus*	Ranchi	05.08	200	Fresh	DL	30-35°C

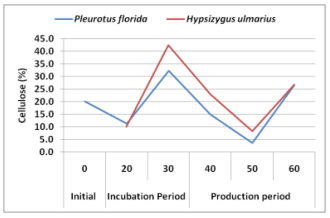
NK=Not Known, DL=Decaying leaves, TN=Termite nest



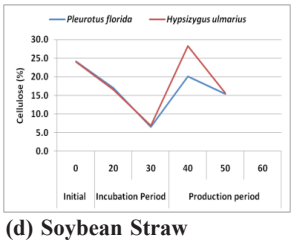
(a) Paddy straw substrate



(b) Maize Straw substrate



(c) Ragi Straw substrate



(d) Soybean Straw

Fig. 69. Substrate wise cellulose utilization (a, b, c & d) by two oyster mushrooms

Muchu Khukhri

***Polypore* sp. on *Zizuphus jujuba* tree**

***Termitomycetes* sp. fruiting bodies emerging from termite nest**

***Termitomycetes* sp.**

***Russula* sp.**

***Termitomycetes* in soil**

Tecnas

***Rugra (Scleroderma* sp.)**

***Termitomycetes* sp.**

Fig. 70. Mushroom collected from forest and sold in Ranchi market

Strain evaluation of Oyster Mushroom (*Pleurotus* sp.)

Out of five strains tested in June on paddy straw (Table 41) and six strains in October 2012 (Table 42) on wheat straw, the strain PL-11-04 resulted in maximum BE (60.4%) on paddy straw substrate. On wheat straw, PL-11-02 recorded maximum BE (72.1%) followed by PL-11-04 (64.1%).

Table 41. Performance of strains of *Pleurotus* sp.

Strains	Bag wt (kg)	Av yield /bag	Yield /kg dry wt	BE%
PL-11-01	3.73	418	448.26	44.8
PL-11-02	3.26	215.6	264.54	26.42
PL-11-03	2.79	181	259.50	2595
PL-11-04	3.96	598	604.04	60.4
PL-11-05	3.92	363.5	370.92	37.09
CD (P0.05)		135.30		

Table 41. Performance of strains of oyster mushroom (*Pleurotus* sp.) during 2011 & 2012

Strains	2011		2012*		2012**		Pooled	
	Yield/bag (g)	BE (%)	Av. yield /bag	BE%	Yield /bag (g)	BE (%)	Yield/bag (g)	BE (%)
PL-11-01	298.0	39.7	418.0	44.8	661.8	69.8	459.3	51.4
PL-11-02	782.0	104.3	215.6	26.42	729.0	85.7	575.5	72.1
PL-11-03	216.0	28.8	181.0	2595	571.1	64.7	322.7	39.8
PL-11-04	455.0	60.7	598.0	60.4	614.8	71.2	555.9	64.1
PL-11-05	220.8	29.4	363.5	37.09	499.7	60	361.3	42.2
PL-11-06	510.0	68.0	-		308.5	37.6	363.8	35.2
CD(P0.05)	265.39		135.30		140.0		180.2	

* Mean of 10bags during June 2012 ** Mean of 20 bags during October to Dec. 2012

10

Makhana

Collection, Characterization, Bioevaluation, Conservation Descriptor, Documentation, Value Addition and Utilization of Makhana

Fourteen germplasm from Purnia and Katihar districts of Bihar and 2 germplasm from Odisha were collected for their characterization, multiplication and utilization. Twenty six makhana germplasm were characterized and evaluated for various qualitative andquantitative characters (Table 43 & Fig. 71).

Development of Sequential Double Cropping of Makhana for Increasing Its Production and Productivity

Makhana is a very important aquatic crop of north Bihar, grown in thousands of natural water bodies. In these water bodies, it takes on an average 10 months to complete one cycle. Due to its longer growth period, only one crop of makhana in a year is possible in these water bodies. To enhance the production and productivity of makhana, an experiment on sequential double cropping of makhana was conducted. To verify the validity of experimental results over the years, same experiment was repeated during the year 2012. In this experiment, to raise first crop of makhana (spring crop), healthy seedlings of Sel-6 strain were transplanted at a spacing of 1.20 x 1.25 m in a well prepared shallow field on 15th February, 2012. All standard packages of practices were adopted to raise the crop. The harvesting was done on 2nd July, 2012 with the seed yield of 3.12 t/ha (Fig. 72). Immediately after the harvesting of spring crop, the transplanting of off-season crop was made on 5th July, 2012 in the same experimental field. All standard packages of practices were also adopted for this crop. The crop of makhana was ready by the end of October and harvesting was made on 9th November, 2012 with a seed yield of 2.27 t/ha (Fig. 73). The yield data of these two sequential crops of makhana revealed that in agriculture fields, makhana crop can be grown successfully twice in a year. The findings of this study could be of immense help to enhance the production and productivity of makhana in agricultural fields.

Makhana cultivation in agricultural fields through adoption of Barseem-Green gram-Makhana cropping system

In this experiment, sowing of barseem was made on 15th November, 2011. All the standard packages of practices were adopted to raise the crop. Total fodder yield of 82.6 t/ha was obtained in four cuttings. Green gram was cultivated in the same field on 17th April 2012

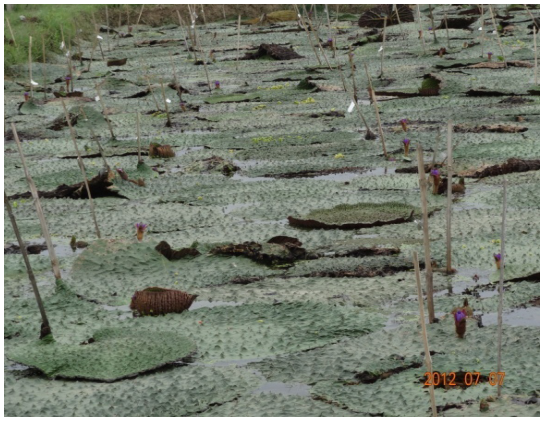


Fig. 71. Growth of makhana germplasm

Fig. 72. Rabi season makhana crop

Fig. 73. Rainy season makhana crop

Table 43. Germplasm data of year 2012-2013

Code	Average no of leaves	Leaf size (LxW)(cm)	Total no. of flowers	Total no. of fruits (Av.)	Average diameter of fruits (cm)	Average weight of fruits (gm)	Average No. of spines (cm)	Average biomass (fresh weight) kg)
DR-1	4.1	83.6X75.69	9.00	9.00	24.00	130.930	15.00	14.238
DR-2	4.2	78.8X72.2	9.00	9.00	25.00	108.715	18.00	10.211
DR-3	4.2	79.8X74.6	8.00	10.00	22.00	121.494	13.00	11.242
DR-4	4.4	60.8X54.6	8.00	9.00	21.00	174.169	15.00	14.241
DR-5	4.2	71.4X66.6	8.00	10.00	23.00	106.433	26.00	10.211
DR-6	4.0	64.6X62.0	9.00	10.00	22.00	95.265	22.00	13.202
DR-7	3.4	67.2X62.6	7.00	8.00	24.00	185.094	9.00	14.087
DR-8	3.4	71.4X65.8	8.00	11.00	23.00	130.930	11.00	12.214
MN-1	3.0	55.2X49.8	8.00	10.00	20.00	185.094	19.00	14.242
MN-2	4.2	60.8X56.0	9.00	11.00	22.00	120.202	10.00	11.200
MN-3	4.0	49.8X45.8	8.00	9.00	21.00	118.233	29.00	11.111
MN-4	3.75	61.5X55.2	7.00	8.00	19.00	124.211	28.00	12.122
MN-5	4.2	69.6X63.4	7.00	8.00	23.00	125.422	39.00	7.635
MN-6	3.0	64.2X60.2	8.00	10.00	24.00	180.242	27.00	5.412
MN-7	3.2	67.6X56.8	8.00	9.00	22.00	100.202	30.00	6.875
MN-8	3.8	62.4X57.2	8.00	8.00	21.00	175.160	27.00	7.450
MN-9	3.2	58.4X54.4	7.00	8.00	24.00	190.875	9.00	4.064
MN-10	4.0	54.7X51.0	8.00	8.00	22.00	200.121	23.00	5.598
MN-11	4.2	70.2X66.0	9.00	10.00	23.00	125.265	24.00	8.910
MN-12	4.2	76.2X70.4	10.00	10.00	21.00	173.242	44.00	13.245
MN-13	4.2	65.0X60.0	9.00	11.00	25.00	160.505	20.00	5.721
MN-14	4.0	56.2X51.6	8.00	9.00	20.00	140.212	30.00	7.851
MN-15	4.2	71.4X65.6	10.00	10.00	21.00	150.232	21.00	10.230
MN-16	5.0	76.2X75.8	9.00	10.00	19.00	98.211	15.00	6.421
MN-17	4.4	55.0X69.2	8.00	10.00	22.00	180.233	29.00	9.635
MN-18	4.8	86.4X82.4	9.00	9.00	25.00	190.567	25.00	14.120

without any application of chemical fertilizers. By the end of June, green gram was harvested with a grain yield of 1.36 t/ha. After harvesting of green gram, the field was ploughed twice for preparation of makhana transplanting and was filled with water for fast decomposition of green gram residues. Makhana was transplanted on 7th July, 2012 without application of chemical fertilizers. It was ready for harvest by the end of October, 2012 and harvested on 9th November, 2012 with the grain yield of 2.07 t/ha. From the findings of this experiment, it is revealed that in agricultural fields, makhana can be grown in an organic way with the inclusion of barseem and green gram (Fig. 74-76).

Evaluation of an Elite Strain (Sel-6) of Makhana

Through pure line selection, some strains of makhana were developed. On the basis of yield potential, one strain (Sel-6) has been identified most suitable so far in productivity is concerned. For stability point of view as-well-as farmer's acceptance, this strain is under testing for last three years. During 2011-12, the seed yield of this strain was recorded to be 3.16 t/ha against 1.83 t/ha of local check at the experiemental farm of the institute. In farmers' field, the productivity of this strain was recorded to be 3.09 t/ha against 1.68 t/ha from local check (Fig. 77).

Fig. 74. A view of barseem crop

Fig. 75. A view of mung crop

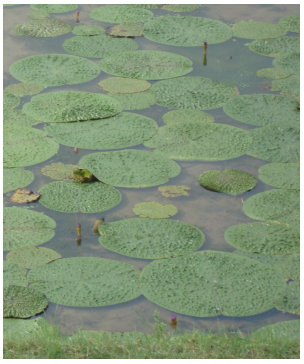


Fig. 76. A view of makhana crop

Fig. 77. Growth of Sel-6 strain of makhana

11

Farming System Research

Development of Location Specific Integrated Farming System Modules for Small and Marginal Farmers' of Bihar

More than 75% of farmers of Bihar fall under small and marginal category with land holding size of 0.32 to 0.5 ha and a high degree of fragmentation. Hence, the livelihood of the farmers itself is at the stake. Keeping this fact in view, integrated farming system models were developed on one acre and two acre area not only for food and nutritional security of the farming family but also to generate round the year employment opportunities to the farming family. The area under different components has been allocated as per need and in view of nutrient recycling within the system.

In one acre model, goat, poultry, mushroom, and vermicomposting were integrated with the crop components. Under crop components, rice-wheat, rice maize, rice-lentil and rice-mustard (as cereal based cropping system) and cowpea-okra-tomato, okra-pea-cabbage and cucurbits-cauliflower-onion (as vegetable based cropping systems) were followed and nutrient recycling from the system was studied. Cowpea-cauliflower-onion cropping system along with poultry+mushroom+goatry fetched the highest net income of ₹ 1,42,708 in comparison with other cropping system in a farming system mode which was about five times more than rice-wheat cropping system (₹ 24,235) in isolation. In addition, 2.2 tonnes of vermicompost, 4.5 tonnes of goat manure and 2.0 tonnes of poultry manure was produced, which was equivalent to 224.6 kg of urea, 481.3 kg of SSP and 106.3 kg of MOP. An additional employment of 60 man-days was also generated through the system over traditional farming (Fig. 78).

In two acre IFS model, livestock (3 cows+3 calves), fisheries, duckery, and vegetables and fruits were integrated with prevalent rice-wheat, rice-maize, rice-lentil and rice-mustard cropping system. Different enterprises were evaluated with the same cropping system for their economic return and employment within different farming systems. It was found that rice-wheat+vegetables+livestock+fisheries+duckery model gave the maximum

Fig. 78. Integrated farming system model for 1 acre under irrigated ecosystem

return of ₹ 2,02,874 with additional employment opportunity of 269 man-days. In addition to above income, 3.0 t of vermicompost and 10.4 t of cow dung were also produced which were recycled within the system and due to its recycling, 10 kg of N, 80 kg of P and 74 kg of K were added into the soil (equivalent to 240 kg of urea, 500 kg SSP and 124 kg MOP).

Based upon different enterprises, many combinations were made and analyzed statistically viz. Crop+veg., Crop+veg.+fruits, Crop+fish+poultry, Crop+fish+duckery, Crop+fish+goat, Crop+fish+cattle, Crop+fish+poultry+duck, Crop+mush+goat, Crop+ hort.+fish/duck+cattle, Crop+hort.+fish/duck+goat. Among different combinations, crop (0.6 ha)+ hort. (0.2 ha)+fish/duck (0.15 ha)+goat (20) integration resulted in maximum net returns of ₹ 348941/year with a sustainability index of 0.71, followed by crop (0.8 ha)+fish (0.15 ha)+poultry (500)+duck (35) integration with a sustainability index of 0.56. Further, it was also observed that due to waste recycling within the system there was an increase in organic carbon upto 3.2%, N 5.8%, P 9.9% and K 2.6% in the soil. Detail economics of the developed models are given in the Tables 44 & 45.

Table 44. Expenditures and income statement of 1 acre IFS model (2011-12)

Components	Estb. cost (₹)	Recurring expd/year (₹)	NI at 3rd year (₹)
Crop (0.2 ha)	-	16,007	11,035
Horticulture (0.09 ha)	1,080	20,900	19,750
Fodder	--	6,380	10,820
Goat (20+1) (0.018 ha)	65,000	52,826	24,444
Mushroom (0.003 ha)	10,000	9,500	16,100
Poultry (700 chicks) (0.0015 ha)	12,000	53,810	39,205
Crop waste	--	1,050	9,090
V.C. & manure pits	8,000	2,650	5,150
Other costs fruits		7,424	7,114
Total	96,080	1,70,547	1,42,708

Table 45. Expenditures and income statement of 2 acre IFS model (2011-12)

Components	Estb. Cost (₹)	Total expd. / yr. (₹)	Net monetary benefits at 3rd year (₹)
Crop (0.4 ha)	-	29,618	28,748
Veg. (0.15 ha)	--	27,841	24,659
Orchards/fruits	2,500	15,119	14,701
Fodder (0.01ha)	-	9,216	11,584
Fishery (0.1 ha)	70,000	17,119	11,961
Duckery (on the pond)	18,000		
Dairy (3+3) 0.016 ha	1,00,000	1,35,241	70,295
Crop waste	-----	1,578	31,267
V.C.	15,000	5,341	8,659
Total	2,05,000	2,40,093	2,02,874

Development of Vegetable Based Integrated Farming System for Marginal Farmers of Irrigated Upland

Study on vegetable based integrated farming system for one acre land was conducted to identify suitable cropping system and other components for obtaining maximum productivity and profitability by effective recycling of farm wastes/organic residues. Six cropping systems like rice-wheat-green gram (C_1), rice-potato-green gram (C_2), Lady's finger- potato-onion (C_3), bitter gourd-tomato-bottle gourd (C_4), lady's finger-coriander-sponge gourd (C_5), brinjal-carrot-cowpea (C_6) with two levels of fertilizer, i.e., F_1-recommended dose of fertilizer (RDF), F_2-50% of recommended dose of fertilizer+goat manure & vermicompost were tested in RBD. The area under different components was allocated as per need and in view of nutrient recycling within the system. Soil samples were collected from the experimental plots and analyzed for physical and chemical properties. The texture of the soil was silt clay loam with pH 6.6, electrical conductivity 0.14 dS/m, organic carbon 1.2 per cent, available nitrogen 313 kg/ha, available phosphorous 38.5 kg/ha and available potash 259 kg/ha.

Yield of all crops were converted into lady's finger equivalent yield (LFEY) and on this basis promising cropping systems were evaluated. Results revealed that there was significant variation among cropping systems. In case of rice based cropping system; lady's finger equivalent yield of rice-potato-green gram (11.60 t/acre) was found significantly superior than that of rice-wheat-green gram (7.05 t/acre). Among vegetable based cropping systems maximum lady's finger yield equivalence was recorded in bitter gourd-tomato-bottle gourd (15.04 t/acre) followed by lady's finger-potato-onion (13.63 t/acre). Maximum net return (Table 46) was recorded in bitter gourd-tomato-bottle gourd (₹ 81857/acre) followed by lady's finger-potato-onion (₹ 71128 t/acre). Similar trend was observed in benefit: cost ratio (3.1 and 2.9) in bitter gourd-tomato-bottle gourd and lady's finger-potato-onion, respectively.

After identification of suitable cropping system, one each from vegetable and rice based cropping sys-

Table 46. System productivity and economics of different cropping system (2011-12)

Treatment	System wise LFEY (t/acre)	Gross income (₹/acre)	Cost of cultivation (₹ /acre)	Net return (₹ /acre)	B:C ratio
Cropping system					
Rice-wheat-green gram (C_1)	7.05	56,400	24,840	31,560	2.3
Rice-potato-green gram (C_2)	11.60	92,800	32,105	60,695	2.9
Lady's finger-potato-onion (C_3)	13.63	1,09,040	37,912	71,128	2.9
Bitter gourd- tomato- bottle gourd (C_4)	15.04	1,20,320	38,463	81,857	3.1
Lady's finger- coriander- sponge gourd (C_5)	7.98	63,840	25,512	38,328	2.5
Brinjal- carrot- cowpea (C_6)	9.36	74,880	26,545	48,335	2.8
SEm ±	0.47	-	-	-	-
CD (P=0.05)	1.48	-	-	-	-
Fertilizer level					
Recommended dose (F1)	11.21	89,680	33,225	56,455	2.7
50% of recommended dose + goat manure & vermicompost (F2)	10.34	82,720	28,567	54,153	2.9
SEm ±	0.08	-	-	-	-
CD (P=0.05)	0.25	-	-	-	-

tem were integrated with other components in a model form. Cultivation of rice-potato-green gram as field crop and bitter gourd-tomato-bottle gourd as vegetable crop in integrated manner with goatry and recycling of vermicompost and goat manure in the allotted area gave a net return of ₹ 96,255 per acre along with 2.0 t of goat manure and 2.1 t of vermicompost (Table 47) with additional employment opportunity (120 man-days). Fodder was cultivated throughout the year and 5.5 tonnes of fodder was obtained from the allotted area which was fed to goats.

Development of Location Specific Integrated Farming System Modules for Rainfed Ecosystem for Eastern Plateau and Hill Region

The experiment was conducted for development of location specific integrated farming system module in 1 acre area under rainfed ecosystem to enhance the productivity and improve livelihood and socio-economic status of people of eastern plateau and hill region. The allocation of area under different IFS components is given in Fig. 79. Border plantation of *Flemengia semialata* for lac cultivation was done. The initial soil status of different blocks is depicted in **Table 48**. The soil pH varied from 5.61 to 6.10.

Under the vegetable components, bottle gourd-basmatic soyabean and pea were grown. A total yield of 1500 kg (6.44 t/ha) of bitter gourd, 135 kg (1.02 t/ha) basmatic soyabean with biomass yield of 200 kg (1.51 t/ha) was recorded from vegetables.

Under the component of cereal crops, sweet corn, maize and paddy were grown. In sweet corn, a total yield of 193 kg (3.0 t/ha) with straw yield of 388 kg (6.0 t/ha) was obtained. In case of maize, a total production of 220 kg (3.4 t/ha) with straw yield 537 kg (8.4 t/ha) was obtained whereas in case of paddy, a total yield of 151 kg (2.3 t/ha) with straw yield of 300 kg (4.7 t/ha) were obtained.

Table 48. Soil status of IFS of different blocks

Block	Soil reaction	Nutrient content (kg/ha)		
	pH	N	P	K
Vegetable	5.90	166	68.88	269
Fodder	6.10	166	BDL	442
Oil seed	5.81	156	BDL	259
Pulses	5.67	166	1.45	253
Fruit	5.61	171	11.53	288
Oil seed	6.03	146	0.68	392

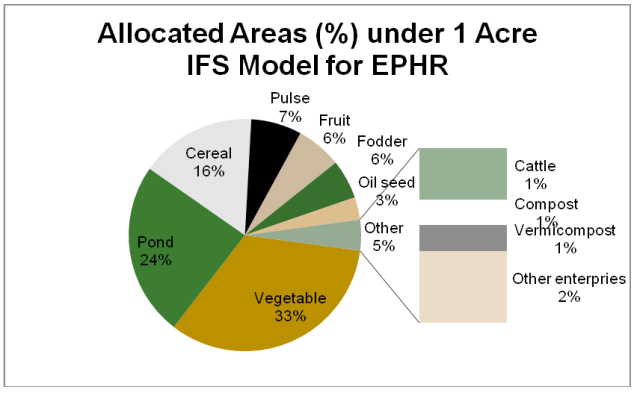


Fig. 79. Layout of different components of IFS

Table 47. Contribution of different components in vegetable based IFS

Enterprises	Area (m^2)	LFEY (t)	Gross return (₹)	Production cost (₹)	Net Return (₹)	B:C ratio
Rice-potato-green gram	1,040	3.36	26,880	8,500	18,380	3.5
Bitter gourd-tomato-bottle gourd	2,160	10.25	82,000	21,325	60,675	
Goat (10+1) Kids - 22	200	3.15	25,200	8,000	17,200	
Vermicompost	100	Used within the system				
Total	3,500	16.76	1,34,080	37,825	96,255	

Inter cropping of french bean-bottle gourd-french bean crop sequence was done in fruit block of guava (High density orcharding) to fetch initial income from the newly established orchard. In french bean, a yield of 52 kg (2.0 t/ha) with straw yield of 180 kg was obtained whereas in bottle gourd, a total production of 445 kg (17.8 t/ha) was obtained.

Among the pulse, chick pea, mung bean and urd bean were taken. Total yield 106 kg (5.7 t/ha) of black gram bushes with pod, 8 kg (0.29 t/ha) of mung bean with straw yield of 25 kg (0.92 t/ha) and 14 kg (0.51 t/ha) urd bean with straw yield of 50 kg (1.8 t/ha) was obtained. Among the oil seed crops, mustard yielded 12 kg (0.9 t/ha) with straw production of 40 kg (3.2 t/ha).

The fish integration was done as composite culture of *Rohu, Catla, Mrigal* and common carp in last week of September, 2011 and harvested in last week of December. The fish yield from the pond was 16 kg. (0.18 t/ha) and yield of bottle gourd grown on bund of pond was 493 kg. Two non descript cattle reared in the farming system produced 850 litres of milk per annum. A total of 0.2 tonnes of vermicompost was obtained by use of plant residues and weeds from the plot and a total of 135 cu ft. of compost could be obtained by using the cow dung. From the 400 numbers of *Flemangia semialata* planted as border for lac production, a total biomass of 2.0 t could be obtained.

Hence, a total gross income of ₹ 86,020/- could be obtained from the 1 acre IFS model during the first year with a net monetary returns of ₹ 45060/- per acre of land in Hill and Plateau region (Fig. 80).

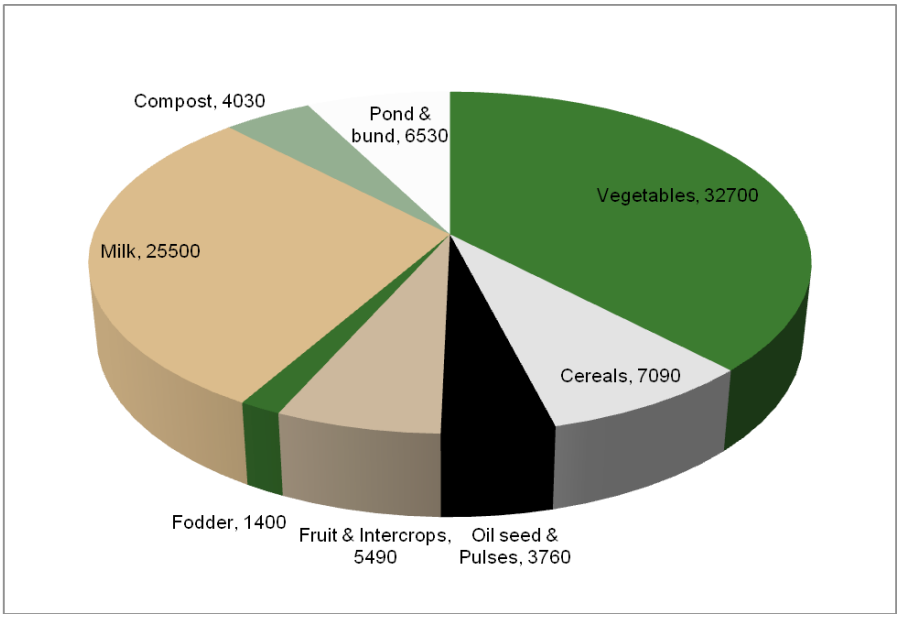


Fig. 80. Yield attributes of different enterprises from different components under integrated farming system

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Cropping System

Studies on Irrigation and Nutrient Requirement of Diversified Cropping System in Irrigated Eco-System of Central Bihar

A field experiment was conducted in split-split plot design replicated thrice allotting cropping systems in main plot, levels of irrigations in sub plot and levels of nutrients in sub-sub plot at main campus farm during *kharif* 2011, so as to find out the irrigation and nutrient requirement of different crops under diversified cropping systems. Five cropping systems *viz.,* C_1 (rice-tomato-bottle guard), C_2 (rice-potato-onion), C_3 (rice-mustard-sponge gourd), C_4 (rice-coriander-lady's finger) and C_5 (rice-cabbage-cowpea) were tested (Fig. 81). These cropping systems were tested at two levels of irrigations *viz.* I_1-optimum level, I_2- sub- optimum level and two levels of nutrients *viz.* F_1-recommeded level and F_2-50% of recommended level, respectively. Soil samples were collected from the experimental plots and analyzed for physical and chemical properties (Table 49). The texture of the soil was silt clay loam with mean value of pH 6.73, electrical conductivity 0.12 ds/m in 1:2 soils: water solution, organic carbon 6.92 g/kg, available nitrogen 285.93 kg N/ha and available phosphorus 28.68 kg P/ha, respectively.

Four crop cycles for all diversified cropping systems has been completed and the yield of different crops was converted in terms of paddy (Table 50). Results of paddy yield equivalence revealed that during fourth year of experimentation, there were significant variations among cropping systems, levels of irrigation and nutrients and their interactions. Among the cropping systems, maximum yield equivalence was recorded in paddy-tomato-bottle gourd (37.93 t/ha) followed by rice-coriander-ladies finger (21.40 t/ha), rice-potato- onion (21.33 t/ha), rice-cabbage-cowpea (19.99 t/ha), and rice-mustard-sponge gourd (18.96 t/ha), respectively, but the variation among remaining cropping systems was non-significant except rice-tomato-bottle gourd. Among levels of irrigations, maximum yield equivalence was recorded at optimum level (24.62 t/ha) followed by sub- optimum level (23.22 t/ha) and the increase was to the tune of 6.03 per cent, respectively. Among levels of nutrients, maximum yield equivalence was recorded at recommended level (24.91 t/ha) followed by 50 % of recommended level of fertilizer and the increase was to the tune of 8.59 per cent, respectively. Maximum net profit (Table 51) was recorded in rice-tomato-bottle gourd (₹ 2,08,020/ha) followed by rice-coriander-ladies finger (₹ 96,095/ha) and rice-cabbage-cowpea (₹ 83,651/ha), respectively. Whereas, benefit cost ratio was maximum in rice-tomato-bottle gourd (2.82) followed by rice- coriander- ladies finger (2.12) and rice-mustard- sponge gourd (1.98), respectively. Among levels of irrigation, maximum net profit was recorded at optimum level of irrigation (₹ 1,18,661/ha) as compared to sub-optimum level (₹ 1,01,945/ha). Among levels of nutrient, maximum net profit was recorded at recommended level (₹ 1,08,125/ha) followed by 50% of recommended level (₹ 1,00,100/ha), respectively.

Soil studies indicated that there was significant variation in pH, EC, organic carbon, available nitrogen and phosphorus after fourth crop cycle. It has been observed that in all the systems there was increase in pH, EC, nitrogen and phosphorus, but reduction in organic carbon from initial status of the nutrient. This may be attributed to exhaustive cropping. There was decreasing trend in organic carbon in all the systems from initial status of the soil but variations among cropping systems, levels of irrigation and nutrient was found significant. This may be because of vegetable dominated crops in the system, whose organic matter requirement is quite higher than other crops in the system (Table 49).

During five year of experimentation only rice crop has been taken. Growth and yield parameters were recorded and analyzed. Results revealed that variation among most of the growth and development characters were non-significant except plant height, grain/ panicle and grain yield in all the cropping systems, levels of irrigation and nutrients (Table 52). It indicates that there is built up of available nutrient particularly nitrogen and phosphorus after fourth crop cycle, which in turn

C_1 I_1F_1 (Rice-Tomato-Bottlegourd)

C_1 I_1F_2 (Rice-Tomato-Bottlegourd)

C_4 I_1F_1 (Rice-Corainder-Lady's Finger)

C_4 I_1F_2 (Rice-Corainder-Lady's Finger)

Fig. 81. Different cropping systems developed for irrigated ecosystems

resulted in significant variation in grain yield of rice crop.

Eco-Biology and Management of Rodent Fauna of Rice-Wheat Cropping System

The observations were recorded on incidence of live burrows of *Bandicota bengalensis* and *Mus booduga* in three levels of residue, i.e., no residue (M_1), 30 cm residue (M_2) and full mulch (M_3) conditions and three seed rate (75, 100 and 125 kg/ha) situations. At 75 kg/ha seed rate, average numbers of live burrows of *B. bengalensis* in M_1 & M_2 was observed 37.63 and 75.56, respectively (Fig. 82). However, burrows of *M. booduga* was observed in all residue condition higher than *B.bengalensis.* Burrows of *M.booduga* ranged from 0-265.67 in all three replications. The incidence of live burrows of *B.bengalensis* in M_1 of 100 kg/ha seed rate were higher as compared to M_2 & M_3 while reduced (Fig. 83) in 30 cm residue and full much conditions. Bandicoots burrows in no residue (M_1) were higher (1063.85

Table 49. Effect of levels of irrigation and nutrient on chemical status of soil after fourth crop cycle in diversified cropping system (2011-12)

Treatments	pH	EC	Org. Carbon (g/kg)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potash (kg/ha)
Initial status of nutrients in the soil of experimental site	6.50	0.11	10.5	281.00	23.56	193.20
Average nutrient status after first crop cycle (2008-09)	7.08	0.10	8.52	247.62	24.17	151.01
Average nutrient status after second crop cycle (2009-10)	6.97	0.12	6.64	262.68	26.40	181.02
Average nutrient status after third crop cycle (2010-11)	6.73	0.20	7.20	356.95	30.32	135.72
Average nutrient status after fourth crop cycle (2011-12)	6.73	0.12	6.92	285.93	28.68	145.65
Rice-Tomato-Bottle gourd (C_1)	7.16	0.13	7.10	320.71	29.83	149.40
Rice-Potato-Onion (C_2)	7.03	0.12	7.00	271.56	29.66	147.19
Rice-Mustard-Sponge gourd(C_3)	7.13	0.12	6.60	282.56	30.33	143.93
Rice-Coriander-L. Finger (C_4)	7.26	0.11	6.60	285.20	26.07	141.49
Rice-Cabbage-Cowpea(C_5)	7.07	0.12	7.30	270.73	27.51	146.24
SE m (±)	0.04	0.003	0.10	6.14	0.52	0.50
CD at 5%	0.13	0.010	0.30	20.02	1.70	1.63
Level of Irrigation (I)						
I_1	7.01	0.12	7.20	276.24	29.90	147.20
I_2	7.26	0.12	6.60	295.91	27.46	143.78
SE m (±)	0.016	0.002	0.06	3.26	0.31	0.46
CD at 5%	0.05	0.006	0.20	0.02	0.98	1.45
Level of Nutrient (N)						
F_1	7.02	0.12	6.87	281.13	30.47	151.23
F_2	7.24	0.12	6.94	291.02	26.88	139.75
SE m (±)	0.016	0.002	0.06	1.81	0.50	0.62

Table 50. Effect of levels of irrigation and nutrient on yield (t/ha) equivalence in terms of paddy (2011-12).

Cropping Systems	Irrigation		Mean	Fertilizer		Mean
	I_1	I_2		F_1	F_2	
Rice-Tomato-Bottle gourd (C_1)	38.94	36.93	37.93	39.32	36.54	37.93
Rice-Potato-Onion (C_2)	22.14	20.52	21.33	22.10	20.56	21.33
Rice-Mustard-Sponge gourd(C_3)	19.46	18.46	18.96	19.93	17.98	18.96
Rice-Coriander-L. Finger (C_4)	22.04	20.76	21.40	22.31	20.50	21.40
Rice-Cabbage-Cowpea(C_5)	20.53	19.45	19.99	20.88	19.10	19.99
Mean	24.62	23.22	-	24.91	22.94	-

Factors	C	I	F	C x I	C x F	I x F	C x I x F
SE(m) ±	0.88	0.31	0.14	0.68	0.31	0.20	0.44
C.D. at 5 Percent	2.87	1.08	0.41	2.14	0.91	0.59	1.30

Cost of rice: ₹ 8500/t taken for converting yield of different crops to the paddy yield equivalence.

Table 51. Yield equivalence in terms of rice, net-return, cost of production and benefit cost ratio in different cropping systems (2011-12)

Cropping Systems	Yield equivalence of different crops t/ha			Paddy yield equivalence (t/ha)	Gross return (₹ / ha)	Cost of cultivation (₹/ha)	Net return (₹ / ha)	B-C ratio
	Kharif 2011	*Rabi* 2011-12	Summer, 2012					
Rice-Tomato-Bottle gourd (C_1)	3.98	22.93	11.02	37.93	3,22,405	1,14,385	2,08,020	2.82
Rice-Potato-Onion (C_2)	3.93	10.26	7.14	21.33	1,81,305	1,22,347	58,958	1.48
Rice- Mustard-Sponge gourd (C_3)	4.08	4.74	10.14	18.96	1,61,160	81,287	79,873	1.98
Rice-Coriander-L. Finger (C_4)	4.00	8.20	9.20	21.40	1,81,900	85,803	96,095	2.12
Rice- Cabbage-Cowpea (C_5)	3.91	10.32	5.76	19.99	1,69,915	86,264	83,651	1.97
SE m (±)	0.07	0.62	0.30	0.88	-	-	-	-
CD at 5%	NS	2.02	0.98	2.87	-	-	-	-
Level of Irrigation (I)								
I_1	3.96	11.79	8.86	24.62	2,09,270	1,00,609	1,18,661	2.08
I_2	3.96	10.78	8..45	23.22	1,97,370	95,425	1,01,945	2.07
SE m (±)	0.07	0.16	0.21	0.31	-	-	-	-
CD at 5%	NS	0.50	0.66	1.08	-	-	-	-
Level of Nutrient (N)								
F_1	4.31	11.53	9.07	24.91	2,11,735	1,01,145	1,08,125	2.07
F_2	3.62	11.04	8.24	22.94	1,94,990	94,890	1,00,100	2.05
SE m (±)	0.05	0.08	0.11	0.14	-	-	-	-
CD at 5%	0..14	0.24	0.32	0.41	-	-	-	-

Table 52. Effect of levels of irrigation and nutrient on different growth and developmental characters of rice in different cropping systems (2012).

Treatment	Plant height (cm)	No. of tiller	Length of panicle (cm)	Root length (cm)	No. of grain / panicle
Cropping System					
Rice-Tomato-Bottle gourd (C_1)	72.27	17.83	11.58	21.07	129.57
Rice-Potato-Onion (C_2)	74.46	17.25	10.50	21.61	141.02
Rice-Mustard-Sponge gourd(C_3)	72.78	15.25	10.67	21.22	128.05
Rice-Coriander-L. Finger (C_4)	73.02	17.00	10.92	21.70	131.22
Rice – Cabbage – Cowpea(C_5)	76.38	16.33	11.67	22.29	131.48
SE m (±)	1.53	0.92	0.50	0.67	3.97
CD at 5%	NS	NS	NS	NS	12.95
Level of Irrigation (I)					
I_1	72.64	17.57	10.80	21.70	136.72
I_2	74.93	15.90	11.33	21.45	127.73
SE m (±)	0.89	0.69	0.30	0.23	2.82
CD at 5%	NS	NS	NS	NS	8.88
Level of Nutrient (N)					
F_1	74.90	17.37	10.77	21.79	136.07
F_2	72.66	16.10	11.37	21.36	128.39
SE m (±)	0.71	0.57	0.37	0.29	2.19
CD at 5%	2.09	NS	NS	NS	6.46

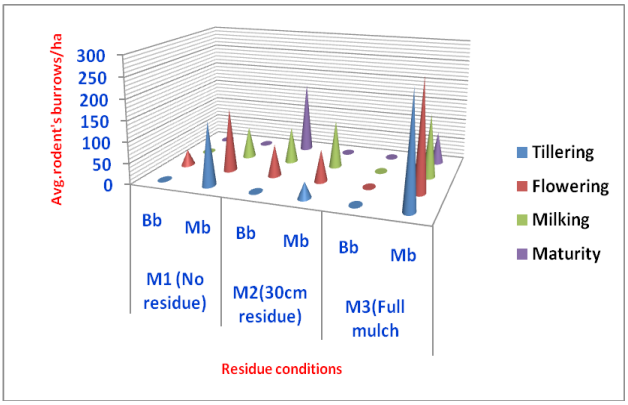

Fig. 82. Average burrows density/ha. of *B. bengalensis* (Bb) and *M. booduga* (Mb) in in 3 residue condition @ 75kg/ha seed rate

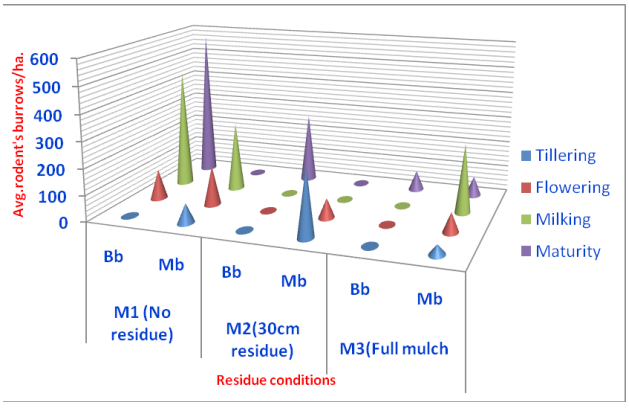

Fig. 83. Average burrows density/ha of Bb and Mb in 3 residue condition with 100 kg/ha seed rate

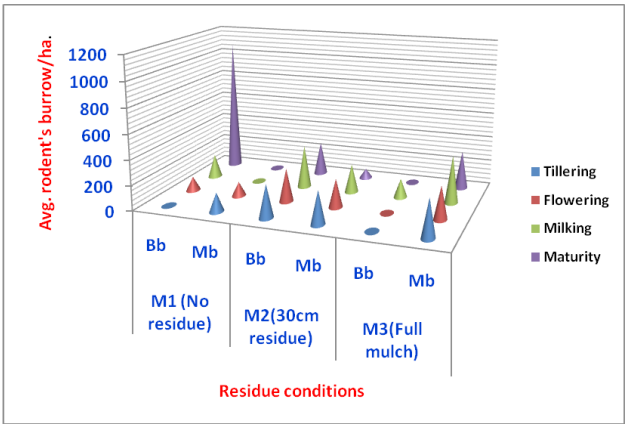

Fig. 84. Average burrows density/ha of Bb and Mb in 3 residue condition with 125 kg/ha seed rate

burrows/ha) as compared to M_2 (265.67 burrows/ha) and M_3 (303.30/ha) at maturity stage. However, incidence of *M. booduga* burrows ranged from 0 to 303.30 in all three conditions (Fig. 84).

The incidence of live burrow in 3 residue conditions (No residue, 30 cm residue and full mulch) and 3 seed rates (75,100 and 125 kg/ha) revealed that the maximum burrow density of *B. bengalensis* was observed in 125 kg/ha seed rate in no residue condition because *B. bengalensis* is extensive burrowing animal and residue either 30 cm or full mulch restrict its burrowing habit, therefore, the number of burrows are higher in the no residue, secondly high seed rate condition having thick canopy that provides protective covering to the *B. bengalensis* from predators. Likewise, in 75 kg/ha seed rate condition the less incidence of bandicoot's burrow in all residue condition, may be due to less canopy cover which provide protective covering from the predators during night particularly from owls.

Annual trap index of bandicoot rat indicates that less number of rat were trapped during April to August. *B. bengalensis* trapped during this period was mostly adults. It shows restriction of breed during these months. Again number of trapped bandicoots increased during September to December (Fig. 85). Average body weight was recorded 109.60 ± 22.41 g for male and 108.60 ± 25.79 g for female in November, and 143.00 ± 19.26 g (male) and 86.05 ± 15.34 g (female) in December, respectively. Lowest body weight during November and December indicates the prevalence of breeding during these months.

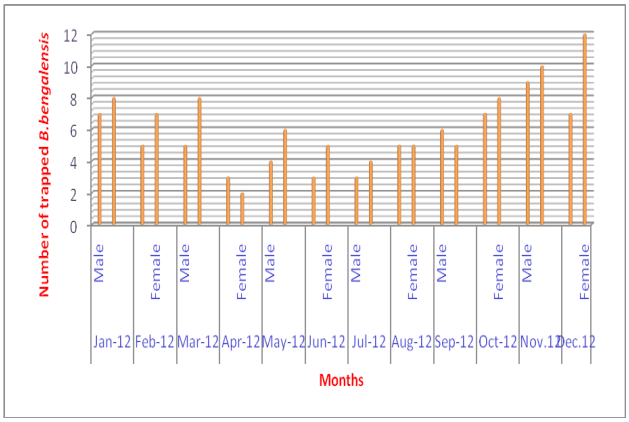

Fig. 85. Average burrows density/ha of Bb and Mb in 3 residue condition with 125 kg/ha seed rate

Intercropping of Rice and Vegetable Soybean in Hill and Plateau Region

In rice-legume cropping system under rainfed upland situation in *kharif* season, the upland rice (variety *Anjali*) and vegetable soybean (variety *Swarna Vasundhara*) were grown both as sole crop (12 rows) and intercrop (10 row rice + 2 row vegetable soybean), (8 row rice + 4 row vegetable soybean) and (6 row rice + 6 row vegetable soybean). The plot size of each treatment was 16.2 m^2. The experiment was conducted under rainfed upland situation to find out the best combination of rice + soyabean during *kharif*, 2012 (Fig. 86). The green pods of vegetable soybean and rice were harvested at 88 days and 105 days after sowing. There was significant differences among the different treatments (Table 53). The sole crop of vegetable soybean recorded the maximum rice equivalent yield of 24.66 kg (15.22 t/ha), followed by the combination treatment of (6 row rice + 6 row vegetable soybean) (17.66 kg; 10.9 t/ha). The result indicated that growing of sole crop of vegetable soybean in rainfed upland situation during *kharif* season would be more profitable.

Fig. 86. Rice-legume cropping system under rainfed situation

Table 53. Rice equivalent yield in rice-vegetable soybean cropping system

Treatments	Rice equivalent yield (kg /16.2 m^2)
T-1 Sole rice	8.26 (5.09 t/ha)
T-2 Sole Vegetable Soybean	24.66 (15.22 t/ha)
T-2 Rice + Vegetable Soybean (10:2)	11.31 (6.98 t/ha)
T-2 Rice + Vegetable Soybean (8:4)	13.76 (8.49 t/ha)
T-2 Rice + Vegetable Soybean (10:6)	17.66 (10.90 t/ha)
CD at 5%	**1.02**

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Soil Science

Dynamics of Nutrients Under Makhana and Makhana-Based Cropping Systems Grown in Inceptisols of North Bihar

Nutrient dynamics

The average concentration of nitrogen (N), phosphorus (P) and potassium (K) in biomass of makhana plant was 0.18, 0.15 and 0.19%, respectively. The makhana plants were raised at a distance of 1.25 x 1.25 m, accommodating 6400 plants/ha. Biomass of makhana plants containted 88 to 91% moisture. On the basis of available moisture content in the vegetative tissues of the makhana plant, it was recorded that it added biomass to the soil @ 6.4 to 8.9 t/ha (dry weight basis). The nutrient contribution study has shown that makhana plants could add N, P, and K in the range of 11.5-16.0, 9.6-13.44, and 12.0-17.0 kg/ha, respectively.

Soil fertility status after one year of makhana cultivation

Soil pH ranged from 6.75 to 7.19 with a mean value of 7.01. The soil pH was found unchanged during the year. Soil electrical conductivity (EC) registered slight decrease in their values due to cultivation of makhana. It ranged between 0.06 and 0.07 dS m^{-1}, with a mean value of 0.064. These values of EC indicated that soils were devoid of salinity or similar to plain soils. Soil carbon varied from 0.17 to 0.62% (mean: 0.40%).

The available nitrogen (N) content was found to be unchanged over its initial content due to makhana cultivation and same ranged from 207 to 276 kg/ha (mean: 222 kg/ha). The status of potassium (K) also showed the similar trend.

The makhana cropping was highly beneficial for soil medium as it had registered increase in available phosphorus (P) content (7.05 to 38.50 kg/ha) (mean: 19.8 kg/ha) over its initial value (7.36 to 10.93 kg/ha) (mean: 9.14 kg/ha).

Evaluation of Soil Fertility Status of Acid Soils of Different Mango Orchards of Eastern Plateau and Hill Region

The experiment was initiated during 2011 to study the soil fertility status of acid soils, collected from different depth of soil profiles of different mango orchards. Soil samples were collected from different situations, i.e., T_1: Control (no orchard); T_2: 1-3 yr old orchard; T_3: 4-5 year old orchard and T_4: 6-7 year old orchard.

pH and organic carbon content

The pH of the acid soils at different depths of soil profile comprising of all the treatments varied from 4.6 to 5.9. The pH of the soils gradually increased with increasing depth of soil profiles (Fig. 87). Higher pH value was recorded with increasing age of mango orchard. The organic carbon content of the soils gradually decreased with increasing depth of soil profile (Fig. 88). The organic carbon content of most of the soil profiles were below normal range and varied from 0.14-0.63% throughout the soil profiles of different aged mango orchard. The organic carbon content was better with higher age group of mango orchard (T_3 and T_4) compared to control.

Available potassium content

The available K content of orchard soils at different depth varied from 188-348 kg/ha (**Fig. 89**). Higher K content was recorded in 0-30 cm depth of soil in 6-7 year old mango orchard. With increasing depth (60 cm) of soil profiles, the K content gradually decreased in the treatment, T_1, T_2 and T_3. However, the K content gradually decreased from 0-120 cm depth in the treatment T_4.

Exchangeable (available) calcium and magnesium content

The exchangeable Ca^{++} content of different soil profiles gradually increased with increasing depth (Fig. 90). Due to heavy rainfall in the rainy season in Jharkhand, the exchangeable bases like, Ca^{++} and Mg^{++}

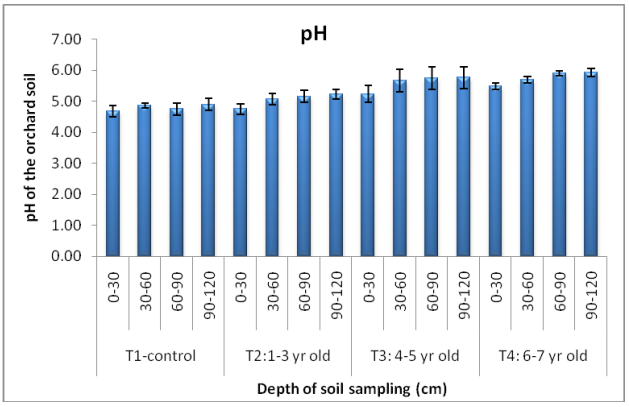

Fig. 87. pH of different mango orchard soils

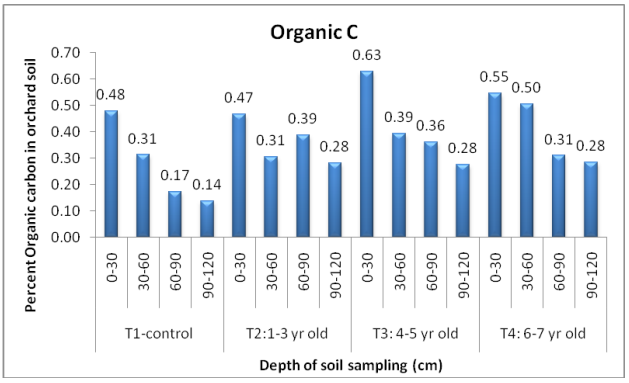

Fig. 88. Organic carbon content of different mango orchard soils

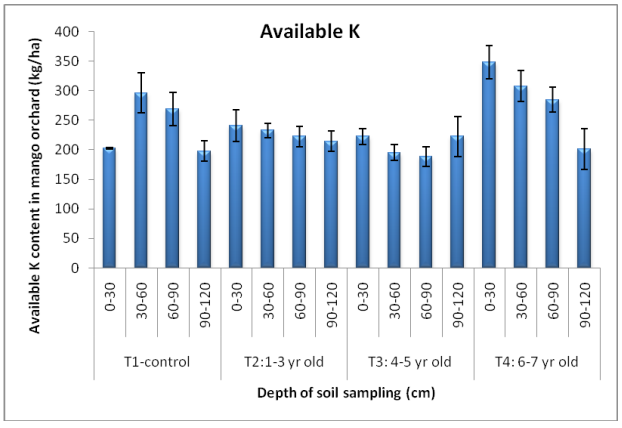

Fig. 89. Available K content of different mango orchard soils

leaches down to lower depth resulting in higher content. The exchangeable Ca^{++} content varied from 2.37-5.97 cmol(p^+) kg^{-1}. The exchangeable Ca^{++} content gradually decreased in the soil profiles with increasing age of mango orchard.

The exchangeable Mg^{++} content of different soil profiles gradually increased with increasing depth of profile in all the mango orchard soil (Fig. 91). The exchangeable Mg content varied from 2.48-3.64 cmol (p^+) kg^{-1} throughout the soil profiles of different age

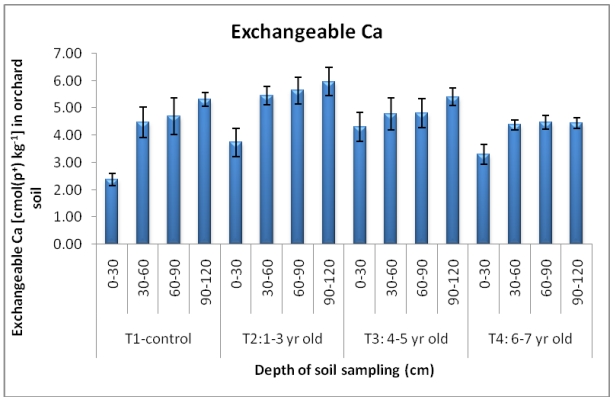

Fig. 90. Exchangeable calcium content of different mango orchard soils

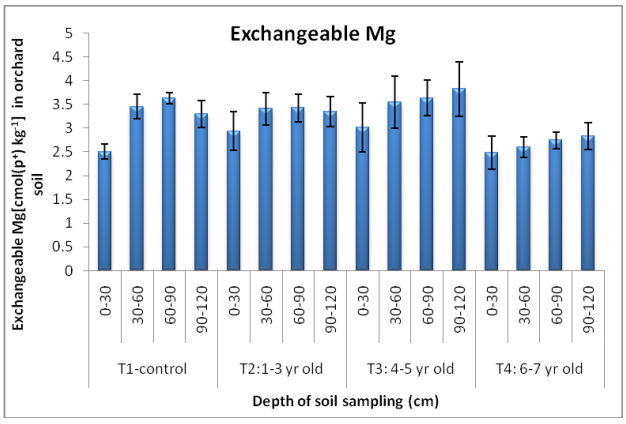

Fig. 91. Exchangeable magnesium content of different mango orchard soils

mango orchard. The exchangeable Mg^{++} content was recorded lowest value in the soil profiles of older age group of mango orchard (T_4) compared to younger age group (T_2 and T_3).

DTPA-extractable micronutrient content

The DTPA-extractable Fe content of the soils of different mango orchards varied from 5.71-20 mg kg^{-1} (Fig. 92). The DTPA-Fe gradually decreased with increasing depth of soil profiles throughout the age group of different mango orchard. All the soils had DTPA-Fe with high status exceeding the critical level of deficiency (2.5-5.8 mg Fe kg^{-1}).

The DTPA-Mn content was more in the surface soils of 0-30cm depth throughout the soil profiles of different age mango orchard (Fig. 93). The DTPA-Mn gradually decreased with increasing depth of soil profile and varied from 10-20 mg kg^{-1}. The DTPA-Mn content of all the soil profiles exceeded the critical level of deficiency (2-4 mg Mn kg^{-1}). The DTPA-Zn gradually decreased with increasing depth of soil profiles and varied from 0.2-0.4 mg kg^{-1} (Fig. 94). All the soils at

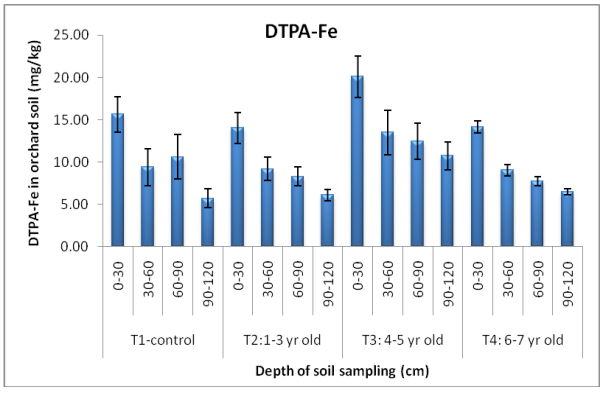

Fig. 92. DTPA-Fe content of different mango orchard soils

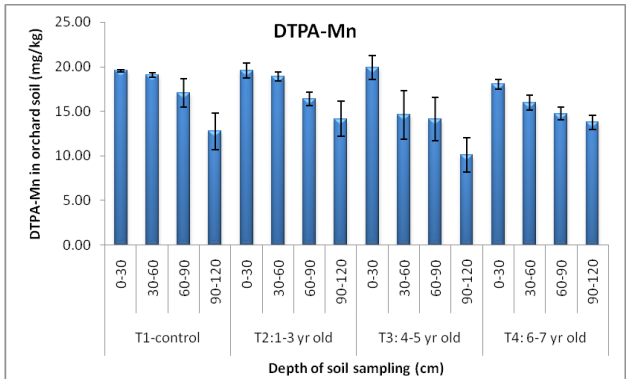

Fig. 93. DTPA-Mn content of different mango orchard soils

different depths were deficient in Zn and below the critical level of deficiency of 0.5-1.0 mg kg^{-1}. The surface soils (0-30 cm) of different mango orchards recorded the average Zn content of 0.4 mg kg^{-1}. The DTPA-Cu gradually decreased with increasing depth of soil profile and varied from 0.54-1.2 mg kg^{-1} (Fig. 95). The DTPA-Cu content was more in the soils of younger age orchard (T_2 and T_3) compared to control and older age orchard (T_4). However, the DTPA-Cu content exceeded the critical level of deficiency of 0.2-0.5 mg kg^{-1}.

Leaf nutrient status of fruit plants of different orchards

Leaf samples were collected from the 27 different mango orchards in the month of January 2012, before the flowering season. Leaf sampling (**Fig. 96**) was done as per standard method by choosing the 3rd and 4th leaf from the terminal end of 7-8 months old branch. About 30 leaves were plucked from each mango tree and dried.

The total N, P and K content of mango leaf of different age group decreased with increasing age of orchard. The total N content varied from 1.0-1.4%, P-0.12-0.22% and total K content 0.77 to 0.79%, respectively. The N, P and K content in younger age orchard (1-3 yr) was more compared to older age (4-5 yr and 6-7 yr) (Fig. 97).

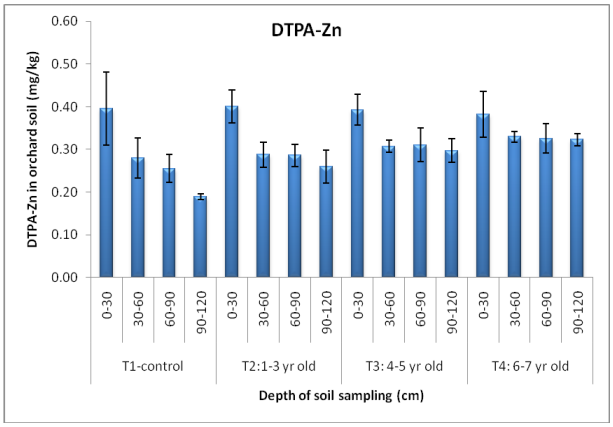

Fig. 94. DTPA-Zn content of different mango orchard soils

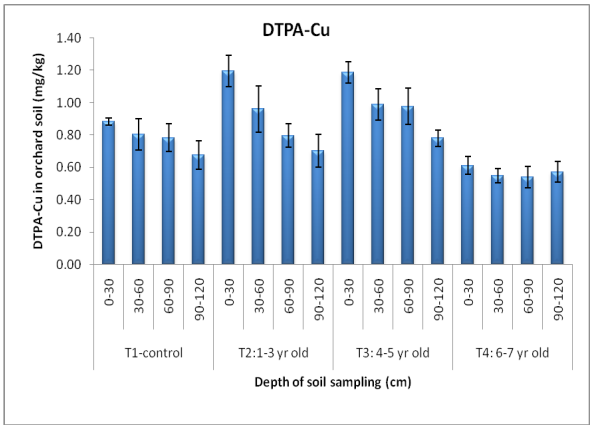

Fig. 95. DTPA-Cu content of different mango orchard soils

Fig. 96. Leaf sampling in mango orchard

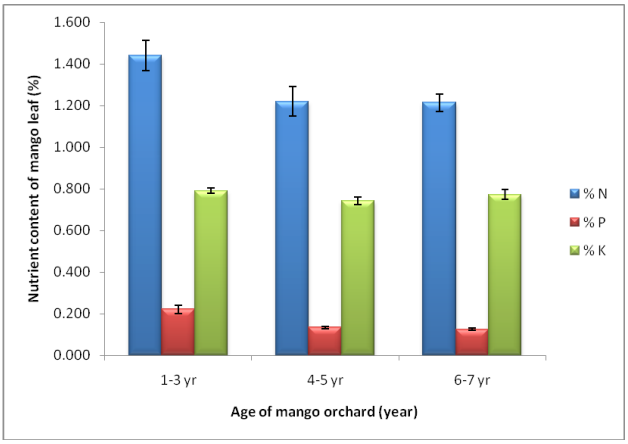

Fig. 97. Total N, P and K content of mango leaf of different age group

Phosphorus Solubilization by Native Fungal Strains

An experiment was conducted to evaluate the native fungal strains on inorganic phosphate solubilization in the acid soils of Jharkhand. Mineral phosphate solubilizing activities of three isolates were tested in tricalcium phosphate and ferric phosphate medium by analyzing the possible phosphorus release and phosphatase activity from 5th, 10th and 15th day of incubation. Different fungal isolates namely *Aspergillus niger*, *Penicillium chrysogenum* and *Trichoderma viride* were obtained from the rhizospheric soils (acid soils, pH 5.5) of pea, mango and cauliflower, respectively from Plandu, Ranchi and screened for their ability to solubilize inorganic phosphate in Pikovskaya medium.

The availability of P from the insoluble inorganic source of P was significantly better with the inoculation of isolated native fungal strains from acid soils. Among the isolates, *Aspergillus niger* was found to be most efficient in mobilizing P from tricalcium phosphate (Fig. 98) and ferric phosphate (Fig. 99). The study revealed highest P solubilization of 75 and 77 % in tricalcium phosphate and ferric phosphate, respectively. The pH of the culture medium gradually decreased with the progress of incubation up to 5 days and thereafter increased. Further, the availability of P was negatively correlated with the pH of the culture medium. The acid phosphatase activity induced by *Aspergillus niger* and *Trichoderma viride* was comparatively better than *Penicillium chrysogenum* in tricalcium phosphate medium. However, the acid phsophatase activity of all the native strains in ferric phosphate medium was statistically at par at the highest activity.

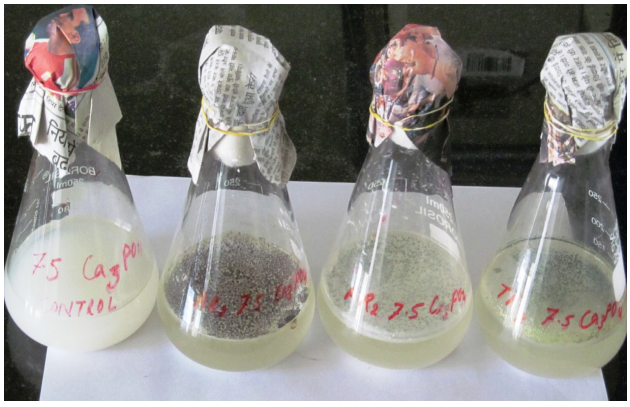

Fig. 98. Calcium phosphate solubilisation by native phosphate solubilising fungi

Fig. 99. Ferric phosphate solubilisation by native phosphate solubilising fungi of Jharkhand

Exploration of Biocontrol Agents for the Management of Soil Borne Phytopathogens in Eastern Plateau and Hill Region

The work was undertaken to isolate native microbial isolates from soil for biocontrol of soil borne phytopathogens in Eastern plateau and hill region. Soil samples were collected from the Jharkhand, Bihar, Odisha and Eastern Part of Uttar Pradesh and isolation of different microbes was made from the various soil samples. Among the microbes, twenty potential biocontrol isolates of *Trichoderma*; one of *Penicillium chrysogenum;* one of *Aspergilius niger*, and sixteen strains of *Pseudomonas* were isolated. Out of them, ten isolates of *Trichoderma*, one isolate each of *Aspergillus niger, Penicillium chrysogenum* were identified as phosphate solubilizer. Thirty six isolates of plant growth promoting rhizobacteria were isolates from the soil samples. The 20 potential strains of *Trichoderma* were characterized on the basis of their antagonism/antibiosis, plant growth promotion and phosphate solubilization under laboratory conditions. Among the characterized strains of *Trichoderma*, strain T7 and T14 were found promising antagonist against almost all the soil borne fungal pathogens viz., *Fusarium, Phythium, Rhizoctonia, Sclerotium, Sclerotinia.* Mass multiplications (Fig. 100) of potential strains were also carried out on the *Sorghum* and *Pennisetum* grains. *Pennisetum* (Bajra) was found highly potential for the multiplication of *Trichoderma*.

Fig. 100. Mass multiplication of *Trichoderma* using sorghum grains as a substrate

14

Water Quality and Productivity

Application of Micro-Irrigation in System of Rice Intensification for Enhancing Water Productivity

An experiment was conducted to investigate the performance of three irrigation methods *viz.* Low Energy Water Application (LEWA), micro-sprinkler and surface irrigation (check basin) along with three rice establishment methods *viz.*, system of rice intensification (SRI), line transplanting (TP) and farmers' practices of TP (staggered transplanting) for enhancing water productivity. It has been observed that rice grain and straw yield were significantly influenced by different irrigation methods as well as different establishment methods (Table 54). Significantly higher grain and straw yield were observed in LEWA compared to micro sprinkler and surface irrigation (Fig. 101). In case of establishment methods, the SRI recorded significantly higher grain and straw yield over line transplanting (TP) and farmers' practices of transplanting. The interaction between irrigation methods and establishment methods were, however, statistically insignificant. The highest irrigation water use efficiency was observed in micro sprinkler irrigation system (1.05 kg/m^3) followed by LEWA (1.01 kg/m^3) and check basin irrigation (0.82 kg/m^3). The water productivity was recorded to be 3.90, 6.26 and 2.66 kg/m^3, respectively, in case of LEWA, micro sprinkler and check basin methods.

Table 54. Effect of different irrigation and establishment methods on grain and Straw yield of rice.

Treatments	Grain yield (t/ha)	Straw yield (t/ha)
Irrigation methods		
LEWA	10.38	13.61
Microsprinkler	10.05	13.21
Check basin	9.47	12.49
CD (0.05)	0.29	0.39
Establishment methods		
SRI	10.85	14.24
Line transplanting (TP)	9.78	12.86
Farmers' practice of TP	9.27	12.20
CD (0.05)	0.29	0.39

Fig. 101. Performance of LEWA under SRI

Standardization of Planting Geometry and Growth Stage Based Fertigation Patterns for Commercial Cultivation of Vegetables Using Drip Irrigation System

An experiment was conducted to standardize fertigation method and crop geometry of sweet corn and tomato for their commercial production under drip irrigation system in acid soils of eastern plateau and hill region. The experiment comprised of 12 treatment combinations of three fertigation levels *viz.* F_1, F_2 &F_3 and four crop geometry *viz.,* S_1, S_2, S_3 & S_4. The experiment was laid out in replicated manner in split plot design of summer crops (sweet corn, cauliflower, tomato) and winter crops (tomato, broccoli, chilli).

In sweet corn, the recommended dose of nutrients (150:60:60 kg NPK) was applied at different growth stage based fertigation schedule *viz.* FP_1(1st-4th week- 6%, 5-12th week- 8% & 13th-14th week- 6%); FP_2 (1st-5th week- 8%, 6th-9th week- 10%, 10th-12th week-5%, 13th week- 3% & 14th week- 2%), and FP_3 (1st-3rd week- 4%, 4th -6th week- 6%, 7th-9th week- 8%, 10th-12th week- 10% and 13th-14th week- 8%). With respect to planting geometry, the seeds were sown as S_1-Plant to plant (PP) 15 cm; Row to row (RR) 50 cm (rectangular with two rows per lateral system), S_2-PP 25 cm; RR 40 cm; BPR 60cm (triangulated paired rows per lateral system), S_3-PP 25 cm; RR 40 cm; BPR 60 cm (triangulated paired

row system) and S_4- PP 35 cm; RR 30 cm: BPR 70 cm (triangulated paired row system).

In case of tomato the recommended dose of 120:60:60 kg of NPK was applied at different fertigation schedule *viz.* FP_1(1st-6th week- 5%, 7th-16th week- 6% & 17th-18th week-5%), FP_2 (1st-6th week- 6%, 7th-8th week- 8%; 9th-11th week- 10%; 12th-13th week- 4% & 14th-18th week- 2%) and FP_3 (1st-6th week-2%; 7th-9th week-4%; 10th-12th week-8%; 9th-11th week-10%;12th-13th week-4% & 14th-18th week-2%). The tomato seedlings were transplanted as per the planting geometry of S_1- plant to plant (PP) 75 cm; row to row (RR) 50 cm (rectangular with two rows per lateral system), S_2-PP 30 cm; RR 40 cm; between plant & row (BPR) 60 cm (triangulated paired row system), S_3-PP 50 cm; RR 40 cm; BPR 60 cm (triangulated paired row system) and S_4-PP 70 cm; RR 40 cm; BPR 60 cm (triangulated paired row system).

Similarly the fertigation schedule in cauliflower of recommended dose 150:60:60 NPK was applied as depicted in Fig. 102.

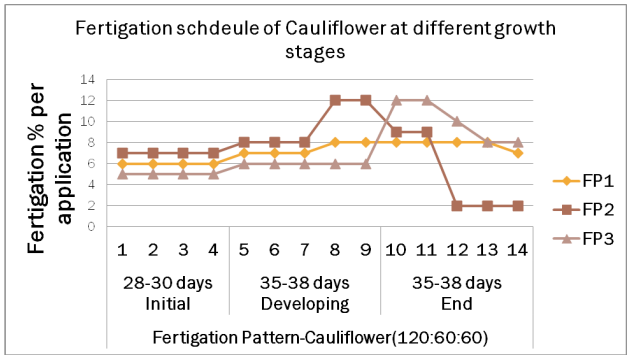

Fig. 102. Fertigation schedule of cauliflower

Analysis of initial soil fertility status of experimental plots showed soil pH of 4.65, EC-0.30 (mS/cm), available nitrogen (147 kg/ha), available potassium (200 kg/ha) and below detection level of available phosphorus.

Effect of different treatments on sweet corn

The height of sweet corn plant was recorded at 30, 60 and 90 days after sowing (DAS). None of the treatment showed significant influence on sweet corn plant height at 90 DAS. Average weight of cob obtained under the treatment FP1 was significantly better than that of FP3 (Fig. 103). The average fruit weight under FP2 pattern was also at par with the best treatment. Effect of any planting geometry was non-significant. With respect to yield, the treatment FP_2 recorded the highest yield of 14.4 t/ha (Fig. 104) which was at par with FP_3. The best treatment combination was fertigation pattern FP_2 with S1 planting geometry which showed the highest yield of 20.4 t/ha. Different planting geometries did not have significant influence on sweet corn yield. The fertigation pattern in which the fertilizer is applied in equal amounts in each fertigation (FP_2) showed better yields. This means that increasing the fertilizer dose during initial phase of the plant growth (FP_1) or during the late maturity phase of the crop (FP_3) is not a better option.

The water use efficiency of sweet corn was recorded for each of the plot. The statistical analysis revealed that none of the treatment had significant effect on water use efficiency. However, the highest water use efficiency (6.3 kg/m^3) were observed in case of fertigation pattern FP3 and under planting geometry S_2 followed by 5.9 kg/m^3 in FP_3 with S_1 planting geometry. Similarly, none of the treatment had significant effect on water productivity. However, the highest water productivity (127.0 ₹/m^3) were observed in case of fertigation pattern FP_3 and under planting geometry S2 followed by 117.5 ₹/m^3 in FP_3 with S_1 planting geometry.

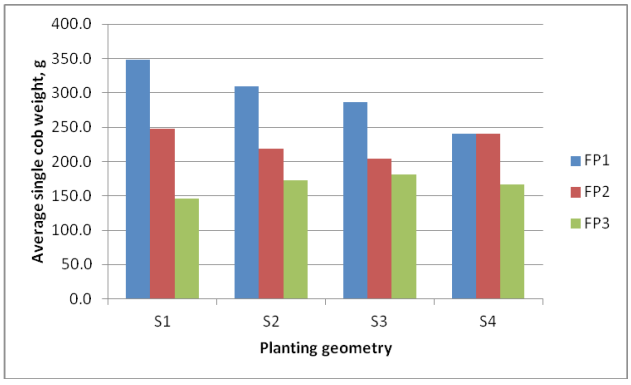

Fig. 103. Comparison of average single cob weight under different treatments

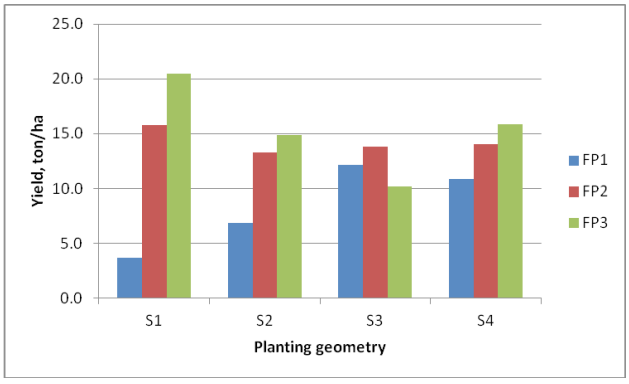

Fig. 104. Sweet corn yield as affected by fertigation pattern and planting geometry

Effect of different treatments on tomato

None of the treatment resulted in significant influence on plant height at 60 and 90 days after transplanting. Total number of fruit per plant was significantly influenced by fertigation pattern (Fig. 105). The fertiga-

tion pattern FP_1 resulted in highest number of fruits per plant (267.8) followed by fertigation pattern FP_2 (242.3). The number of fruits per plant remained unaffected by the planting geometry. The average fruit weight was not significantly influenced by any of the treatments. Fertigation pattern and planting geometry had significant effect on the yield of tomato (**Fig. 106**). The highest yield was recorded with fertigation pattern FP_2 (22.2 t/ha) followed by the fertigation pattern FP_1. The planting geometry S_1 showed highest tomato yield with treatment mean yield of 23.3 t/ha. The tomato yields obtained under planting geometries S_4 (19.9 t/ha) and S_3 (18.8 t/ha) were also statistically at par with the best treatment. Rectangular planting geometry with plant to plant spacing of 75 cm and row to row spacing of 50 cm has been found better arrangement in case of tomato cultivation.

Significant effects of the treatments of planting geometry could be recorded on water use efficiency of tomato (Table 55). The S_2 planting geometry showed the highest water use efficiency of 11.7 kg/m^3 which was at par with S_3. The fertigation pattern FP_2 with planting

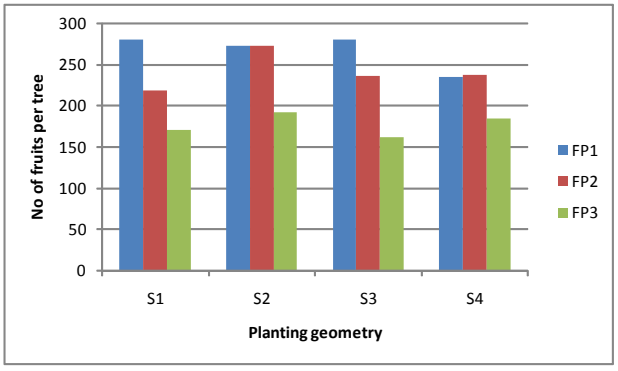

Fig. 111. Comparison of number of fruits per plant of tomato under different treatments

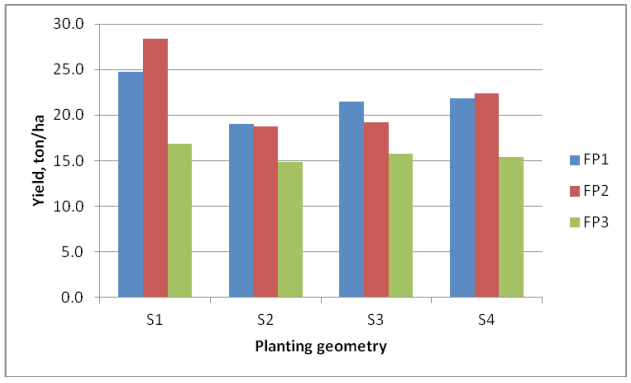

Fig. 112. Tomato yield as affected by fertigation pattern and planting geometry

geometry S_2 showed maximum water use efficiency of 11.7 kg/m^3. However, the fertigation pattern was found non-significant. With respect to water productivity, S_2 planting geometry resulted in the highest value (₹ 234.7/m^3) which was at par with S_2 and S_3. The fertigation pattern FP_2 with planting geometry S_2 showed maximum water productivity of 234.7 ₹/m^3 and found at par with $FP_1$with crop geometry S_2 & S_3.

Table 55. Water use efficiency of tomato as affected by fertigation pattern and planting geometry

Spacing, B	Fertigation pattern			Spacing total	Spacing means
	FP_1	FP_2	FP_3		
S_1	7.7	7.3	4.7	19.66	6.6
S_2	10.9	11.7	10.0	32.60	10.9
S_3	10.1	9.8	8.1	28.01	9.3
S_4	8.7	8.2	5.7	22.53	7.5
Main plot total	37.4	37.0	28.4		
Main plot means	9.3	9.3	7.1		
CD for fertilizer pattern	NS				
CD for planting geometry	2.4				

Gravity Sub Surface Drip and Fertigation for Cucurbits in Sandy Loam Soils of Eastern Plateau Region

The experiment was conducted to standardize depth of placement of laterals and fertigation for growing cucurbits in sandy loam soils of eastern plateau region. The treatments comprise of sub-surface placement of laterals at four depths *viz.,* 0.05 m, 0.15 m, 0.30 m and 0.45 m and four doses of fertilizer applied through fertigation. Fig. 107 illustrates soil moisture content under different depths of lateral measured at 0.15 m away along lateral. It was observed that the variation in moisture content increased with depth in case of SDI at 0.10 m and 0.15 m while in case of surface and near surface SDI (5 cm) the trend was reversed. The loss of moisture due to evaporation reduced the availability of water to move down to the root zone which was reflected in reduced moisture levels at deeper depths. The weekly variation in soil temperature under mulch and non mulch in bitter gourd rows are depicted in Fig. 108.

Germination of bitter gourd (%)

The highest germination percentage was recorded with placement of lateral at a soil depth of 0.15 m (Fig. 109). Overall the average germination in surface placement of laterals was 41.8%. The low value of

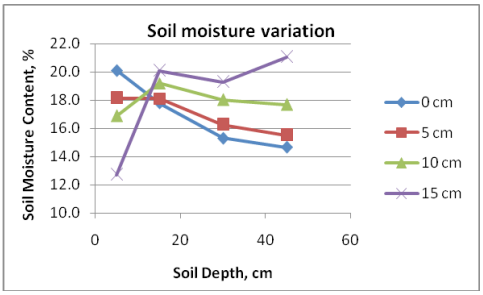

Fig. 107. Soil moisture variation under different depths of lateral placement

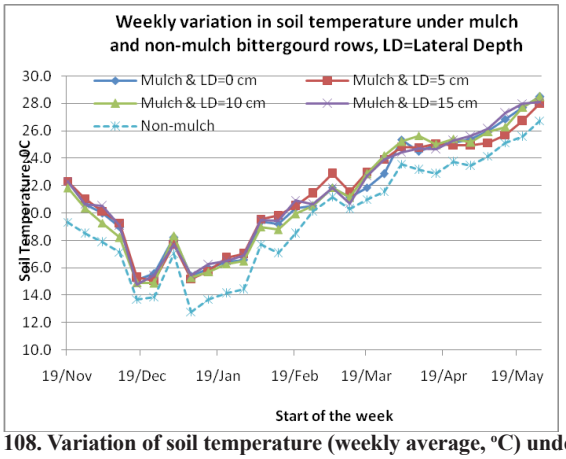

Fig. 108. Variation of soil temperature (weekly average, °C) under mulch (for different depths of lateral placements) and non-mulch non-irrigated conditions

germination under surface drip may be attributed to alternate drying and wetting of soil layer in which the seed was placed. Conversely, in case of SDI, as water was applied below certain depth, moisture loss due to evaporation was minimized and the rate of moisture loss was comparatively slower which ensured that soil remained wet until next irrigation.

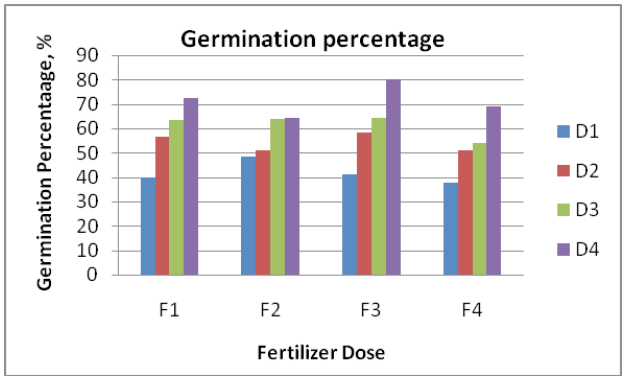

Fig. 109. Germination percentages of bitter gourd seeds under different fertilizer doses and under different lateral placement depths

Growth of bitter gourd

Data on growth of bitter gourd was recorded at 90, 120, 150 & 180 DAS. Non-significant difference in vine lengths was recorded at 60 and 90 days after sowing. However, at the end of 150 DAS, vine lengths obtained under fertilizer dose F_4 and under all SDI treatments was statistically better over surface drip. Towards the end of the season, the values of vine length did not vary among the treatments on depth of lateral placement. Only fertilizer treatment F_4 showed statistically better vine lengths (Fig. 110).

Bitter gourd yield

Bitter gourd yield (t/ha) was higher for the placement of laterals below the surface at 0.05, 0.10 cm and 0.15 m. The highest yield of 22.9 t/ha was observed in case of 0.10 m SDI in fertilizer dose F_4 (Table 56).

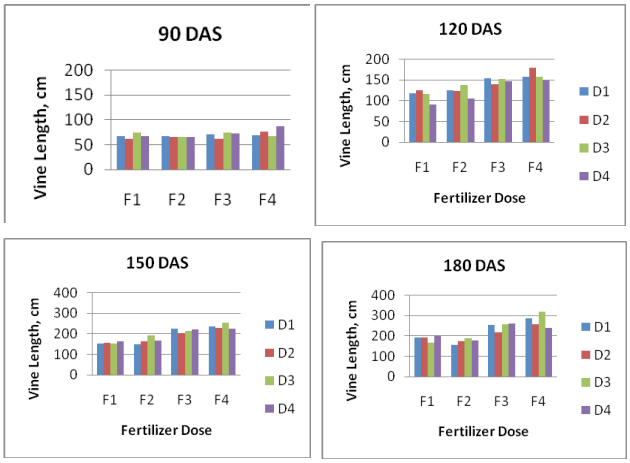

Fig. 110. Bitter gourd plant growth at different DAS during 2012

Table 56. Bitter gourd yield (t/ha) under different treatments of subsurface drip and fertigation

Depth of lateral placement	Fertilizer dose				Average
	F_1	F_2	F_3	F_4	
D_1	2.9	7.9	9.2	19.2	9.79
D_2	4.4	4.5	15.2	20.2*	11.05
D_3	6.4	14.0	17.0	22.9*	15.08*
D_4	6.5	11.9	17.5	20.7*	14.13*
Average	5.0	9.6	14.7	20.7*	

* Significantly better at $t_{0.05}$, CD depth =1.39, CD fertilizer = 2.17, CD depth x fertilizer=3.02

Water use efficiency

The water use efficiency (kg/m^3) of bitter gourd under SDI was calculated based on mean yields observed under different treatments and the quantity of water used (**Fig. 111**). It was observed that highest water use efficiency of 6.5 kg/m^3 was obtained in fertilizer treatment F_4 under 0.10 m SDI treatment. Lowest water use efficiency of 0.8 kg/m^3 was, however, recorded for the fertilizer treatment F_1 and for surface SDI.

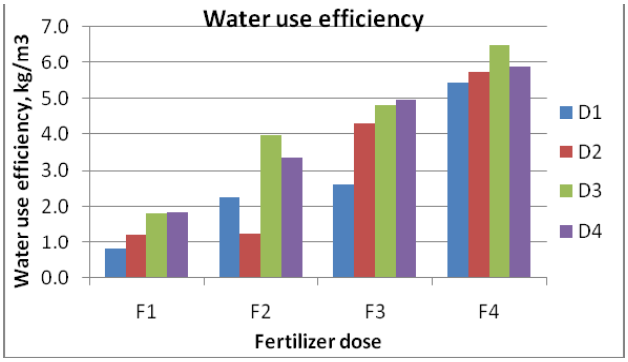

Fig. 111. Water use efficiency under different treatments of subsurface drip and fertigation

Water Harvesting and Better Cropping Systems for the Benefit of Small Farmers in Watersheds of the East India Plateau

The project was undertaken during 2005 to 2012 with the focus on water harvesting as a basis for livelihood improvement. The most important technical conclusions relate to the risks of growing transplanted rice in medium uplands (the main land class for growing rice, especially for poorer families) where, even after full watershed development (WSD), crop failure is inevitable in dry years when there is little water to harvest for irrigation. An unexpected but important conclusion is that even without water harvesting, land and water resources can be used much more productively in well-managed climate-responsive cropping systems. These flexible systems have the potential to respond to opportunities. Climate-responsive systems contrast with the rigid systems now practiced and often promoted to farmers. Crop options for use in climate-responsive systems were identified with farmers, but both in Amagara and in the scaling out to more than 2,000 families, farmers themselves developed new systems, each to suit their own unique circumstances. Well-managed climate-responsive systems may have the potential to make rural development largely independent of government input subsidies; however, the need for greater expertise will need to be met though improved training. In terms of the processes used in development, adult-learning provides the foundation for breaking dependency on extension professionals, whether from the government or NGO's. Development involves complex changes and demands a new approach to extension based on adult-learning principles with a central focus on the meaningful engagement of women as farmers.

The biophysical reasons for low productivity and high climate risk soil water measurement and two different approaches to modelling show that transplanted rice is inevitably a risky crop in 'medium uplands', as the necessary ponding cannot be assured. Shorter-duration varieties alone cannot deal with variable rainfall (and climate change). Alternatives to transplanted rice are needed for the medium uplands. There is large yield variation between fields of rice within land classes in the same year, which is mostly related to N and P nutrition and plant protection, pointing to relatively easy potential gains in rice productivity. Some farmers already achieved 7 t/ha in lowlands and medium lowlands, and even in medium uplands when water is not limiting. Soil surveys and participatory fertilizer experiments reveals unusually variable soil, which is probably related more to land levelling for rice and variation in the level of inputs used by farmers, than to soil type and topography. Field-specific fertilizer management is needed to support efficient use of water resources. Acute P-deficiency and insufficient P-fertilizer may explain why past *rabi* cropping mostly failed, not primarily the lack of irrigation although irrigation increases production from crops with adequate nutrition. Soils degraded by rice culture, especially by the puddling that is needed to reduce infiltration to retain ponded water, will need remediation for greatest productivity from other crops.

15

Conservation Agriculture

Delivery and Rolling Out of Conservation Agriculture Based Resource Conserving Technologies (RCTs)

Cereal System Initiative for South Asia (CSISA) project is an initiative to strengthen the South Asian food security. Farmers participatory trials (FPT) on conservation agriculture based resource conserving technologies (RCTs) targeting prevalent and emerging cropping system, and adaptive trials for refining and fine tuning on existing conservation agriculture (CA) based technologies were taken at farmers' field in participatory mode in different blocks of Patna district.

Evaluation studies on following resource conserving technologies were conducted during *rabi* season 2011-12 and *summer* and *kharif* seasons of 2012.

- Refinement of zero tillage (ZT) methods (equal row, paired row)
- Double no-till (zero till cultivation in rice-wheat cropping system)
- Laser land leveling and residue management
- Introduction of last irrigation at grain filling of wheat to overcome the terminal heat and for providing residual moisture to summer crops
- Crop intensification through spring maize, summer green gram and cowpea through ZT machine after rice-wheat cropping system and crop diversification (Potato+Maize)
- Effect of various zero tillage methods on yield and economics of direct seeded zero till rice (ZTDSR) /direct seeded rice (DSR) during *kharif*
- Integrated weed management in DSR
- Brown manuring through co-culture of *Sesbania*
- Mechanical unpuddled transplanted rice (MUTR)
- Pre-germinated rice sowing through drum seeder
- Adaptive trials of rice through RCTs

Wheat cultivation by different zero till methods

Different practices of sowing (equal row and paired row) by eleven tynes zero till machines and residue management through turbo seeder was used and crop was monitored throughout the season till harvesting. During 2011-12, on-farm participatory trials were adopted by 228 farmers, covering 142 ha of area in 22 villages of Patna district. The minimum wheat yield was recorded at 3.1 t/ha with highest yield of 5.2 t/ha. The surface seeded wheat yielded around 2.7 t/ha. The tillage cost of sowing by zero till machine and turbo seeder was ₹ 560/acre and ₹ 960/acre, respectively.

Residue management

The combined harvesting has been very common in Bikram and Bihta blocks of Patna district where farmers are compelled to burn the rice straw for wheat sowing. Wheat was sown in an area of 30 ha spread over 10 villages with the help of turbo seeder. The yield was in the range of 3.5-5.8 t/ha.

Screening and evaluation of wheat cultivars under resource conserving technologies

Thirty high yielding varieties of wheat were sown on 24 November 2011 through ZT machine. The normal common farming practices like seed rate, fertilizers, irrigation etc were adopted. Yield and yield attributes of the different varieties were regularly monitored and recorded (**Table 57**). The climatic parameters like temperature, relative humidity and sunshine hours were also recorded. Though there were slight differences in the maturity days of the different varieties of the crop, but all varieties were harvested on 11 April 2012. CSW-12, CSW-10, CSW-15, CSW-1 and CSW-4 were found as the best varieties in this agro-climatic zone in respect of grain yield. Varieties like Baaj, Munal, Sarpat, CSW-16 and CSW-17 also performed well and their yield were around 4.0 t/ha. However, CSW-22, Agrim and HD-2643 produced less than 3.0 t/ha of wheat.

Table 57. Screening and evaluation of wheat cultivars under zero till with residue at ICAR-RCER Research Farm, Patna (*Rabi* 2011-12)

Varieties	Early vegetative vigour *	Days to 50% flowering (DFF)	Average plant height (cm)	Day of maturity	Grain yield (t/ha)
CSW-1	A	70	104.02	119	4.90
CSW-4	B	87	89.12	124	4.50
CSW-5	A	68	95.04	116	3.84
CSW-10	A	76	103.6	120	4.88
CSW-12	A	83	99.44	124	5.02
CSW-15	A	66	94.22	117	4.90
CSW-16	B	78	94.62	118	4.20
CSW-17	A	66	92.14	122	4.13
CSW-18	B	84	103.2	124	3.80
CSW-19	B	69	83.16	115	3.07
CSW-20	B	87	85.92	126	3.37
CSW-21	B	64	79.22	119	3.30
CSW-22	B	72	88.08	118	2.31
DBW-17	B	84	74.96	125	4.01
K-307	B	82	92.32	121	3.32
PBW-621	B	85	87.72	120	3.15
HI-1563	B	71	82.36	126	3.31
HD-2643	C	87	84.72	125	3.02
HD-2687	B	86	88.22	124	2.90
HD-2733	C	90	74.6	130	4.34
HD-2824	B	88	85.36	125	3.54
HD-2967	B	88	88.76	126	3.15
HD-2985	B	73	86.8	120	3.68
RAJ-4120	B	73	81.1	120	3.70
Agrim	B	76	97.98	117	2.65
Baaj	B	81	90.12	118	4.25
Munal	C	92	94.1	131	4.34
Ruby	B	86	99.02	119	2.90
Sarpat	B	86	89.12	125	4.16
Ufan	B	80	94.8	118	3.66

* A-Higher, B-Medium, C-Lower; Plot size - 15 m x 2 m - 30 m^2; Total net plot size - 900 m^2; Date of sowing - 24.11.2011; Date of harvesting - 11.04.2012; Residue - 30 %

Crop diversification of rice-wheat System through potato + maize on raised bed

During 2011, crop diversification of rice-wheat system through potato (Cv. Kufari Ashoka) + maize (hybrid N6240) on raised bed was undertaken after the harvest of rice. Potato was sown in November, 2011 and harvested by the middle to end of February 2012. The normal basal doses of NPK were given and most of the farmers applied the 2nd dose of nitrogen through top dressing. In general, three irrigations were given. The potato yield was observed in the range of 24.00 to 30.50 t/ha. The yield of maize was in the range of 2.5 to 4.6 t/ha.

Potato was sown on the bed at the distance of 15 cm and maize was sown at the slope of the bed, which is 5 cm above the furrow and distance between seed to seed was 20 cm. The seed rate for maize was 20 kg/ha.

Crop intensification in rice-wheat cropping system

The spring maize was sown with no tillage operation. The yield was recorded in the range of 5.20 to 6.50 t/ha. Summer moong bean (green gram-*Cultivar* SML 668 & Pusa Vishal) was grown as relay cropping before the harvesting of wheat and also by ZT machine after the harvest of wheat. This crop was 60-65 days old and harvested by the end of May, 2012 before the ZTDSR. The average yield was in the range of 0.52 to 0.90 t/ha. The cowpea was sown through zero till machine by 12 farmers as a vegetable crop. The average yield was in the range of 1.7 to 2.5 t/ha.

Zero till direct seeded rice (ZTDSR)

During 2012, on-farm participatory trials were taken in 16 villages in 5 blocks of Patna district by 50 farmers. ZTDSR sowing was started as early as on 4th July 2012 and continued till 25th July 2012 (**Fig. 112**). However, mechanical unpuddled transplanting (MUT) was done during 22-24th August 2012. In few villages, rice was sown through drum seeder during 3-4th August 2012. The minimum rice yield of grain was recorded to be 4.0 t/ha and the highest yield was obtained at 5.6 t/ha.

Adaptive trials of rice through RCTs

The adaptive trials were taken in farmers' field to evaluate the rice cultivars under zero tillage cultivation and was compared with conventional transplanted puddled rice. The hybrid rice performed better under ZTDSR. However, MTU-7029, BPT-5204 Sub-1 and Swarna sub-1 performed better under transplanted pudlled rice (Table 58).

Another adaptive trial was taken to assess the suitability of molecules for weed control under ZTDSR. Bispyribac sodium (nominee gold) was found most

Table 58. Evaluation of Rice cultivars under different resource conservation technology (*Kharif* 2012)

Varieties	Yield (t/ha)	
	ZTDSR	Wet seeding/ puddle condition
Arize Dhani (Hybrid)	6.49	6.83
Arize Prima (Hybrid)	6.82	6.90
Arize-6444 (Hybrid)	6.10	6.32
MTU-7029	4.23	5.10
Rajendra Bhagwati	3.56	3.88
Rajendra Sweta	3.90	4.17
Rajendra Subhasini	4.01	4.39
BPT-5204 Sub-1	4.57	5.00
Swarna Sub-1	3.50	4.07

Fig. 112. Zero till direct seeded rice cultivation in farmers' field

effective molecule to control the weeds under ZTDSR (Table 59).

Table 59. Weed management in direct seeded Satyam variety of rice (*Kharif* 2012)

Treatment	Yield (t/ha)
DSR-weedy	1.06
DSR-pendimethalin1 kg ai/ha fb one hand weeding at 30 days	3.67
DSR-pendimethalin1 kg ai/ha pre emergence fb ethoxysulfuron 18g ai/ha at 20 DAS	4.75
DSR-pendimethalin1 kg ai/ha pre emergence fb bispyribac sodium at 25g ai/ha at 20 DAS	4.98
Weed free	4.19

Effect of mulching and seed rate on plant growth and productivity of ZT wheat in eastern plains of India

In the eastern part of India, rice is harvested late and at the time of harvesting, excess moisture persists in the heavy soils, i.e., one has to wait for cultivating the soil and thus sowing of wheat gets delayed. It is proved from the experiments that each day delay in the sowing costs about 30-35 kg yield reduction on hectare basis. In such prevailing conditions, sowing by zero tilled machine or seed drill is better option. After sowing of wheat the soils gets dry due to loss of moisture and in eastern part no winter rain or a little rain is expected which does not fulfill the irrigation requirement. Mulching is, however, used to ensure soil moisture and to maintain optimum temperature during the chilled cold (Fig. 113). Secondarily, for obtaining an optimum yield level and to maintain the optimum plant density, a proper crop stand is required. Experiment conducted at ICAR-RCER, Patna research farm during 2011-12 on seed rates and residue retention of previous crop revealed that crop sown under 30 cm. standing mulch of the previous crop resulted in significantly superior grain yield (5.7 t/ha) over full mulch (4.9 t/ha) or bare soil (5.1 t/ha). Weed population and weed dry weight was also found minimum under mulched condition over unmulched condition while a seed rate of 100 kg/ha was found optimum if sown as zero tilled wheat. On farmer's field, ZT wheat had performed at par with the conventional wheat in respect of grain yield but ZT wheat resulted in more returns (18 per cent) over conventional wheat and had saved 12 cm of irrigation water (two irrigations).

Fig. 113. Mulching : a viable option for soil moisture conservation and to maintain the optimum temperature in the beds

Effect of tank mixture application of post emergence herbicides on complex weed flora under Direct Seeded Rice (DSR)

The risk of yield losses due to weed is greater in DSR which is influenced by weed seed bank, tillage systems, weed flora and herbicides. Weed management is the key issue under DSR. Integrated weed management is an important tool for weed management in DSR in which tank mixtures of herbicides can play a vital role in controlling complex weed flora. Keeping this fact in view, an experiment was conducted at ICAR-RCER Research Farm, Patna during *Kharif* 2012 to evaluate the efficiency of tank mixture of POE herbicides on control of complex weed population under DSR and to study the shifting and control of weed flora. The findings revealed that the plots where tank mixture of Bispyribac+Azimsulfuron were applied had controlled the weeds most efficiently over other combinations except weed free treatments. It was followed by the tank mixture of Bispyribac+Ethoxysulfuron (as lesser weed dry wt. at 40 DAS and at flowering stage was recorded). The seed yield ranged from 5.5 to 5.7 t/ha, which was at par with the yield of weed free plots (5.8 t/ha). Weed control efficiency was also found higher to the tune of 84.9% with tank mixture of Bispyribac+Azimsulfuron (Fig. 114).

The major weed population observed under ZTDSR are of complex nature, i.e., mixed population of narrow leaved, broad leaved and sedges (Table 60). *Echinochloa colona, Cynodon dactylon, Leptochloa chinensis* under

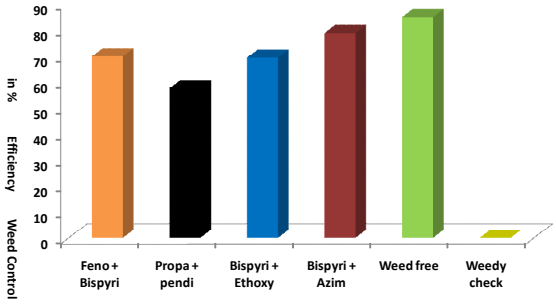

Fig. 114. Weed Control efficiency as affected by different tank mixture of herbicides

narrow leaved weed, *Physalis minima, Ageratum conyzoides* under broad leaved weed, *and Cyperus rotundus* under sedge group were more dominant.

Table 60. Weed flora identified under ZTDSR during *Kharif* 2012

Grasses	Sedges	Broadleaf
Echinochloa crus-galli	*Cyperus difformis*	*Physalis minima*
Echinochloa colona	*Cyperus rotundus*	*Cleome viscosa*
Digitaria adscendens	-	*Ageratum conyzoides*
Eleusine indica	-	*Commelina diffusa*
Cynodon dactylon	-	*Alternathera sessilis*
Leptochloa chinensis	-	*Trianthema portulacastrum*

Comparative performance of ZTDSR, unpuddled mechanical transplanted and Conventional transplanted rice on farmers' field under laser leveled and non- laser leveled condition

Labour and water scarcity have been experienced as a most critical problem in IGPs for agricultural growth. DSR and unpuddled mechanical transplanted rice are, therefore, getting momentum to save time, energy, water, labour and pushing conservation agriculture over traditionally transplanted rice. To minimize the cost of cultivation and increasing net returns, trials on 30 farmers fields at Simra, Chiraura and Mahangupur of Phulwari block were conducted during *kharif* 2012. A group of 10 farmers were selected for DSR, unpuddled mechanical rice transplanting and puddled rice transplanting for evaluation of cost of cultivation and yield level. DSR showed least input cost (₹ 10,850/-), followed by unpuddled mechanical transplanting of rice (₹ 15,080) over traditional method of rice transplanting in the puddled condition (₹ 23,600/-). Yield advantage

of 2.2% in laser leveled condition and 11.1% under non-laser leveled fields were obtained in case of unpuddled mechanical transplanting of rice and DSR, respectively. However, DSR resulted in lowest yield in other methods of rice cultivation. From cost of cultivation point of view, it stands at par with traditional method of rice transplanting (Fig. 115a-b).

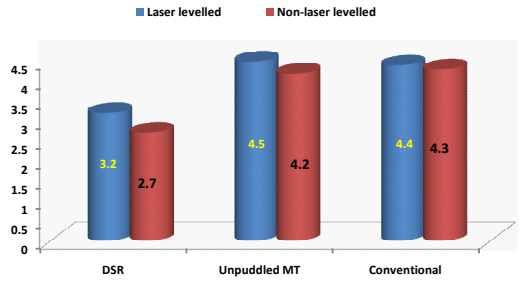

Fig.115a. Yield (t/ha) under laser and non- laser fields with different methods of rice cultivation

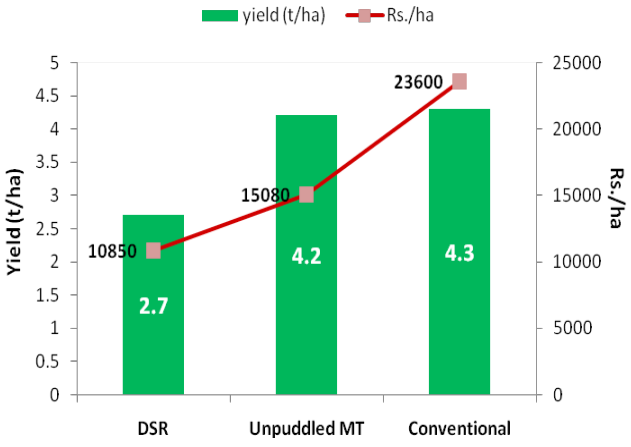

Fig. 115b. Yield (t/ha) and cost of cultivation (Rs.ha) in different methods of rice cultivation

DSR is preferred by the farmers due to less labour and energy requirements. DSR and unpuddled mechanical transplanting of rice saved about 52 cm. and 40 cm. of irrigation water, respectively over puddle transplanted rice. Performance of mechanical transplanter was also studied and it was found that the transplanter was able to transplant one ha of land in about 8.00 hrs with a fuel consumption of approximate 1.00 lit/hr (Table 61).

Table 61. Performance evaluation of manual operated mechanical rice transplanter

Model no.	Petrol engine
Average planting speed (km/hr)	1.1
No of rows	4
Row spacing (cm)	30
Distance between Hill (cm)	14
Width of seedling mat (cm)	30
Age of seedling (days)	16
Total study area (ha)	0.86
Speed of operation (kmph)	1.1
Width of transplanter (m)	1.2
Actual field capacity (ha/hr)	0.13
Theoretical field capacity (ha/hr)	0.155
Field efficiency (%)	85.20
Labour requirement (man days /day)	2.0
Fuel consumption (l/hr)	1.17
Fuel consumption (l/ha)	8.70
Time taken to cover 1 ha (hrs)	7.58
	8.0 (approx.)

Crop and Resource Management Practices for Sustainable Future Cereal-base Systems (CSISA-2 Platform Research)

Cereal System Initiative for South Asia (CSISA) is being conducted at Sabjpura farm in Patna for strategic experimental research for future cereal systems with focus on rice-wheat system, its intensification and diversification for higher cereal production with sustainable natural resource management. The four scenarios of cropping with different management practices like farmer's practices (S_1), best available practices (S_2), conservation agriculture practices (S_3) and best practices (S_4) were sown in three replications having plot size of 1900 m^2.

Among the different scenarios, the grain yield of wheat in year 2011-12 in conventional practices was recorded lowest (3.63 t/ha). However, in scenario S_2 and S_3, grain yield was recorded to be 4.59 and 5.16 t/ha, respectively. Maximum wheat equivalent yield (18.21 t/ha) was recorded in scenario 4 in which 23.81 t/ha residue was recycled **(Fig. 116).** Likewise in *kharif* crop, the rice grain yield was recorded minimum (6.89 t/ha) in S_1 scenario and maximum (7.36 t/ha) in S_2 and S_3 scenario (Fig. 117).

To determine the use efficiency of major nutrients (NPK) in potato and maize crop, omission plots were established in S_4. Potato yield in NPK and NPK_O treated plots were recorded higher as compared to other two combinations. However, maize yield was recorded higher in NPK treated plots. It indicates that the potato is more responsive towards NPK and NPK and maize towards NPK and NP_oK (Fig. 118).

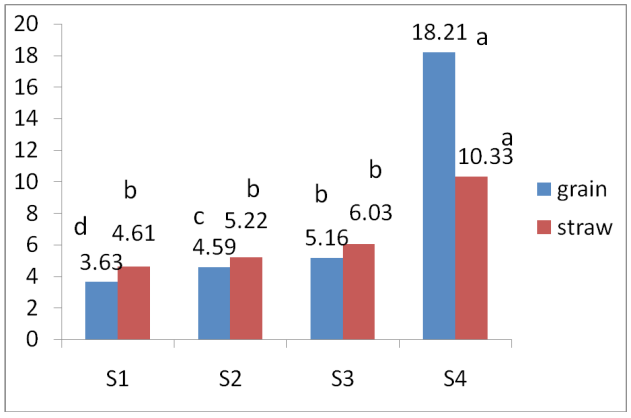

Fig. 116. Wheat yield t/ha in different scenario in 2011-2012

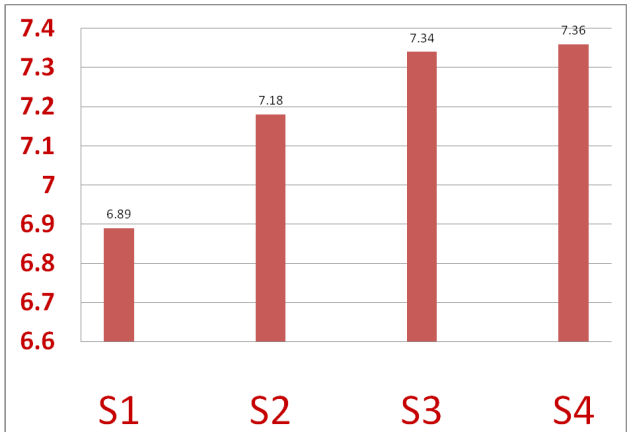

Fig. 117. Rice yield (t/ha) in *Kharif* 2012

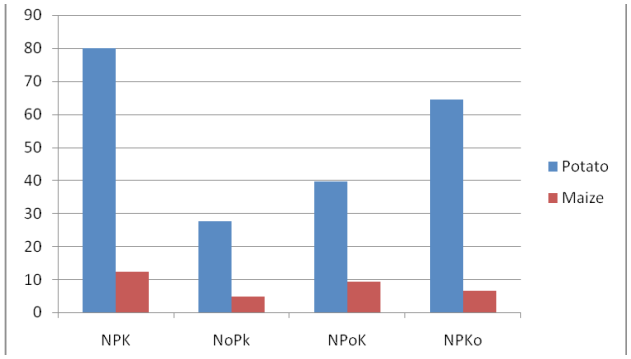

Fig. 118. Yield of potato and maize in omission plots in scenario-4

Resource Conservation and Methods of Planting in Acid Soils by Vegetable Cropping System

A field experiment was conducted to standardize technologies on resource conservation & methods of planting for vegetable cropping system (cauliflower-brinjal-tomato) in acid soil of eastern plateau and hill region. The experiment comprised of six treatments, i.e., T_1 (flat bed and no plastic mulch), T_2 (flat bed with plastic mulch), T_3 (broad bed with no plastic mulch), T_4 (broad bed with plastic mulch), T_5 (ridge & furrow with no plastic mulch) and T_6 (ridge & furrow with plastic mulch) based on drip irrigation. The 75 % manures and fertilizer were applied of recommended basal dose in first crop and 50% in subsequent 2nd & 3rd crops supplemented by fertigation. The minimum tillage was practiced in mulched treatment by uprooting of crop and planting seedlings of subsequent crop directly.

The results revealed that the growth attributes were not influenced significantly by different methods of planting and mulching in vegetable crops. However the weed biomass and yield attributes showed significant differences. Plastic mulch with ridge and furrow resulted in the maximum yield (Fig. 119) (53.07 t/ha) in cauliflower (Table 62). Mulching in flat bed resulted in 16.42% higher yield in comparison to non mulched plots. Similarly, in broad bed, mulching resulted in 15.44% higher yield in comparison to non mulched fields. Ridge and furrow method of planting was found to be the superior to other methods of planting, irrespective of mulch or non mulch situations. In brinjal, maximum yield (29.9 t/ha) was recorded in case of mulch with flat bed which was at par with T_4 and T_6 whereas minimum yield of 1.2 t/ha was recorded in treatment broad bed with no mulch. In tomato, highest yield was obtained in mulch with ridge and furrow treatment (7.29 t/ha) which was at par with T_2 and T_4.

Fig. 119. Yield of different vegetables crop under mulch, without mulch & planting methods.

Hence, the ridge and furrow planting method was found superior to other methods of planting, irrespective of mulch or non mulch situation in case of cauliflower, brinjal and tomato.

Table 62. Effect of different treatments on yield of cauliflower, brinjal and tomato (t/ha)

Treatment	Cauliflower	Brinjal	Tomato
T_1	40.7	21.1	3.7
T_2	47.3	29.9	6.2
T_3	41.8	18.2	4.4
T_4	48.6	28.9	5.6
T_5	43.7	19.5	3.6
T_6	54.6	26.7	7.2
CD at 5%	8.3	6.4	2.1

The mulch treatment in general showed significantly less weed biomass yield compared to non mulch conditions (Fig. 120).

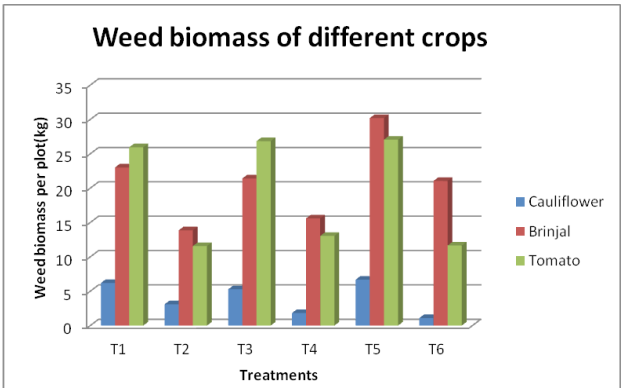

Fig. 120. Weed biomass/ plot (kg) in different crops

Effect of different resource conservation technology on uptake of nutrients by cauliflower, nitrogen, phosphorus and potassium content in different parts of brinjal, available nutrient content in the post harvest soil of brinjal are depicted in Table 63-65, respectively.

The data pertaining to water use efficiency (WUE) and gross economic return (GER) of vegetable crops revealed that the mulched treatment recorded higher WUE and GER than the non mulched one and required less water to produce per kg of fruits (kg/m^3) and more economic return (₹/m^3). In cauliflower, the highest WUE (14.55 kg/m^3), economic gross return (₹ 72.80 / m^3) was found in ridge and furrow. For production of 1 kg of cauliflower, 68.72 litre of water was required. Whereas in brinjal, the highest WUE of 7.98 kg/m^3, and economic gross return of ₹ 39.92 /m^3 was found in flat bed. For production of 1 kg of brinjal, 125.31 litre of water was required. Similarly, in tomato, the highest water use efficiency of 4.85 kg/m^3, economic gross return of ₹ 48.61/m^3 was found in ridge and furrow. For production of 1 kg of tomato, 206.18 litres of water was required.

Table 63. Effect of different resource conservation technology on uptake of nutrients by cauliflower

Treatments	Total N uptake (g/p)					Total P uptake (g/p)					Total K uptake (g/p)				
	Curd	Leaf	Stem	Root	Total	Curd	Leaf	Stem	Root	Total	Curd	Leaf	Stem	Root	Total
T_1	1.76	2.25	0.22	0.08	4.31	0.15	0.16	0.07	0.02	0.40	0.83	1.01	0.16	0.06	2.06
T_2	1.84	2.45	0.20	0.09	4.58	0.14	0.20	0.11	0.05	0.50	0.86	1.13	0.19	0.11	2.29
T_3	1.47	1.82	0.20	0.04	3.53	0.12	0.14	0.08	0.02	0.36	0.74	0.89	0.15	0.05	1.83
T_4	0.86	1.57	0.17	0.07	2.67	0.14	0.09	0.10	0.04	0.37	0.86	0.78	0.18	0.11	1.93
T_5	1.97	1.95	0.19	0.09	4.20	0.14	0.14	0.08	0.02	0.38	0.87	0.76	0.15	0.10	1.88
T_6	1.06	1.77	0.19	0.07	3.09	0.10	0.11	0.10	0.03	0.34	0.70	0.80	0.18	0.08	1.76

Table 64. Nitrogen, phosphorus and potassium content in different parts of brinjal under different resource conservation technology

Treatments	Total N (%)			Total P (%)			Total K (%)		
	Leaf	Root	Stem	Leaf	Stem	Root	Leaf	Stem	Root
T1: Flat bed with tillage & no plastic mulch	2.26	1.56	0.97	1.10	0.18	0.16	1.50	1.40	1.01
T2: Flat bed with minimum tillage & plastic mulch	2.60	1.63	0.83	1.64	0.17	0.14	1.54	1.25	0.83
T3: Raised bed with tillage & no plastic mulch	2.34	1.56	0.72	1.25	0.15	0.19	1.35	1.21	0.60
T4: Raised bed with minimum tillage & plastic mulch	2.63	1.40	0.75	1.54	0.18	0.14	1.31	1.20	0.95
T5: Ridge furrow with tillage & no plastic mulch	2.49	1.36	0.71	0.70	0.17	0.16	1.42	1.30	1.15
T6: Ridge furrow with minimum tillage & plastic mulch	2.51	1.37	0.72	1.05	0.24	0.17	1.39	1.31	0.94

Table 65. Available nutrient content in the post harvest soil of brinjal under different resource conservation technology

Treatments	Available nutrient (kg/ha)		
	N	P	K
T1: Flat bed with tillage & no plastic mulch	99.20	201.50	821.33
T2: Flat bed with minimum tillage & plastic mulch	133.50	178.03	820.00
T3: Raised bed with tillage & no plastic mulch	149.70	207.74	791.00
T4: Raised bed with minimum tillage & plastic mulch	126.00	229.50	810.13
T5: Ridge & furrow with tillage & no plastic mulch	111.84	233.17	780.26
T6: Ridge & furrow with minimum tillage & plastic mulch	81.50	223.00	769.06

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Livestock and Fisheries

LIVESTOCK

Growth Performance of Poultry and Pig as Influenced by Phytase Supplementation in Eastern Region

Performance of finisher pigs fed on rice polish supplemented with phytase

Feeding experiment for the period of 80 days was conducted on cross bred (Hampshire x Ghunghroo) 16 male finisher pigs (**Fig. 121**) (40.63±1.30 kg BW) having 50% exotic inheritance at NRC on Pig, Rani, Guwahati to study the growth performance and nutrient digestibility on rice polish based feeding regime supplemented with phytase. Four isonitrogenous (CP 16%) diets were prepared by incorporating rice polish at 50% level supplemented with phytase @ 20 and 40 g/100 kg feed, respectively and designated as T_1 and T_2. Similarly, rice polish was incorporated at 70% level supplemented with phytase @ 20 and 40 g/100 kg feed, respectively and designated as T_3 and T_4. The phytase supplemented @ 20 and 40 g/100 kg feed were provided enzyme activity 1 and 2 lacs FTU in the respective diets. These rations were offered in weighed quantity, one half in the morning and another half in the evening in wet mash system as per their body weight. Digestion trial was conducted at the end of feeding experiment and the data has been shown in **Table 66**.

The levels of inclusion of rice polish with different doses of phytase enzyme supplementation did not exhibit any significant effects on the performance of finisher pigs. However, highest average daily gain (ADG) with better feed conversion ratio (FCR) and lower feeding cost per kg gain was recorded in pigs fed on rice polish at 50% level with one lac unit of phytase enzyme (20g/100 kg feed). Digestibility of protein (CPD) was decreased significantly by increasing rice polish from 50 to 70% in diet, irrespective of phytase level. On the other hand, digestible energy (DE) values increased significantly by increasing the rice polish from 50 to 70% in diet. Thus, it is concluded that rice polish can be fed up to 50% with 20 g phytase (one lac unit/100kg feed) to finisher pig for maximum growth performance. However, resource poor farmers can feed rice polish up to 70% with 20 g phytase enzyme for acceptable growth performance.

Effect of phytase supplementation on the performance of Divyan Red poultry

Feeding experiment for the period of 85 days was conducted on 40 day old Divyan Red poultry (421±4.58g BW) to study the growth performance of birds fed on ration supplemented with phytase (**Fig. 122**). A ration with 21% dietary crude protein was prepared by incorporating maize (55 parts), rice polish (7 parts), soybean (35 parts) and additives (3 parts) and designated as control diet (T_1). The control diet was supplemented with phytase enzyme @ 10 and 20 g per 100 kg feed and designated as test diets T_2 and T_3,

Fig. 121. Feeding trial in pigs

Table 66. Influence of phytase on performance of pigs fed on rice polish

Particulars	Treatment mean ±SE			
	T_1 (RP50+P20)	T_2 (RP50+P40)	T_3 (RP70+P20)	T_4 (RP70+P40)
ADG (g/d)	385±16.34	380±28.27	354±16.52	346±8.21
FCR	4.36±0.18	4.47±0.33	4.75±0.23	4.84±0.12
Feeding cost (Rs/kg gain)	64.79±2.73	66.69±4.98	66.78±3.19	68.41±1.71
DE*(Kcal/kg)	2849a±17	2859a±24	2932b±20	2941b±07
DMD**(%)	79.22c±0.46	82.97d±0.63	74.08a±0.49	76.83b±0.57
CPD*(%)	83.42b±0.24	82.31b±0.46	81.67a±0.18	81.01a±0.57

Value having different superscripts in a row differ significantly at 5%* and 1%**

Fig. 122. Divyan Red poultry

respectively. All three rations were provided @ 100g/d/head and experiment was conducted under complete randomized design. The results (**Table 67**) revealed that supplementation of phytase in diets improved daily growth rate of 18.38% with improvement of 15.12% in FCR value in chicks than control group. However, the overall growth performance of Divyan Red poultry under confined condition in deep litter system was very poor and un-economical.

Table 67. Performance of Divyan Red poultry

Particulars	Treatment mean ±SE		
	T_1	T_2	T_3
Initial Wt. (g)	430±11.54	415±18.93	418±11.67
Final Wt. (g)	967±18.78	1047±29.06	1057±37.12
ADG (g/d)	6.31±0.19	7.43±0.49	7.51±0.33
FCR	15.87 ±0.48	13.58 ±0.95	13.37 ±0.57

Evaluation of Feeds and Fodders in Ruminants to Develop Mixed Ration for Production of Milk and Meat

Study on livestock production system in eastern region of India

A survey was conducted in seven states of the eastern region during the year 2011-12. Two districts were chosen from each state (Assam: Barpeta, Hailakandi; Bihar: Buxar, Patna; Chhattisgarh: Durg, Rajnandgaon; Eastern UP: Azamgarh, Ballia; Jharkhand: Dumka, Ranchi; Odisha: Keonjhar, Sambalpur; West Bengal: Burdwan, Hooghly) in consultation with associated research stations of ICAR/SAU's. Twenty-five farmers from each district were selected as the target group and information were collected through participatory rural appraisal technique. The information was collected on farmer status, animal strength, production, feeding system, health and input needs aspects. The information so recorded was analyzed.

Farmer status: Majority of the farmers were educated and having more than 0.5 ha agriculture land. Only 29.14% farmers spared their agriculture land for fodder production (Table 68).

Animal herd size: Majority of farmers of Assam, Chhattisgarh and Jharkhand were having non-descript (ND) cows. However, majority of farmers of Bihar and Eastern UP were having crossbred (CB) cows. Maximum numbers of buffalo were reared by the farmers of Eastern UP. Maximum population of goat per fam-

Table 68. Status of farmers in different eastern states

State	Av. family size (No.)	Education level of Head of family (%)		% Farmer having Agric. Land (h)			% Farmer practice fodder production (h)		
		Un-Edu.	Edu.	Nil	>0.5	<0.5	Nil	>0.1	<0.1
Assam	6.64	6.00	94.00	2.00	36.00	62.00	76.00	2.00	22.00
Bihar	8.56	10.00	90.00	8.00	18.00	74.00	30.00	20.00	50.00
Chhattisgarh	5.93	14.00	86.00	4.00	28.00	68.00	96.00	0.00	4.00
Eastern UP	9.48	30.00	70.00	10.00	20.00	70.00	42.00	38.00	20.00
Jharkhand	6.34	6.00	94.00	18.00	44.00	38.00	86.00	10.00	4.00
Odisha	6.78	23.00	77.00	4.00	18.00	78.00	66.00	0.00	34.00
West Bengal	5.31	8.00	92.00	46.00	45.50	8.50	100.00	0.00	0.00
Av. Eastern India	7.01	14.00	86.00	13.14	29.92	56.93	70.86	10.00	19.14

Table 69. Animal strength at farmer house in different eastern states

State	% Farmer having animal					Av. population per family (No)				
	ND Cow	CB Cow	Buffalo	Cow & Buff.	Goat	Cow		Buffalo		Goat
						Total	In milk	Total	In milk	
Assam	64.0	22.0	20.0	16.0	46.0	3.54	1.12	0.60	0.12	2.64
Bihar	12.0	62.0	40.0	16.0	4.0	1.56	0.70	0.80	0.36	0.24
Chhattisgarh	63.9	4.1	30.0	4.1	0.0	4.19	1.72	7.28	3.32	0.00
Eastern UP	52.0	46.0	60.0	48.0	16.0	1.84	0.92	1.32	0.78	0.82
Jharkhand	64.0	34.0	42.0	32.0	34.0	2.34	1.28	1.22	0.54	1.16
Odisha	50.0	18.0	6.0	4.0	64.0	3.22	0.96	0.30	0.08	8.58
West Bengal	45.5	33.0	4.5	4.5	63.0	1.37	0.53	1.45	0.58	3.77
Av. Eastern India	50.2	31.3	28.9	17.8	32.4	2.58	1.03	1.85	0.83	2.46

ily was recorded in Odisha followed by West Bengal (**Table 69**).

Production status: Average milk production (kg/d), lactation length (m) and dry period (month) were recorded for ND cow (2.48, 7.71, 6.66), CB cow (7.20, 9.08, 3.85) and buffalo (5.54, 8.56, 6.93), respectively (**Table 70**). The goats were sold at average age of 11.73 month and 12.75 kg weight in eastern region of India.

Feeding system: Most of the farmers followed traditionally feeding practices and offered self-produced feeds (**Table 71**). Most of the animals were under-fed and majority of them (63%) followed grazing. The farmers of Eastern UP, Bihar and Chhattisgarh used to feed wheat and paddy straw both as per availability in mixed feeding method, however, farmers of rest of the states used only paddy straw as dry roughage.

Health status, breeding method and input needs: Majority of the farmers (72%) of the region reported the incidence of FMD and 54% followed routine vaccination of animals. Almost half of the farmers of the region were not satisfied with their breeds of animals and production level. Majority need assistance in the form of subsidy and loan for procurement of high producing animals (**Table 72**).

The data revealed that livestock farmers of eastern region of India need improved breed and exposure to balanced feeding and general management practices so as to achieve higher production.

Table 70. Animal production status in different eastern states

State	Production status										
	ND Cow			CB Cow			Buffalo			Goat	
	MD	LL	DP	MD	LL	DP	MD	LL	DP	SA	SW
Assam	1.95	8.02	6.50	7.86	8.05	3.36	3.87	9.31	5.69	8.42	9.63
Bihar	3.58	7.66	4.83	9.12	8.49	4.10	7.16	7.57	5.39	9.50	12.50
Chhattisgarh	1.63	6.77	14.28	3.00	10.50	7.50	4.80	9.16	14.23	--	--
Eastern UP	4.12	10.90	5.05	7.30	10.80	3.75	6.78	10.22	5.06	14.37	13.37
Jharkhand	2.06	7.64	6.18	7.66	9.43	2.56	6.16	9.12	5.25	16.23	17.13
Odisha	2.49	6.42	5.34	7.08	8.00	3.17	4.50	6.00	6.00	10.78	12.70
West Bengal	1.56	6.60	4.47	8.41	8.32	2.55	--	--	--	11.10	11.20
Av. Eastern India	2.48	7.71	6.66	7.20	9.08	3.85	5.54	8.56	6.93	11.73	12.75

MD: Milk/d/head (kg); LL: Lactation length (m); DP: Dry period (m); SA: Slaughter age (month); SW: Slaughter weight (kg)

Table 71. Feeding system in cow/buffalo and source of feed in different eastern states

State	Feed offered (kg/d/h)			Graz. (%)	Feeding method (%)			Source of feed (%)					
	Dry	Green	Conc.		Ind.	Dry + Green	Mix	Dry Roughage		Green Fodder		Concentrate	
								Self	Pur.	Self	Pur.	Self	Pur.
Assam	6.69	10.25	1.66	80	86	14	0	70	20	72	22	54	36
Bihar	6.38	8.11	1.81	18	00	6	94	90	6	98	2	46	26
Chhattisgarh	5.12	--	1.71	100	0	0	100	56	26	100	0	50	50
Eastern UP	7.35	5.93	2.21	32	0	10	90	78	10	96	4	18	20
Jharkhand	7.69	3.86	1.25	63	36	18	46	56	30	98	0	50	48
Odisha	4.73	6.68	1.73	86	94	0	6	90	4	90	6	76	16
West Bengal	5.00	2.62	0.78	65	74	26	0	59	3	96	2	74	22
Av. Eastern India	6.14	5.35	1.59	63	41	11	48	71	14	93	5	53	31

Table 72. Animal health status, breeding method and input needs in different eastern states

State	Incidence of major diseases (%)			% Farmer followed vaccination schedule	Breeding method followed (%)		% Farmer satisfied with stock / prod.	% Farmer need input assistance				
	Viral	B act.	Other		Natural	AI		Sub.	Loan	AI	Tr.	CB
Assam	82	12	14	40	84	30	28	42	38	26	18	52
Bihar	52	50	20	48	8	92	82	28	36	34	22	2
Chhattisgarh	100	100	0	100	100	0	34	0	10	0	35	32
Eastern UP	76	56	4	62	46	64	86	14	20	6	0	10
Jharkhand	96	58	0	64	52	54	35	68	16	32	16	62
Odisha	24	4	4	44	72	30	16	84	12	10	40	70
West Bengal	75	16	2	20	62	45	61	82	80	35	0	0
Av. Eastern India	72	42	6	54	61	45	49	45	30	20	19	33

Round the year fodder production

Legume fodder soybean (NRC-37), rice bean (RBS-16) and cowpea (RS Gomti) were grown during rainy season (**Fig. 123**) whereas, oat, berseem and maize were grown on same piece of land during winter season for round the year fodder production for feeding dairy animals. Soybean fodder was harvested at different cropping periods from above first node. Plant further grew and additional biomass and grain yields was recorded (total crop duration 120 days).

Dry matter yield and protein content of different fodder were recorded (**Table 73**). Maximum forage yield for legume crops were obtained at 65 days of cropping period. Additional grain yield of 1.69±0.03 t/ha was obtained from soybean crop harvested as fodder at 65 days which was 33.72% less than soybean crop (2.55±0.14 t/ha) harvested without cutting as fodder. Overall total protein yield from fodder and grain was obtained 1.26 t/ha from soybean harvested as fodder at 65 days, whereas total protein yield of 0.80 t/ha was recorded without cutting as fodder at 120 days. This type of food-feed crop may be encouraged for cultivation in eastern region.

Fig. 123. Rainy/winter fodder (cowpea, soybean, maize, oat, berseem) for livestock feeding

Nutritive value of total mixed ration (TMR) in cow

Feeding experiment for the period of 60 days duration was conducted on total mixed ration (TMR) in crossbred cows to study the effect on milk production, milk composition and nutrient digestibility. Total four cows of Ist lactation was selected from the dairy herd of the institute for the study and distributed into two groups referred herein as T_1 (TMR) and T_2 (individual feeding plane). TMR was prepared by mixing wheat straw (2 kg), chapped green forages (oat 15 kg and berseem 16 kg) and concentrate feed (16.5% dietary CP, 4.5 kg) (**Fig. 124**). The half of the quantity of this mixed ration was offered in the morning and remaining half in the evening after mixing with water to the cows of group T_1. The cows of group T_2 were fed with the same quantity of above feed ingredients separately, one half in the morning and another half in the evening. First wheat straw and concentrate feed was offered after mixing with water and then after a gap of 2 hrs, unchapped green forages was offered. Total 11.28 kg DM per day per head was provided to both the groups. Daily milk production data was recorded before and during experimental period. Similarly, milk was estimated for fat, protein, lactose, SNF contents at weekly intervals. Digestion trial during mid of experimental period was also conducted.

Fig. 124. Preparation of TMR and feeding to experimental cows

Table 73. Fodder yields and nutrient content

Particulars	Summer/rainy season fodders				Winter season fodders		
	Rice bean	Cow pea	Soybean	Soybean grain	Oat (in 2 cuts at 50 & 90 d)	Berseem (in 4 cuts at 50, 80, 105 & 125 d)	Maize (at 105 d)
Fodder/grain yield (t/ha)							
At 55d	18.67±1.20 *(16.60)*	23.00±2.08 *(20.04)*	12.67±0.33 *(26.10)*	1.98±0.06	31.45±1.10 *(14.18)*	69.81±0.85 *(11.65)*	53.07±3.76 (17.40)
At 65d	33.00±3.05 *(16.69)*	37.33±1.20 *(17.48)*	15.67±0.33 *(25.45)*	1.69±0.03			
	30.50±1.15 *(15.78)*	30.67±0.44 *(17.30)*	13.50±0.29 *(26.52)*	1.07±0.06			
At 75d Without cut	--	--	--	2.55±0.14			
Av. CP (g/100g DM)	17.27	15.49	18.33	31.28	9.21	16.69	8.59

(The values given under parentheses represent DM per cent)

The results (**Table 74**) indicated that feeding of TMR had increased feed intake and milk production. The digestibility of DM, CP & DE value of ration increased in cows fed on TMR than individual feeding plane. However, the composition of milk was not much influenced by the different types of feeding system. Thus, it is concluded that TMR feeding is beneficial for higher feed intake, nutrient digestibility and production point of view.

Table 74. Performance of cow fed on TMR

Particulars	T_1		T_2	
Expt. from date of calving (d)	98±28.50		84±31.50	
Av. body wt. before expt. (kg)	362±20.50		385±19.00	
Av. body wt. after expt. (kg)	363±18.00		385±19.00	
Av. DMI (kg/100 kg body wt.)	3.11		2.64	
Average milk yield (kg/d/head)				
Before experiment	6.13±0.16		6.24±0.39	
During experiment	7.17±0.12		6.91±0.28	
Nutrient Digestibility (%)				
DM	68.44		68.17	
CP	47.84		43.51	
DE (Kcal/kg)	2754		2687	
Milk composition (%)	Before expt.	During expt.	Before expt.	During expt.
Fat	3.20	3.20	3.24	3.30
Protein	3.69	3.67	3.75	3.81
Lactose	5.38	5.40	5.48	5.42
SNF	9.85	10.03	10.05	10.22

Nutritive value of forages for goat feeding

Study was conducted to evaluate the nutritive value of oat and berseem forages in Black Bengal goats through digestion trial. Oat forage was offered *ad-libitum* to goats in the morning and berseem in the evening *ad-libitum* (T^1) and compared with goats received only oats both the times (T^2). The results (**Table 75**) indicated that supplementation of berseem fodder to oat increased dry matter intake (DMI), digestibility of dry matter (DMD) and crude protein (CPD) which in turn increased digestible crude protein (DCP) and digestible energy (DE) value of the ration for goats. Thus, it may be concluded that nutritive value of oat forage can be improved through supplementation of berseem fodder.

Table 75. Fodder intake, nutrient digestibility and nutritive value of forage in goats

Particulars	T_1	T_2
DMI (kg/100 kg body weight)	3.85±0.12	2.91±0.11
% Intake of oat	52.06±4.14	100.00±0.00
DMD (%)	75.74±0.97	70.46±1.60
CPD (%)	70.17±2.41	58.73±1.97
DCP (%)	8.69±0.49	5.39±0.18
DE (Kcal/kg)	2621±23.55	2344±53.90

Formulation of Area Specific Mineral Mixture Based on Soil-Plant-Animal Continuum in Bihar

To formulate area specific mineral mixtures for Bihar based on soil-plant-animal continuum, soil, feed and blood samples were collected from 8 districts of Bihar representing 4 agro-climatic zones. The content of calcium and phosphorus in rice and wheat straw has been presented in **Table 76**. It was observed that concentration of calcium in both the straws was above the critical level which exhibited in physical appearance of animals (**Fig. 125**); however, concentration of phosphorus in all straw samples was below the critical level indicating the deficiency in major crop residues. The calcium content in rice and wheat straw varied from 0.7 to 1.5% and 0.9 to 1.3%, while the phosphorus content varied from 0.013 to 0.086 and 0.014 to 0.059%, respectively.

Table 76. Major minerals status of crop residues in different districts of Bihar

Districts	Ca (%)		P (%)	
	Rice straw	Wheat straw	Rice straw	Wheat straw
Patna	0.8-1.3	1.0-1.2	0.02-0.20	0.04-0.05
Buxar	0.8-1.5	0.9-1.2	0.02-0.03	0.04-0.05
Darbhanga	0.9-1.1	0.9-1.2	0.032-0.041	0.014-0.043
Madhuvani	0.7-1.0	1.0-1.2	0.015-0.04	0.39-0.046
Jamui	0.7-1.0	0.9-1.0	0.019-0.041	0.037-0.045
Munger	0.8-1.3	1.0-1.3	0.013-0.086	0.035-0.042
Katihar	0.7-1.0	1.0-1.2	0.015-0.04	0.039-0.05
Purnea	0.8-1.4	0.8-1.2	0.013-0.037	0.042-0.059

Fig. 125. Physical appearance of animals fed on minerals deficient residues

Field Bailing of Crop Residues for Animal Feeding

Survey in three districts of Bihar namely Buxar, Bhabua and Bhojpur revealed that height of cut of crop residues varied in different fields from whole cut to 35 cm from the top and burnt in the field (**Fig. 126**). The potential rice straw loss in whole, 25 cm and 35 cm cut was estimated at 5.2, 1.25 and 3.38 t/ha, respectively. The chemical compositions and energy values of residues at different height of cuts are presented in **Table 77.** Residues collected by mechanical harvester had

higher crude protein, organic matter and gross energy but lower acid insoluble ash than the residues which was cut manually, indicating better quality for animal feeding.

Table 77. Chemical compositions of crop residues cut manually or mechanically

Type of Straw	Manually cut	Harvester (whole cut)	Harvester (35 cm cut)	Harvester (25 cm cut)
Rice straw				
Availability (t/ha)	5.2	5.2	3.95	1.82
CP	3.6	3.5	4.3	4.7
OM	84.2	83.9	85.7	86.8
AIA	11.98	12.08	9.98	8.46
Energy (MJ/g)	13840	14141	15647	16106
Wheat straw				
Availability (t/ha)	6.1	6.1	2.08	1.46
CP	4.1	4.1	4.8	5.2
OM	91.5	91.8	93.2	93.9
AIA	8.18	8.45	7.32	6.88
Energy (MJ/ g)	15120	15577	16652	16786

Fig. 126. Burning of wheat straw in the field

Production Performance and Management Study of Rabbit in Bihar

Growth performance of rabbit and nutritive value of forage

Two breeds of broiler rabbit namely Soviet Chinchilla (SCH) and New Zealand White (NZW) were maintained for adaptability and management study for one year. The rabbits were under feeding management regime with available berseem, oat, cowpea and rice bean forages along with concentrate feed. The average daily gain in NZW and SCH were recorded at 17.55 ± 0.19 and 17.87 ± 0.56 g, respectively. No disease incidence and mortality was observed during the period. The average litter size at birth and weaning were recorded at 6 and 5, respectively.

The nutritive value of winter forage (oat and berseem) was studied in 8 NZW rabbits (1487±42.70g body weight) through digestion trial (**Fig. 127**). The concentrate feed (dietary CP 16%) was offered *ad-libitum* during morning hour and green forage either berseem

Fig. 127. Digestion trial in rabbit

(T_1) or oat (T_2) in the evening hours *ad-libitum*. The results (**Table 78**) indicated that berseem fodder is better than oat in terms of digestibility of DM, CP, DCP and DE values. However, total DMI and per cent fodder intake was higher in rabbits fed on oat fodder. Thus, it is concluded that almost 50% concentrate feed can be saved by feeding of green forage either berseem or oat to grower/adult rabbits.

Table 78. Nutritive value of forage used for rabbit rearing

Particulars	Group	
	T_1	T_2
DMI (g/d)	66.04±4.69	79.01±4.90
% Fodder intake	43.78±2.85	48.00±2.98
DMD (%)	81.83±1.79	73.63±2.14
CPD (%)	82.03±1.83	66.78±3.21
DCP (%)	13.60±0.30	8.69±0.56
DE (Kcal/kg)	3203±67	3006±76

Exploring Growth Hormone Gene for Improvement of Growth Performance Traits in Black Bengal Goat

Genomic DNA was isolated from 100 goats and used to amplify a 245 bp fragment (partial intron 1, exon 2 and partial intron 2) of growth hormone gene by polymerase chain reaction (**Fig. 128**). Primer was designed on the basis of sequence available publicly at NCBI. PCR programme followed for amplification of gene fragment was initial denaturation for 95°C for 2 min than 30 cycles of denaturation at 95°C for 30 sec, annealing at 60°C for 45 sec, extension at 72°C for 45 sec and then final extension of 72°C at 5 min.

Subsequently, the SSCP study was carried out to identify different allelic patterns and genotypes of the animal included in the study. Native PAGE gel (12%) was run for 12 hr at 4°c to identify various allelic pattern of growth hormone gene. SSCP typing in Black Bengal goat revealed five genotypes AA, AB, AC, BB and BC and three alleles A, B and C (**Table 79**) of growth hormone gene.

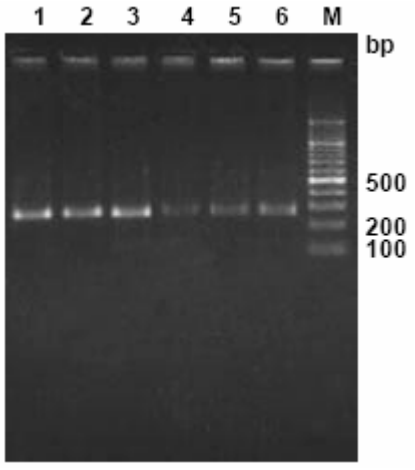

Fig. 128. Amplified 245bp fragment

Table 79. Genotype and gene frequency for 245bp fragment of growth hormone gene

Species	Genotype frequency				
	AA	AB	AC	BB	BC
Black Bengal	0.28 (n=28)	0.34 (n=34)	0.19 (n=19)	0.15 (n=15)	0.04 (n=4)
	Gene frequency				
	A		B	C	
	0.545		0.340	0.115	

Growth performance traits like birth weight, body weight at 3 and 6 month of age, body length, body height and heart girth at birth, 3 month and 6 month of age was recorded and presented in **Table 80**.

Table 80. Growth performance traits of Black Bengal goat

Trait	Birth	3 month	6 month
Body weight (kg)	1.14±0.03	4.58± 0.22	6.76±0.35
Body length (cm)	-	36.02±0.73	40.35±0.82
Body height (cm)	-	38.92±0.77	43.10±0.87
Chest girth (cm)	-	38.02±0.87	42.55±0.87

Study of prolificacy genes in Black Bengal goat by molecular methods

Blood samples of Black Bengal goat (20 Nos.) were collected. The extraction of genomic DNA was attempted using kit method (**Fig. 129**). Primers specific to prolificacy genes were designed from NCBI database using PRIMER 3 software. Reproductive data collection is in progress.

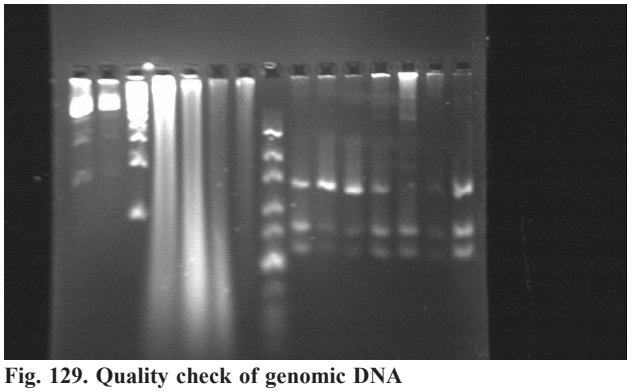

Fig. 129. Quality check of genomic DNA

Network Project on Buffalo Improvement

Ten Murrah Buffalo and heifers were procured from their breeding tract of Hisar and nearby areas of Haryana. Recording of milk production, body weight and reproduction traits were started (**Fig. 130**). Linkage was established with COMFED, Patna for field progeny testing. Three AI centers have been selected in both Patna and Vaishali districts and 270 doses of semen were supplied for AI in the field. Animal card was developed for recording the data in the field.

Fig. 130. Elite Herd of Murrah Buffalo

Health Monitoring and Surveillance of Farm Animals

Cattle

Cattles suffered with FMD (**Fig. 131**). Various other diseases recorded during the period under report include lameness due to post FMD complication, clinical mastitis, indigestion in adult cattle, calf diarrhoea and lymphadenopathy. Thus, it is concluded that six monthly prophylactic vaccination of FMD should be provided to all susceptible (cloven footed) animals to maintain proper herd immunity.

Fig. 131. Symptoms of FMD in cattle/buffalo

In case of buffalo, vaginal prolapse (**Fig. 132**), followed by pyometra, lameness, mastitis and dystocia in adults and diarrhoea in calves has been recorded.

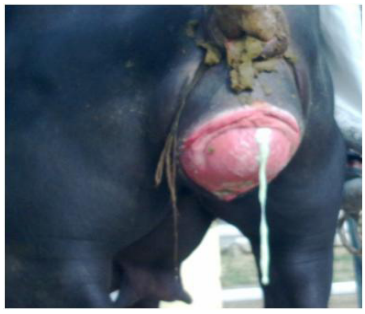

Fig. 132. Vaginal prolapse in buffalo

FISHERIES

Breeding, Rearing and Culture of Magur (*Clarius batrachus*) for Eastern Region

Induced breeding of magur

About 500 numbers of desi magur (*Clarius batrachus*) advanced yearlings (56±8g) were procured from different parts of Bihar and maintained at ICAR farm for further gonadal development and maturation. Fishes were fed with egg and high protein formulated diet on regular basis for attaining maturation. During the breeding season, both males and females were collected from the brood stock pond for breeding operation. The males were selected on the basis of pointed and reddish genital papilla, while females by a round and reddish papilla, softness of abdomen and uniform size of intra-ovarian oocytes (**Fig. 133**). For egg incubation, a low cost Flow Through Magur Hatchery was designed and fabricated at ICAR-RCER farm (**Fig. 134**). Induced breeding of magur was successfully attempted in the month of July and August and incubation of eggs was carried out in the fabricated magur hatchery. Among several inducing agents used in fish breeding, salmon gonadotropin releasing hormone (sGnRH) or luteinising hormone releasing hormone (LHRH) analogues in combination with dopamine antagonists was found to be effective in fish breeding. The use of synthetic inducing agents for successful ovulation followed by stripping in catfish is followed and has been studied. Inducing agent Ovaprim was administered @ 1.0-1.5 ml/kg of body weight. The males and females were kept separately. Hormone injections were administered intramuscularly, in the dorsolateral region of the body of fish. A total of seven sets of breeding trial were carried out where 19 numbers of male brooders (105±10g) and 25 numbers of female magur brooders (94±15g) were used. Breeding response of the mangur was evaluated and found to be good. The translucent eggs containing embryonic eyes were considered fertilised. Unfertilized eggs were removed immediately from the tray to avoid the fouling of water.

Fig. 133. Desi magur (male)

Fig. 134. Low cost hatchery

Hatchery water temperature, pH, dissolved oxygen and total alkalinity were in the ranges of 27-28°C, 7.4-7.6, 5.5-6.1 mg/l and 120-146 mg/l, respectively. More than 1000 early fry and fingerlings with average length (100 ±13 mm) and average weight (9.2±0.10g) were obtained after first month of sampling. After hatching to at least 16-20 days they were maintained in the hatchery itself and than transferred to FRP tanks of 2 x 0.5 x 0.3 cm^3 size for another 30 days. After that fishes (8-10 cm size) were released to the nursery pond for further rearing. For feeding the early fry after yolk absorption, eggs yolk suspension was given and later on crumbled powder feed having 20% protein as well as boiled eggs were fed. The present investigation demonstrated that the highest production of good larvae could be obtained by injecting 1 ml Ovaprim per kg body weight to fish.

Natural breeding of magur

Natural breeding of magur was attempted after suitably modifying the breeding ground with 70-80 cm water depth in pond (**Fig. 135**) as per the breeding behavior of the species. About 20 breeding pits were dugged. Several earthen pots, aquatics weeds and hideouts were provided for facilitating good breeding response. The 25 numbers of brood stock of magur out of which in 5 brood fishes only (3 female, 2 male) were administered with inducing agent Ovaprim @ 1 ml/ kg body weight and were released in modified breeding pond for further breeding and spawning. Water level in the breeding ground was maintained at 15-20 cm above the breeding pits. The breeding and spawning response of magur in natural site was found to be good. About 1000 magur fry and fingerlings were recovered from natural breeding ground.

Fig. 135. Natural breeding ground of m agur

Diversification of Fish Farming System to Maximize the Water Productivity

Breeding protocol, culture and rearing practices of carp species

Regular water quality and sampling were done to monitor and assess the growth and maturation of IMC, Grass carp and *L. bata*. Breeding trails of IMCs, Grass carp and *Labeo bata* were taken up and approximately 2 million fish spawn seed were produced for further rearing to stunted fingerling stage. Studies were also undertaken for assessment and refinement of production technology through stocking the stunted yearlings under multiple stocking and multiple harvesting production system.

The stocking ratio for stunted yearling (average weight 150±20 g) of rohu, catla, mrigal and grass carp was at the rate of 4:3:2:1 following the stocking density of 7,500-8000 fingerlings/ha/yr. The supplementary ration having 20% dietary protein was fed @ 3-5% of body weight daily in divided doses. Feed conversion ratio has been worked out to be 2.2. The specific growth rate (SGR) estimated for Rohu was 1.61 which was higher than catla (1.14) (Fig. 136). The fish productivity was 3.63 t/ha/yr.

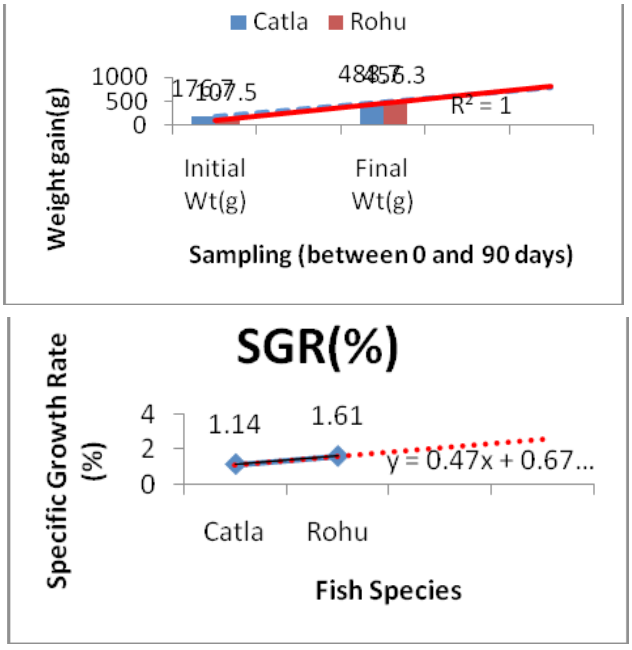

Fig. 136. Specific growth rate in catla and rohu

Makhana cum fish culture

Makhana is major cash crop of north Bihar and called as 'Black Gems of Wetlands'. However, there is no report of makhana cultivation in south Bihar. Considering the crop importance in low laying areas; attempts were made to grow makhana integrated with Indian Major Carp fishes such as rohu and catla species at ICAR-RCER farm in order to maximize the productivity of water bodies. Fish refuge of 10% area of water body as a central refuge was created in makhana growing pond (Fig. 137). Total 200 stunted fingerlings (100 each of rohu and catla) of 100±18 g were stocked. The stocking density of the stunted carp fingerlings was @ 2000 fingerling/ha. Harvesting was done after 6 months

Fig. 137. Makhana cum fish culture

of culture period. The fish yield of 2.4 t/ha and makhana seed yield of 500 kg/ha was recorded in makhana cum fish culture system.

Rice cum fish culture in low laying areas

Rice-fish culture is normally practiced with rice-rice cultivation using trenches type of fish refuge constructed in the field. Central refuge area (10%) was used for rice-fish culture. (**Fig. 138**). Thirty days old rice seedlings of BPT 5204, i.e., Super Mansuri were transplanted in the 1st week of August. Some submergence varieties of rice having sub-1 gene were also being screened for further standardization in rice cum fish culture system. A total of 100 numbers of IMCs stunted carp yearlings (with average weight of 120±8 g) mainly rohu and catla species were stocked @ 10,000 yearlings/ha of refuge area of (100 m^2). The average fish yield of 2.90 t/ha was recorded. It was also recorded that rice production increased by 10-22% at different experimental sites. Therefore, it is concluded that rice cum fish culture is suitable in low laying areas.

Fig. 138. Rice cum fish culture

Livestock based fish farming system

Total 600 fishes (average weight 110± 8 g) of IMCs (Indian Major Carps) were stocked @ 6000 fingerlings/ha in 1000 m^2 area of the experimental pond. Fresh cow urine and manure was applied @100 l/d. The inorganic N and P was estimated and found to be 0.986 mg/l and 0.029 mg/l, respectively. The N/P ratio was estimated to be 36.9 %. The fish productivity was estimated to be 5.46 t/ha/yr after six months of rearing **(Fig 139)**.

Fig. 139. Harvesting of fish after six month of culture

Ornamental Fish Breeding and Hatchery Technology

Different strains of guppies, mollies, sword tails, and Gold fishes has been grown in the tanks (**Fig. 140**) and fed mainly with Daphnia, mosquito larvae, Tubifex and blood worms. Feeding was generally done twice in a day or according to the requirement.

Fig. 140. Different strains of ornamental fishes

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Energy

Solar Energy Utilization in Agriculture

A solar power ground water pumping unit was established at experimental farm of ICAR Research Complex for Eastern Region, Patna **(Fig. 141)**. On an average, 3000-2600 bright sunshine hrs/yr have been recorded at the experimental site. In this system, a crystalline silicon solar array of 3060 Wp drives a 3 HP, three phase AC submersible pump placed in a 4″/6″ at 20 m below the ground level. The power conditioning unit comprised a variable frequency drive (VFD) and a Maximum Power Point Tracker (MPPT). To maximize power gain, solar arrays were mounted on a dual-axis sun tracking structures. The diurnal variation in the solar radiation in different months with no cloud at latitude of 25.65° N (Patna) is shown in **Fig. 141a**. Maximum solar radiation of 6.4 kWhm^{-2}/day was received in the month of April, whereas minimum of 3.4 kWhm^{-2}/ day in December. The diurnal variation of mean monthly daily water output in different months has also been estimated (**Fig. 141b)**. The data indicated the water output of 170 m^3/day in April and 104 m^3 /day in December on a cloud free day.

Ground water was collected in a tank which was delivered by 2 HP DC pump, operated by a 1400 Wp solar array so as to generate enough pressure head to facilitate crop irrigation either by pressurized irrigation or traditional methods like flood or furrow border methods of irrigation. The centrifugal pump generated pressure head of 1.2-1.5 kg/cm^2 with 63 mm conduit during peak sunshine hrs, i.e., 9.00 am-3.00 pm IST when the radiation flux ranged from 600-800 W/m^2 on clear sunshine cloud free days of March-October. The corresponding discharge has been recorded 5.5-4.0 m^3/hr. During peak sunshine hrs of low insolation months of November-January, radiation flux varied from 300-450 W/m^2. The corresponding pressure head ranged from 0.9-1.0 kg/cm^2 with discharge of 4.0-3.5 m^3/hr.

Fig. 141. A view of solar unit for ground water pumping

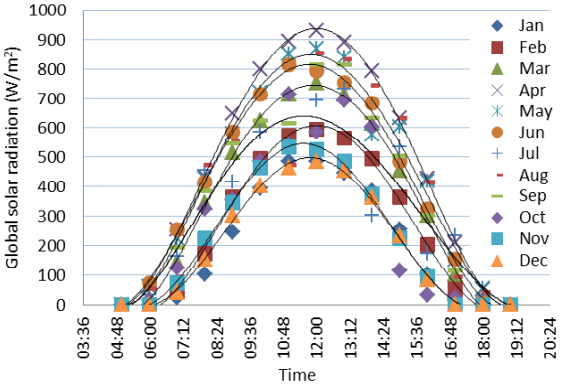

Fig. 141a. Diurnal variation in the solar radiation in different months with no cloud at latitude of 25.65°N (Patna)

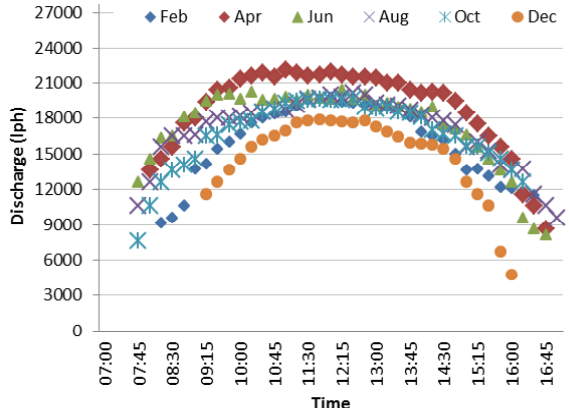

Fig. 141b. Diurnal variation of mean monthly daily water discharge in different months with no cloud

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Post Harvest Technology

Process Development for Production of Dried Products from Selected Fruits and Vegetables

Drying of button mushroom for development of dry instant soup mix

Freshly harvested button mushrooms (*Agaricus bisporus*) were washed under tap water to remove the adhering impurities and kept in potassium metabisulphite solution for 15 minute at room temperature for proper sanitization. After proper straining, they were cut uniformly into four pieces. The cut samples of mushrooms were given pre-drying treatment in a microwave oven at power level 800 W for 3.0 min before drying in convective hot air. The blanched samples were spread in a single layer on stainless steel trays and the trays were kept inside the convective hot air dryer. Drying was accomplished at 60°C air temperature. Drying was continued till the sample reached to dynamic equilibrium moisture content (**Table 81**). Initial physical properties like moisture content, weight, volume and apparent density of fresh and dried pieces were evaluated (**Fig. 142**). The dried slices were packed in PP bags for further processing into powder of uniform particle size for production of soup-mix. Grinding of dried pieces of mushrooms was accomplished in a high speed rotary grinder. The powder of uniform particle size was kept in air tight propylene pouches. Earlier Milky, Oyster and Paddy Straw mushrooms were also dried and powder of them was made for use in preparation of dry instant soup mixes.

Table 81. Drying characteristics of mushrooms

Variety	IMC % (wb)	Drying time (h)	FMC % (wb)	Average DR (%) moisture/h	Drying ratio	Drying yield (%)	Shrinkage (%)
M_1	88.9	8	5.5	10.4	8.5	11.8	76.8
M_2	92.6	7	4.9	12.9	12.9	7.8	85.2
M_3	90.6	7	5.2	12.2	10.1	9.9	89.1

M_1: Milky, M_2: Oyster, M_3: Button

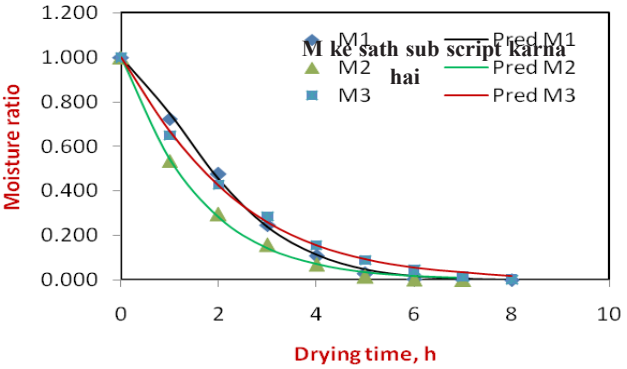

Fig. 142. Effect of Mushroom type on moisture ratios as described by Page's model MR=exp (-kt^n)

(for M_1: k- 0.288, n- 1.462, r^2- 0.998; for M_2: k- 0.604, n- 1.063, r^2- 0.999; for M_3: k- 0.402, n- 1.100, r^2- 0.998)

The dry instant soup mix formulation was achieved by mixing of different ingredients in the proportion as mushroom powder- 20%, tomato powder- 20%, wheat fine flour- 35%, milk solids- 10%, corn starch- 10%, onion and garlic powder- 1% and dried small pieces of cabbage and carrot- 4%. The mix of ingredients was thoroughly blend to achieve a free flowing mixer with a moisture content of 4-5%. The peroxidase value of the prepared dry instant soup mix was nil per g and yeast and mould count was recorded to be zero. The colour of the dry instant soup mix was good and varied depending on the type of mushroom used in preparation of the soup mix such as Button, or Oyster, or Milky, or Paddy straw mushroom. The reconstituted soup mix which was not as much of viscous; and it was served to human subjects for sensory perception. The overall acceptability score obtained were between good to very good (**Fig. 143**).

Fig. 143. Dry instant soup mix of Button mushroom

Drying of unripe jackfruit

Jackfruit is consumed either in unripe or ripe stages depending on the region specific liking. The objective of study was to investigate the drying kinetics of unripe jackfruit at three stages of fruit development and to find out the proper stage for obtaining dried product in good acceptability. The stages were as J_1-Unripe (1-1.5 kg); J_2-Unripe (around 3 kg) and J_3-Unripe (4-5 kg). Jackfruits were properly peeled and cut into small pieces (slice of 6-8 cm^2 and thickness 0.5-0.7 cm) convenient for drying. During cutting, peduncle was removed and only fibrous portion was taken. The cut pieces were immersed in potable water containing little amount of common salt to remove adhered sap. The washed samples were blanched in boiling water for 5 min. After blanching the samples were treated in potassium bisulphate solution (1500 PPM) for 15 minute at room temperature in order to inactivate the enzymes and improve its colour characteristics. Treated samples were kept on sieve for 10 minutes for draining water followed by removal of surface moisture. Another sample in unblanched condition was also taken for drying. Unripe jackfruit in the form of blanched and unblanched slices was dried separately in thin layer under convective type hot air dryer at 60°C. Moisture loss data were recorded at every hour during the process of drying (**Fig. 144**). The samples were continuously dried till the moisture content reaches around 6-7%. Dried samples of unripe jackfruit were kept in PP bags after proper cooling. The dried samples were subjected for rehydration and sensory tests. About 82% moisture was assimilated in 10 min of rehydration under boiling water. The experimental drying data were statistically fitted to selected theoretical models to predict the drying kinetics (**Table 82**). Rehydration tests and sensory perception revealed that middle stage of unripe jackfruit was suitable for the development of dried product.

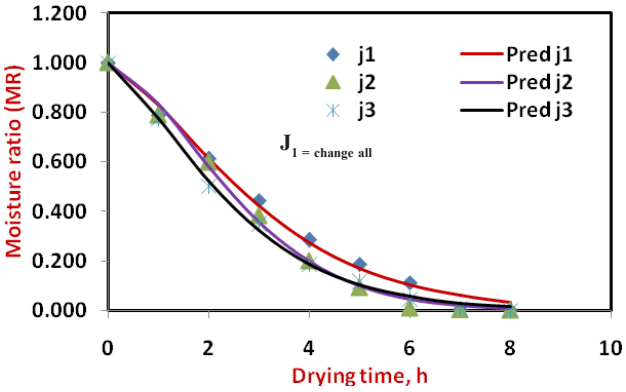

Fig. 144. Effect of Unripe Jackfruit stage on moisture ratios as described by Page's model MR=exp (-ktn)

(for blanched J_1: k- 0.187, n- 1.394, r^2- 0.993; for J_2: k- 0.181, n- 1.582, r^2- 0.969; for J_3: k- 0.256, n- 1.354, r^2- 0.998)

Table 82. Drying characteristics of unripe jackfruit, convective drying of blanched sample

Stage	IMC, %(wb)	Drying time (h)	FMC, %(wb)	Average DR (%) moisture/h	Drying ratio	Drying yield (%)	Shrinkage (%)
J_1	86.4	8	5.2	10.2	7.0	14.3	79.9
J_2	90.0	8	4.9	10.6	9.5	10.5	85.0
J_3	88.5	8	5.0	10.4	8.3	12.0	84.5

Evaluation of Different Weeding Technologies for Direct Seeded Rice -Maize Cropping System

The experiment was undertaken to evaluate the existing weeding technologies and modify the weeders as per local needs. Five treatments namely, hand weeding, herbicide application, single wheel hoe, twin/double wheel hoe (**Fig. 145**) and power weeder **(Fig. 146)** were evaluated in maize crop (Variety: Maharaja Hybrid seed) with 60 x 20 cm spacing. Performances of different weeding equipments were evaluated (**Table 83**). Hand weeding was most accurate with 98 per cent weeding efficiency while among weeding tools, power weeder performed best with weeding efficiency of 88 per cent (**Fig. 147**) The power weeder took the minimum (55.56 hrs) for weeding one ha area while it took 111.48 and 231.41 hrs by twin wheel hoe and single wheel hoe, respectively.

Fig. 145. Field evaluation of double wheel hoe

Fig. 146. Field evaluation of power weeder

Table 83. Performance evaluation of different weeding technologies in maize crop

Parameters	Power weeder	Double/twin wheel hoe	Single wheel hoe
Mode of operation	Power operated	Manual	Manual
Width of blade (cm)	12.00	13.00	12.00
Depth of cut (cm)	3.50	2.50	2.50
Speed of operation (kmph)	1.50	0.69	0.36
Actual field capacity (ha/hr)	0.018	0.009	0.004
Weeding efficiency (%)	88.00	85.00	81.00
Total hrs taken for weeding (hr/ha)	55.56	111.48	231.41
Plant damage (%)	2.00	2.00	5.00
Fuel consumption (l/ha)	27.80	-	-
Fuel consumption (l/hr)	0.50	-	-

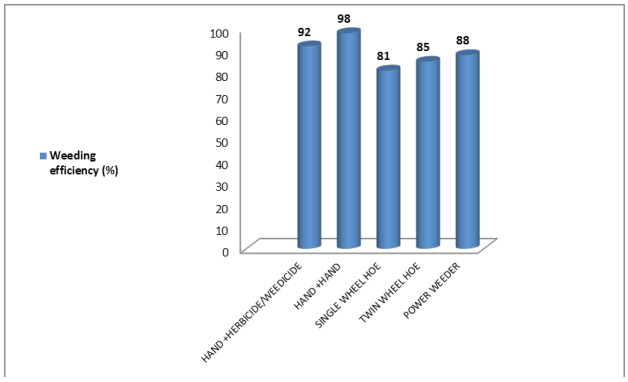

Fig. 147. Weeding efficiencies of different weeding technologies in maize crop

Development of Pedal Operated Makhana Grader

Grading of makhana is gruesome activity being done by women folks, wherein a lot of drudgery is involved. Keeping this fact in view, makhana grader has been developed. Almost 80 per cent of the makhana seeds (*gurri*) fall within the diametric range of 7.96 to 11.15 mm. The grader is pedal operated. The gears are same as used in the cycle. Its gear ratio is 2.44. The bigger gear has 44 teeth while pinion has 18 teeth. The average rpm attained by the operator is 45. The thickness of sieve is 18 gauges. The makhana grader was demonstrated for feedback for its performance at Bhavanichak village of Kevati Block of Darbhanga (**Fig. 148**). Dimensions and specifications of the makhana grader has been depicted in **Table 84**.

Table 84. Dimensions and performance evaluation of Pedal operated Makhana grader

Type	Continuous
Frame (Angle iron)	
Length	77.5 cm
Width	75.0 cm
Height	89.0 cm
Sieve	
Length	91.5 cm
Width	61.0 cm
Height	10.2 cm
Total height	58.4 cm
Height of sieve set border	10.16 cm
Total length	195.6 cm
Ground clearance	30 cm
No of sieves	4
Slope of sieves	150
Diameter of sieve holes	12.74, 11.15, 9.56 & 7.96 mm
Average rpm of the pedal by operator	45 rpm
Capacity	750 kg/hr

Fig.148. Demonstration of makhana grader for feedback at Bhavanichak village of Kevati Block (Darbhanga)

19

Transfer of Technology

Tracking Change in Rural Poverty in Households and Village Economies in South Asia

In Bihar, per capita income differs significantly from one village to another, mainly due to per capita land and educational level. Non-farm employment is the main source of income and income through migration is much higher in all the villages. There is no trend in diversity of income but it is more on large households than labour households. The inequality of income is higher on large households than labour households, mainly due to higher level of education and income diversification on these households. Educational level and number of earning members in the households are main determinants of per capita income.

In Jharkhand state, despite years of concerted efforts, rural poverty is rampant. Although in last couple of decades its pace has reduced but yet in 2009-10 about 36% farming households and 47% agricultural labour households were poor, indicating that their incomes were less than the threshold income level, i.e., annual per capita income of ₹ 7867, which is required to sustain a minimum living. Interestingly, the rate of decline in poverty was more in agricultural labour class households (27%) than that of farming households (1.9%).

In-depth study showed a large gap-more than double (i.e., ₹ 8,493) in annual income of tribal households in Jharkhand. The per capita income/annum in sample villages ranged from ₹ 6,378 to ₹ 14,871. Of many sources, non-farm activity (37.19% to 63.67%) dominated over other income sources.

Risk Proneness of Major Crops of Eastern India

For estimating the risk proneness of major crops in West Bengal, district wise area, production and productivity data on rice, wheat, pulse, oilseed, jute, sugarcane and potato for the period 1980-81 to 2010-11 for all the districts was collected from the Department of Statistics and Programme Implementation, Bureau of Applied Economic and Statistics, Govt. of West Bengal. The distribution of yield was studied and it was observed that the crop yield followed the normal distribution. However, the yield of sugarcane did not follow normal distribution. On the basis of extent of short fall in yield, districts have been classified as low, medium and high risky for growing a particular crop **(Table 85)**.

Table 85. Classification of risk proneness of major crops in different districts of West Bengal

Districts	Aus Rice	Summer rice	Aman Rice	Wheat	Pulse	Oilseed	Jute	Sugar cane	Potato
Burdwan	Low	Low	Low	Medium	Medium	Low	Low	Medium	Medium
Birbhum	Low	Low	Low	Low	Medium	Medium	Low	Medium	Medium
Bankura	Low	Medium	Low	Medium	Medium	Medium	Low	Medium	Medium
Purba Medinipur	Medium	Low	High	Medium	High	Low	Medium	-	Medium
Howrah	Medium	Low	Medium	High	High	Medium	Medium	Medium	Medium
Hooghly	Low	Low	Low	Medium	Medium	Medium	Low	Medium	High
North 24Parg	Low	Low	Low	Medium	Medium	Low	Low	Low	Medium
Nadia	Low	Low	Medium	Medium	Medium	Low	Low	Medium	Medium
Murshidabad	Medium	Low	Medium	Low	Medium	Low	Medium	Medium	Medium
Uttar Dinajpur	Medium	Low	Low	Medium	High	Medium	Low	Medium	Medium
Maldah	Medium	Low	Medium	Low	Medium	Medium	Medium	Medium	Medium
Jalpaiguri	Medium	Medium	Low	Medium	Medium	Medium	Medium	-	Medium
Darjeeling	High	-	Medium	High	Medium	Medium	Low	-	Medium
CoochBehar	Medium	Low	Low	Medium	Medium	Medium	Medium	-	High
Purulia	High	-	Low	Medium	High	Medium	Medium	Medium	Medium

The study indicated that the district wise risk is more appropriate than the state wise risk determination. The crop insurance premium rate for all the crops under study was determined for the crops having high and medium risk in the districts. In case of sugar cane MPD method for premium determination was used as the yield did not followed normal distribution. The premium rate varied from 1.7 to 13.4% for rice and 1.9 to 3.6% for wheat depending upon districts and the type of crop at 90% indemnity level.

Value Chain Study of Selected Commodities-Case of Milk and Vegetables in Bihar

In Nalanda district, in respect of marketing of milk, altogether three marketing channels were observed to be operational with milk price spread ranging from 0 to 57%. These were Producer-Consumer (Price spread: 0%), Producer-Retailer-Consumer (Price spread: 38%) and Producer-Retailer-Milk processor, Creamery-Hotel owner/Consumer (Price spread: 57%). The main constraints of milk producers in the district were costly feed, followed by lack of animal shed, and capital. The milk retailers' constraints were lack of capital, transport facility, storage and organized market in that order. Milk adulteration with water and milking through injection were found to be main constraints faced by milk consumers.

In vegetable (tomato, potato and cauliflower) marketing, different market functionaries were observed to have faced different constraints. The vegetable producers faced constraints like low price, including price fluctuation of produce, costly feed and lack of cold chains to overcome problem of vegetable perishability. Middlemen, wholesalers and retailers faced mainly the constraints of lack of capital, market infrastructure and price fluctuation owing to unpredictable nature of supply and demand of vegetables.

The price spreads in Patna and Nalanda districts in case of cauliflower was observed to be 132 and 48%, respectively, while same in case of tomato were observed to be 167 and 84%, respectively. In case of potato the price spreads in Patna and Nalanda were observed to be 51 and 57%, respectively. Thus, the highest price spread of 167% was observed in cauliflower marketing in Patna, while the lowest in potato (51%) in the same district. The price spread in Patna in case of vegetables were found to be far more than those in Nalanda, reflecting lower efficiency of vegetable market in Patna as compared to Nalanda. However, reverse was observed to be the case in case of milk market.

Constraints and Issues of Water Management in Crop Production in Bihar

Study was conducted in canal command area of Patna district and tubewell command area of Vaishali district of Bihar state. The study revealed that small and marginal farmers constituted 77 and 75% of the sample size in tubewell and canal area, respectively. In tubewell area, 65% of farmers had their own tubewell. Every farmer had cattle or buffalo in canal command whereas 84% farmers had cattle or buffalo in tubewell area. Eighty five per cent had sufficient irrigation water in tubewell area; whereas only 39.16% farmers had sufficient irrigation water in canal command. Irrigation through portable pipes was most prevalent in tubewell operated area; in canal area more than 90% farmers applied field-to-field irrigation. Ninety per cent pump sets were diesel operated. Most of the farmers (97%) applied 2 to 3 irrigation in wheat. In tube well area, 76% farmers applied 3 to 4 irrigation in rice. In canal command, majority of farmers (93%) applied 6-8 irrigation in rice. Percentage of farmers who sold and purchased tubewell water was 18 and 55, respectively. Water was purchased or sold @ ₹ 60-90/hour. Costly irrigation, scattered plots, lack of irrigation implements were major water management constraints in tubewell commands whereas uneven bunds, scattered plots, problems due to neighboring plots were major water management constraints in canal commands.

Sustainable Livelihood Improvement Through Need Based Farming Systems in Disadvantaged Districts of Bihar (NAIP)

The project aimed to improve the livelihood security of the rural people in four disadvantaged districts of Bihar at the 7 selected clusters/sites in a participatory bottom up approach in consortium mode. Suitable land and water-centric and location-specific livelihood options have been introduced through Integrated Farming System models with a potential for up-scaling to mass rural communities in the region. The major achievements under different activities are:

Evaluation of promising cropping systems with improved agronomical practices in participatory mode

In order to increase the production per unit area, one short duration crop was added in the prevailing cropping system (Rice-Wheat) with improved agricultural practices like judicious use of fertilizer, side placement of fertilizer, line sowing and water management. A total of 12 cropping systems were evaluated viz., Rice-Wheat-Moong, Rice-Winter Maize-Moong,

Rice-Winter Maize-Vegetables, Rice-Potato-Moong, Rice-Potato+Maize-Moong, Rice-Potato-Vegetables, Rice-Winter Maize-Green Manure, Rice-Lentil-Moong, Rice-Tori-Moong, Rice-Pea-Vegetables, Rice-Mustard-Vegetales,and Rice-Tori-Wheat/Potato. These 12 cropping systems were tested and demonstrated in the farmers' field in an area of 42 ha (234 farmers) with improved cultivation practices. Out of 12 cropping systems, five best cropping system, namely, Rice-Winter Maize-Moong, Rice-Wheat-Veg., Rice-Potato + Maize - Moong, Rice-Tori- Potato-Veg., and Rice-Wheat-Moong were selected for better sustenance to the farmers. The tested cropping systems were adopted by 60% farmers of the cluster (**Fig. 149**).

With the inclusion of one more crop, cropping intensity of the area increased from 200% to 264% which resulted in increase in farmer's income by 31 to 158% with an increase in employment up to 13.7%. Out of the five cropping systems tested, Rice-Potato+Maize-Moong and Rice-Tori-Potato+Vegetable cropping systems gave higher net income and B/C ratio (**Table 86**).

NAIP on Developing Sustainable Farming System Models for Prioritized Micro Watersheds in Rainfed Areas of Jharkhand

- **Low poly tunnel cultivation of cucurbits in winter for early summer harvest and better remuneration:** In 2012, the maximum income of ₹ 22736/- through sale of produce of 300 plants of bottle gourd grown under low poly tunnel in winter was obtained by Barkat Ansari of village Dharampur, Block- Narayanpur, District Jamtara (**Fig. 150**). The sowing was done on 23.12.2011 and harvest started on 06.03.12 and last harvest was on 07.05.12. The produced was sold @ ₹ 8-10/- per kg.
- **Cultivation of oyster mushroom by farm women:** Forty two farm women under four SHGs in three villages of Jama Block and 129 farmers including 33 men farmers under 2 SHGs and 96 women farmers under 6 SHGs (**Fig. 151**) in 2 villages of Dumka Block of Dumka district (**Fig. 152**) are regularly engaged in production of oyster mushroom and generating income through sale of mushroom @ ₹ 100-130/- per kg in the local markets.

Evaluation of Biopesticide and Chemical Pesticide Against Gram Pod Borer (*Helicoverpa armigera*).

Gram pod borer (Helicoverpa armigera) is a major and serious damaging insect pest of gram in District Buxar. Lack of awareness about bio-pesticide application and indiscriminate use of insecticide kills the natural enemies and develops insect pest resistance and leads to insect pest resurgence. Krishi Vigyan Kendra, Buxar, Bihar conducted On-Farm Trial in 6 locations in different gram field. Results of the trial indicated that Indox-

Fig. 149. Different cropping systems adopted under NAIP in Vaishali district of Bihar

Table 86. Performance of selected cropping systems

Parameters	Traditional practices (REY)	Improved practices Rice Equivalent Yield (REY)	Gross income (₹)		Net income (₹)		Labour employed		B/C (ratio)	
			Traditional	Improved	Traditional	Improved	Traditional	Improved	Traditional	Improved
Rice-Wheat	5.7 t	11.0 t	57,000	1,10,000	19,960	50,860	310	380	1.5	1.9
Rice-Winter Maize-Moong	--	17.5 t	--	1,75,000	--	1,01,200	--	396	--	2.3
Rice-Wheat-Veg.	--	16.6 t	--	1,60,000	--	85,600	--	428	--	2.1
Rice-Potato+Maize-Moong	--	23.8 t	--	2,38,000	--	1,40,770	--	440	--	2.4
Rice-Tori-Potato-Veg.	--	23.5 t	--	2,35,000	--	1,40,780	--	458	--	2.5
Rice-Wheat-Moong	--	15.5 t	--	1,55,000	--	80,800	--	382	--	2.1

Fig. 150. Off-season cultivation of bottle gourd under low poly tunnel in Sarepahari, Jama, Dumka

Fig. 151. Mushroom cultivation by women SHG in Jama, Dumka

Fig. 152.: Mushroom cultivation by Men SHG (Jan Kalyan Samuh) in Karmatand, Jamtara

acarb 14.5 SC, 1 ml/l was found effective as evidence by 21.74% increase in yield (1.4 t/ha) with net return of ₹ 25000/ha. The cost of cultivation was ₹ 17000/ ha and B:C ratio (2.47) was also higher over the conventional method of pod borer management.

On Farm Trail for the Management of Brown Plant Hopper

The Brown plant hopper is the most destructive pest found in high yielding varieties of paddy in Buxar district. An experiment was conducted for the management of Brown Plant Hopper (*Nilaparvata lugens*) in rice crop with six replications. The BPH population was higher at panicle emergence and flowering stage than vegetative stage. Data revealed that alternate drying and wetting the field during peak infestation, draining out the standing water from the field 2-3 times checks the population of the hopper. Alleys of 30 cm wide after every 3 meters of rice planting provided proper aeration to the crop which restricted multiplication of the pest. Spraying of Buprofezine 25 EC and Ethiprole +Imidacloprid 40% WG and nozzle directed at the basal portion of the crop, minimized the pest population below economic injury level and found effective to control of Brown Plant Hopper **(Fig. 153-154)**.

Frontline Demonstration of Water Harvesting Technology (Doba)

Under Tribal Sub-plan, polythene sheets were provided to farmers in East Singhbhum (200 numbers of polythene sheets), West Singhbhum (250 numbers of polythene sheets), Saraikela (200 numbers of polythene sheets), Gumla (200 numbers of polythene sheets), Ranchi (150 numbers of polythene sheets), Dumka (300 numbers of polythene sheets), Jamtara (295 numbers of polythene sheets) districts of Jharkhand and Keonjhar (250 numbers of polythene sheets) district of Odisha for demonstration of technology on rainwater harvesting in Polythene lined *Doba* (**Fig. 155**). Technical

Fig. 153. Gram crop and pod borer infestation

Fig. 154. Management of brown plant hopper

Fig. 155. Rainwater harvesting in plastic lined *Doba* and vermicomposting in HDPE vermibeds at farmers' fields in Potka block of East Singhbhum district in Jharkhand

guidance on construction, maintenance and utilization of the *Doba*s were also provided to the farmers. For demonstration of technology on *in situ* water harvesting by use of water absorbing gel, 20 kg of water harvesting gels were provided to tribal farmers in East Singhbhum district of Jharkhand and Keonjhar district of Odisha. Technology on preparation of vermicompost through HDPE vermibeds were demonstrated at farmers' field at Potka block of East Singhbhum (20 numbers), Ranchi (20 numbers) and Jamtara (10 numbers) districts of Jharkhand. The interventions resulted in harvesting of at least 2000 cubic meters of rainwater which will be of immense importance for improving the survival rate of newly established fruit orchards.

Demonstration of Hybrid Rice (Arize 6444)

Rice is the main crop of district Buxar during the *kharif* season. Farmers are generally growing long duration traditional/old and high water consuming varieties. To create awareness and gain high production of rice crop per unit area, KVK Buxar demonstrated Hybrid rice Arize 6444 in 4 ha area at 16 farmer's field in district Buxar (**Fig. 156**). The yield was 15-20% higher over traditional varieties and it matured about 15-20 days earlier than conventional varieties. Farmers have close affinity to grow long duration rice varieties (MTU 7029 and BPT 5204) which delays the sowing of wheat, gram, lentil and other *rabi* season crops resulting in yield loss. To make timely sowing of *rabi* crop, Hybrid rice Arize 6444 has proved its yield potential and adoptability in Buxar district with its average yield recorded at 7.47 t/ha in irrigated condition.

Fig. 156. Hybrid rice Arize 6444 in field

Demonstration of *Flemingia semialata* for Lac Production in Buxar

Due to rigorous price fluctuations and reduction in the population of tree hosts lac production witnessed steep downfall in the past decades. Being eco-friendly in nature and multifaceted users, there is ever increasing demand of this commodity globally. To keep in view, KVK Buxar demonstrated raising nursery and transplanted 300 plants of *Flemingia semialata* at two farmers field covering an area of 300 m^2 in Buxar (**Fig. 157**). *Flemingia semialata* showed greater promise for lac production due to its fast and compact growth, tenders shoots which may help in accommodating more number of plants per unit area of land. This host is highly suitable for production of good quality Kusumi lac crop during winter season (*Agahani*).

Fig. 157. Cultivation of *Flemingia semialata* for Lac Production

Demonstration of IPM Technology in Rice Crop

To avoid indiscriminate use of organic insecticide and maintain natural enemies of insect pest in rice ecosystem, KVK Buxar demonstrated IPM Technology in rice crop in 2 ha area under NICRA Project at Kukurha Village Buxar **(Fig. 158)**. Stem Borer, Green Leaf hopper (GLH), Brown Plant Hopper (BPH) and Gundhi Bug have been found major insect pest of rice crop. Timely transplanting, proper spacing, balance application of

Fig. 158. Rice pest incidence in Buxar

nitrogenous fertilizers, removal of weeds from fields, however, showed less infestation of insect pest. Spray of Azadirachtin (Neem oil) @ 3 ml/litre at 60 DAT to minimize damage of leaf chafers and GLH, installation of Pheromone trap 15/ ha for catching adult male moths of stem borer, and spraying of Buprofezine 25 SC (Growth regulator) for the control of BPH minimized the pest population below economic injury level and 12% average yield increase was recorded at farmers field.

Model Village Development

Saraitoli village of Ranchi district in Jharkhand was selected to develop a model village for agricultural development. In the initial phase, technologies on fruit based multitier cropping system (1 acre), rainwater harvesting in plastic lined *Doba* (24 numbers) and production of vermicompost in HDPE vermibed (17 numbers) were demonstrated **(Fig. 159-160)**.

Visit of Farmers to the Institute and Field Day Organized

A total of 21709 numbers of farmers visited the farm of ICAR-RCER, Research Centre, Ranchi during the year for the purpose of purchase of seed (16.46%), planting material (23.30%), exposure visit (33.24%), consulting with the scientists (5.96%), student visit (3.39%) and other purposes (18.61%), respectively. The field days organised has been depicted below **(Table 87, Fig. 161-162).**

Table 87. Farmers' Field Days organized in Bihar and Jharkhand State during 2012.

Village	District	State	Approx. Farmers/Women Participated
Baghakole	Patna	Bihar	800
Susari	Darbhanga	Bihar	1000
Dubaliya	Ranchi	Jharkhand	1000
Hesapiri	Ranchi	Jharkhand	1500

Fig. 159. Planting of mango sapling by Dr A.K. Singh, Former DDG (NRM) in farmers' field at Saraitoli village of Jharkhand

Fig. 160. Interaction with farmers and distribution of HDPE Vermibed to farmers at Saraitoli village

Fig. 161. Field day observed at Susari, Darbhanga, Bihar

Fig. 162. Field day observed at Dubaliya, Ranchi, Jharkhand

Training cum Workshop on Real Time Pest Surveillance of Mango

The two days Training cum workshop on "Real Time Pest Surveillance of Mango (RTPS)" was organized during 2nd and 3rd February, 2012 at Regional Fruit Research Station, Vengurle, Maharastra in collaboration with NCIPM, New Delhi. The programme was participated by PIs, Co-PIs and SRFs from Lead centre as well as cooperating centres (IIHR, Bangalore, CISH, Lucknow, FRS, Sangareddy, RFRS, Vengurle and AES, Paria) of the NICRA funded project on Understanding the changes in host-pest interactions and dynamics in mango under climate change scenarios. During the programme, the participants were provided hands on training on RTPS methodology on mango and use of RTPS software **(Fig. 163)**.

Fig. 163. Training cum workshop on Real Time Pest Surveillance of Mango

Capacity Building of Stakeholders

Different capacity building programmes oraganized by the Institute, during the period under report, are depicted in **Table 88-94**.

In addition, capacity building of farmers of Chhattisgarh was done through training-cum exposure visits in collaboration with Institute of Horticulture Technology, Greater Noida. Altogether 570 farmers were trained on different agri-horticultural aspects, like vegetable cultivation in Chhattisgarh, its challenges and possible solutions with innovative technologies, essentials for vegetable nursery and techniques for raising hi-tech nursery, production technology of polyhouse crops, organic horticulture – importance and methodologies, orchard management-high density planting, canopy management and rejuvenation of unproductive orchard, post harvest management in vegetable crops, micro irrigation - different types of drips, their practical application, etc. in different batches at Institute of Horticulture Technology **(Fig. 164)**.

Row-1(Left to Right) = Sunder, Narayan,Sukhdev Singh,Chait Ram,Ms.Anuradha,Dr.J.L.Mangal, Dr. Som Dhar Upadhay,Tikaram Saahu, Kunt Ram, Ganeshram, Uttam Kumar, Hamdas
Row-2(Left to Right) = Sonuram.Santosh, Giriraj,Shiv Kumar,Chhotu, Pavan, Deepakram Saahu, Uderam Saahu, Vasudev, Teju Prasad,Awadh, Ravidas , Rakesh,Gajendra
Row-3(Left to Right) = Devendra Kumar, Toshan Lal,Patchand, Lala Ram, Chimman Lal,Omkar, Suresh,Raja Maheshwari,Purushottam,Palku Ram, Bharat Saahu, Krishan Kumar
Row-4(Left to Right) = Lakhan, Ghanshyam,Onkar, Balaram, Narendra Kumar, Ashok,Kasev Saahu,Radheshyam, Keju Ram, Ganga Verma

Fig. 164. Training conducted for prograssive farmers of Chhattisgarh state

Table 88. Details of training programmes conducted by Institute HQs, Patna

Particulars	No. of Farmers
Integrated fish farming	25
Improved agricultural practices (Inai, Darbhanga)	325
Integrated farming system and INM (Arap, Patna)	350
Tribal farming systems (Durgapur, Dumka)	300
Tribal farming systems(Dumaria, Dumka)	450
RCTs and INM (Baghakole, Patna)	800
RCTs and INM (Susari, Darbhanga)	1000
Agri-horti farming systems (Dubalia, Ranchi)	1000
Agri-horti farming systems (Hesaperi, Ranchi)	1500
Scaling up of water productivity (KVK, Jamui)	50
Scaling up of water productivity (KVK, Barh)	50
Scaling up of water productivity (KVK, Ara)	50
Scaling up of water productivity (KVK, Ara)	50
Scaling up of water productivity KVK, Piprakothi, (East Champaran)	50
Scaling up of water productivity KVK, Piprakothi, (East Champaran)	50
Scaling up of water productivity (KVK, Madhepura)	50
Scaling up of water productivity (KVK, Sitamarhi)	50
Scaling up of water productivity (RCM Darbhanga)	50
Scaling up of water productivity (RCM Darbhanga)	50
Improved agricultural practices (NABARD)	25
Improved agricultural practices (NABARD)	25
Improved agricultural practices (NABARD)	25
Cottage level food processing enterpreneureship development for farmers	30
Agribusiness management through horticulture	15
Integrated fish farming	25
Integrated aquaculture for improving productivity of *chaur* in Bihar	30

Table 89. Training conducted by regional research station on Makhana

Training topic	Collaborating agency	No. of farmers
Improved technologies on makhana cultivation	KVK, Supaul	25
Improved technologies on makhana cultivation	KVK, Saharsa	25
Improved technologies on makhana cultivation	KVK, Purnea	30
Improved technologies on makhana cultivation	KVK, Katihar	30
Modern techniques of makhana production and its processing	NABARD, Lucknow	20
Design clinic workshop	Makhana Processor and Dev. Soc., Baheri, Darbhanga, MSME, Govt. of India & National Institute of Fashion Designning, Ahmedabad	25
A Novel technology for makhana cultivation: an unique model of rainbow agriculture	ATMA, Supaul	25

Table 90. Training programmes conducted by regional research centre, Ranchi

Subject/Topic	No. of farmers
Improved production technique in fruit and vegetables	21
Improved production technique in fruit and vegetables	25
Improved production technique in fruit and vegetables	18
Improved production technique in fruit and vegetables	25
Improved production technique in fruit and vegetables	24
Processing and value addition of fruits and vegetables	20
Improved technique in vegetables production	25
High density in fruits	25
Canopy management and rejuvenation in litchi	24
Mushroom production	25
Nursery management in horticultural crops	17
Management of insect pests and diseases in vegetable crops	25
Cultivation of seasonal vegetables	27
Mushroom cultivation	22
Micro irrigation technique for horticultural crop production	25
. Cultivation of seasonal vegetables	26
Cultivation of seasonal vegetables	18
Cultivation of seasonal vegetables	28
Cultivation of seasonal vegetables	26
Management of insect pests and diseases in vegetable crops	21
Nursery management in horticultural crops	16
Mushroom cultivation	25
Cultivation of seasonal vegetables	22
Cultivation of seasonal vegetables	18
Cultivation of off-seasonal vegetables	20
Management of insect pests and diseases in vegetable crops	21

Table 91. Vocational training programmes conducted by KVK, Buxar

Topic	No. of farmers
Use of microbial pesticide in plant protection	**20**
Identification and use of predatory spiders in rice ecosystem	**20**
Integrated insect pest management in *rabi* vegetable	**20**
Storage pest of pulses and their control measure	**21**
Insect pest management in rice crop	**21**
Integrated insect pest management in *rabi* vegetables (cabbage, cauliflower, pea, brinjal, tomato)	**21**

Table 92. Training programmes conducted for rural youth at KVK, Buxar

Training topic	Total
Seed production technique of cucurbits vegetables	11
Poultry production as entrepreneurship	10
Mushroom production: a source of income generation	10
Beekeeping: a source of income generation	10
Mushroom production: a source of income generation	10

Table 93. Off-campus training programmes conducted at KVK, Buxar

Topic	No. of farmers
Method of bunding and its importance at Rampatti Simari	21
Water management in summer vegetable at Dalsagar	20
Method and importance of Deep Summer Ploughing at Pawani	21
Crop residue management for increasing soil fertility Kukurha	20
Method of soil and water sample collection its importance at Jamuaon	25
Inoculation of Rhizobium culture in Kharif Pulses (Pigeonpea) at Pawani	20
Integrated Nutrient Management in rice at Vishrampur	22
Nitrogen management in Paddy by the Leaf Color Chart (LCC) at Nadaon	20
Method of integrated nutrient management in potato at Khairati	25
Method of Rhizobium culture inoculation and sulphur in rabi pulses (Chick pea, lentil and field pea.) at Hukaha	24
Method of INM in cauliflower at Dhansoi	20
Method of INM in wheat at Baruna	20
Application of sulphur in oilseed crop at Kukurha	24
Method of foliar application of urea in chickpea at Bhitihra	21
Nitrogen management in wheat by the Leaf color chart (LCC) at Turkpurwa.	24
Water management in rabi Pulses at Nat.	22
Foliar application of micronutrients and crucifers at Chilbila	23
Scientific cultivation of ajwain at Karahashi	29
Scientific cultivation of methi at Karmi	33
Scientific cultivation of rose at Udhara	27
Propagation technique of pomegranate Jamuaao	21
Production and management technique of mint at Jagdishpur	26

Nursery production management in tomato at Simari	23
Integrated Nutrient Management in ginger at Dalsagar	21
Production technique of elephant foot yam at Pawani	30
Scientific cultivation of jackfruit at Manshin patti	20
Weaning food preparation for infants	37
Cultivation of Dhengri mushroom	21
Deigning of seasonal vegetables	20
Vaccination schedule for infants	19
Bio-security	23
Mastitis in dairy cows	25
Proper disposal of dead carcass	21
Degnella disease in cattle	27
Year round health protection practices for sheep and goat	21
Feeding of sheep and goat	26
Feeding of pigs	20
Diseases of pigs	21
First Aid for animals	21
Hygienic milk production	22
Control of parasitic diseases in dairy animals	25
Fish cum duck Farming	20
Vaccination in cattle	21
Vaccination in poultry	22
Diseases of pigs	23
Feeding of pigs	23
Degnella disease in cattle	22
Pod borer & wilt management in chick pea and lentil	20
Seed treatment in cereals and pulses crop	20
Use of NSKE in plant protection	20
Damage caused by Aphid in mustard, lentil & their management	20
Management of early and late blight of potato	20
Wilt disease and pod fly of arhar and their management	20
Collection and utilization of neem seeds in plant protection	20
Damage caused by mammals and their management	21
Management of Insect pest by cultural practices in summer season	20
Storage pest of pulses and their control measure	20
Management of diseases and insects through soil solarization in nursery	20
Integrated insect pest management in cucurbits vegetables	20
Integrated Pest Management in rice nursery	20
Damage caused by stem borer and white backed plant hopper in rice and their management	20
Termite damage and their control measure	20
Insect pest and disease management in jowar and bajra	20
Integrated disease management in summer vegetables	20
Use of NSKE in Plant protection	20
Importance of seed treatment in cereals and pulses crop	20
Insect and disease management in oil seed crop	20
Pod borer & wilt management in Chick pea and lentil	20
Conservation of predatory spiders in rice ecosystem	20
Damage caused by Aphid in mustard, lentil & their control measure	20
Storage pest of cereals and their control measure	20
Early and late blight disease of tomato and potato and their management	20
Field management practices for rice production	20
Integrated plant nutrient supply for sustainable production of redgram	20
Integrated crop management for sustainable rice production	20
Weed management in direct seeded rice	20
Abiotic and biotic stress management in rice	20
Abiotic and biotic stress management in redgram	20
Quality seed production of rapeseed and mustard	20
Quality seed production of chickpea	23
Use of rhizobium and PSB culture in chickpea	20
Integrated plant nutrient supply in rapeseed and mustard	20
Abiotic and biotic stress management in lentil and gram	20
Quality seed production technology for wheat	20
Resource conservation technology for pulse production	20
Resource conservation technology for wheat production	20
Weed management in wheat	20
Water management in wheat	20

Table 94. Training programme for extension functionaries conducted at KVK, Buxar

Training topic	No. of trainees
IFS	10
Improved varieties of vegetables	10
Production of quality animal product	13
Avian Influenza	15
Quality control during poultry product processing	17
Resistance management problem in plant protection	20

FLDs, OFTs and Kisan Mela Organized

The front line demonstrations, on farm trials and kisan mela organized by the Institute are depicted below **(Table 95-96) :**

Table 95. FLDs conducted at KVK, Buxar

Topic	Area (ha.)/ No.	No. of beneficiaries	Villages covered
Role of Rhizobium culture in peg ion pea variety Narendra Arhar 1	1.0	05	Nadoan, Mishraulia and Sonapa.
Role of Rhizobium culture in Urd bean variety PU19.	5.86	23	Dhakaich, Nagpura, Simri, and Basgitia.
FLD on Pearl millet. var Banjara Gold.	5.20	13	Simari, Pawni, Majharia and Dullapur.
FLD on Hybrid rice production. variety Arize 6444.	1.0	4	Dubauli, Shivala dera, Ekauna
Demonstration of Vermibed for production of vermi compost.	30	30	Jamuaon, Vishrampur, Pawni, Kamarpur.
FLD on Rural backyard poultry	250	31	Buxar, Itarhi, Nawanagar, Simri, Chausa, Chaugain, Dumraon
FLD on Berseem Vardan, Breeder seed, IGFRI)	1.0	15	Buxar, Chausa,Dumraon, Nawanagar
FLD on Berseem (Muscovy)	1.5	23	Kukurha

Demonstration of Pheromone traps loaded with Heli lure (*Helicoverpa armigera*) (NICRA Project)	3 ha	08	Kukurha
Demonstration of Pheromone traps loaded with Heli lure (*Helicoverpa armigera*)	2 ha	04	Bijhaura
Demonstration of Hybrid rice variety Arize 6444	2 ha	8	Khandhra, Parmanpur, Mukundpur, Dulahpur, Khaira, Akauna, Dubauli
Demonstration of Pigeon Pea variety *Narendra Arhar -1*	3ha	15	Manjharia, Dullahpur, , Gosaipur, Nagpura, Badkagaon, Dubauli, Sarimpur, Balihar,Dumari
Demonstration of Sesamumvar. *RT-27*	1.0 ha	04	Dumari and Nagpura
FLD on Hybrid rice production. variety Arize 6444.	1	4	Ekauna, Niyajipur, Shahiyar
Demonstration of Pigeon pea variety *Narendra Arhar -1*	1	5	Nagpura, Balihar, Dumari
Demonstration of Mustard variety *NDR 8501*	3	12	Pavni, Khairahati, Manikpur, Sardahpur, Surodha, Vikarm English, Pandey patti, Basudhar, Simari
Demonstration of Chick pea variety *PUSA 362 & PUSA 256*	5	35	Vikaram englis, Kailakh, Surodha, Pandeypatti, Dakaich, Dallahpur, Raghunathpur, Basudhar, Kamarpur, Pavni, Karhar, Turkpurva, Vishrampur, Kashiya, Natt, Jagdishpur, Majharia, Bharchakia, Bhabuwar
Demonstration of Lentil variety HUL 57	5	19	Natt, Pavni, Bhabuvar, Simari, Lalgunj, jagdishpur, Vishrampur, Majaria, Bharchakia, Gosaipur, Kanpura, Dallahpur , Kasiya.
Kitchen gardening	38 unit	38	Kathar khurd, Hazipur, Jagdishpu, Nadaon, Bhachakia, Brahampur, Pallahpur, Kasiya

Table 96. OFTs conducted at KVK, Buxar

Topic	Area (ha.)	No. of beneficiaries	Place
Effect of integrated nutrient management on growth and yield in pigeonpea.	1.0	10	Pawni, Darah,Gosaipur, Sikraul and Jalitpur.
Effect of nutrient management practices on yield attributing characters of lentil	1.35	12	Bharchakia, Turkprwa, Pawni, Suruandha and Jagdishpur.
Management of Brown Plant Hopper	1	04	Bishrampur
Pod Borer (*Helicoverpa armigera*) management in chickpea	1	04	Bharchakia, Bishrampur
Efficacy of newly released herbicides against weed flora in transplanted rice	0.5	03	Jagdishpur, Kanpura, Nadav
Assessment of new and released chickpea varieties for Buxar district	0.5	03	Dhakaich, Bharchakia, Jagdishpur

OTHER ACTIVITIES

Important Events

Foundation Day of the Institute

Foundation Day of the institute was celebrated on 22nd February 2012. The Founder Director of the institute Dr. S. R. Singh appraised the scientists and staff of the institute about the genesis of the institute and its vast role in livelihood development of resource poor farmers of the region. Director of the institute briefed about the future planning of the institute and its prime role in dissemination of technologies and ushering 2nd Green Revolution in the region **(Fig. 165)**.

Fig. 165. Celebration of the foundation day of the Institute

ICAR Zonal Sports Tournament for Eastern Zone (TEZ' 2012)

ICAR Zonal Sports Tournament for Eastern Zone was organized by ICAR Research Complex for Eastern Region, Patna during 19-22 March 2012 (**Fig. 166**). The tournament was inaugurated by Prof. Sukhada Pandey, Hon'ble Minister for Sports, Art, Culture and Youth

Fig. 166. Inaugural ceremoney of TEZ' 2012

Affairs, Govt. of Bihar. About 500 sports persons from 17 institutes including 3 research institutes from Nagpur and Jhansi participated as special invitee. During 4 days event, various sport events like football, basketball, volley ball, badminton, kabadi, carom, table tennis, chess and field and track events were played. Sri Abhyanand, DGP (Police), Govt. of Bihar concluded the sports as Chief Guest. Mr Pradeep Parida and Miss Savita Sahoo of CRRI, Cuttack was awarded for the Best Athlete among men and female contingents, respectively. Champion Trophy was awarded to CRRI, Cuttack.

Brain Storming Session on "Water Use Potential of Flood-Affected and Drought-Prone Areas of Eastern India"

Brain storming session on "Water use potential of flood-affected and drought prone areas of Eastern India" was organized at ICAR Research Complex for Eastern Region, Patna on 14th May 2012. The event, jointly organized by NAAS, New Delhi and ICAR RCER, Patna, aimed at formulating policies that will benefit the farmers and usher in second green revolution. Convener of the Brainstorming session, Dr. B.P. Bhatt presented a policy paper. The workshop was attended by several dignitaries including Prof. R. B. Singh, and Prof. Anwar Alam, from National Academy of Agricultural Sciences, New Delhi, Dr. S.A.H. Abidi, Ex-member, ASRB, Dr. Peter Kenmore, FAO Representative and Dr. P.N. Jha, and Dr G. Trivedi (Ex Vice Chancellors, RAU, Pusa), Dr Allauddin Ahmed, and many renowned scientist from different parts of eastern India. President NAAS, Dr. R.B. Singh stressed that water management, its storage, quality and floods need to be addressed sincerely besides conservation of large water ecologies of the region. On this occasion, three publications of ICAR RCER were also released **(Fig. 167)**.

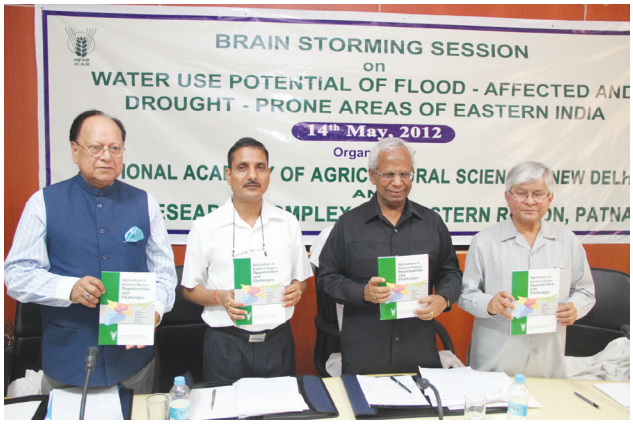

Fig. 167. Release of publications during brain storming session

Farmers' Innovation Day

A workshop on Agricultural Development in eastern region was organized on 15th May 2012 at ICAR Research Complex for Eastern Region, Patna on the occasion of Farmer's Innovation day. The event was inaugurated by Dr. Mangla Rai, Agricultural Advisor to the Hon'ble Chief Minister, Bihar. Several innovative farmers from different eastern states were invited to share their experiences. The workshop was attended by several dignitaries including Prof. R. B. Singh and Prof. Anwar Alam, from National Academy of Agricultural Sciences, New Delhi, Dr. S.A.H. Abidi, Ex-member, ASRB, Dr. R.K. Mittal, Vice Chancellor, Rajendra Agricultural University, Pusa, Dr. V. P. Singh, Director Research, RAU, Dr. G. Trivedi, and Dr. P. N. Jha, both Ex Vice Chancellors, RAU, Dr. Allauddin Ahmed, and innovative farmers from Bihar, Jharkhand, Odisha and Chhattisgarh **(Fig. 168).**

Fig. 168. Farmer's Innovation Day celebrated by the Institute

NAAS Regional Chapter Meeting on "Strategies for Agriculture Development in Eastern Hill and Plateau Region"

NAAS Regional Chapter Meeting on "Strategies for Agriculture Development in Eastern Hill and Plateau Region" was held at ICAR RCER, Research Centre, Ranchi on 25th July, 2012 under the Chairmanship of Dr A.K. Singh, DDG (NRM), ICAR, New Delhi **(Fig. 169)**.

Fig. 169. Regional Chapter Meeting held at Ranchi

The meeting was convened by Dr B.P. Bhatt, Director, ICAR RCER, Patna and attended by representatives from Indian Institute of Natural Resins and Gums, Birsa Agriculture University, Department of Agriculture, Govt. of Jharkhand, Department of Rural Development, Govt. of Jharkhand, NGOs and farming community.

3rd Scientific Advisory Committee (SAC) Meeting at KVK, Buxar

3rd SAC meeting was held at KVK, Buxar on 31st January, 2012. SAC meeting was chaired by Dr. B.P. Bhatt, Director ICAR-RCER, Patna and also attended by Dr. A.K. Singh, Zonal Project Director Zone II, Kolkata and by the line departments. During the SAC meeting, action plan of KVK, Buxar was discussed. Chairman called Programme Coordinator and Subject Matter Specialist to go beyond conducting routine programmes and plan for new initiative and innovative programmes. He also appreciated the various activities undertaken by KVK **(Fig. 170)**.

Fig. 170. SAC meeting of KVK Buxar

Foundation Stone Laying Ceremony of Administrative Building and Farmers Hostel of KVK, Buxar

Foundation Stone of Administrative and Farmers' hostel building was laid by Dr. A.K. Singh, DDG (NRM), ICAR New Delhi on 4th March, 2012 **(Fig. 171)**

Fig. 171. Foundation stone laying ceremoney of administrative block and farmers' hostel by Dr. A.K. Singh, DDG - NRM

in presence of Dr. B.P. Bhatt Director ICAR Research Complex for Eastern Region, Patna, Dr. A. K. Singh ZPD Zone II, Kolkata, QRT Chairman Dr. R. P. Singh and Heads of division Dr. K.M Singh, Dr. S. Kumar, Dr. D.K. Kaushal, Dr. A. Upadhyaya, Dr. R.D. Singh and scientist of ICAR RCER, Patna.

Awareness cum Convergence Workshop under "National Initiative on Climate Resilient Agriculture Project (NICRA)

Awareness cum convergence workshop of NICRA Project was organized on 4th March, 2012. Dr. A.K. Singh DDG (NRM), Dr. B.P. Bhatt, Director ICAR RCER Patna, Dr. A.K. Singh, ZPD Zone II, Dr. RP Singh, QRT Chairman, Heads of Divisions of the institute and scientists of ICAR RCER Visited NICRA Village Kukurha. NICRA activities were shown to DDG (NRM) and other dignitaries. All the dignitaries visited the NICRA village, Kukurha, Buxar district and reviewed the activities undertaken by KVK, Buxar. The dignitaries also interacted with group of 300 farmers and Village Climate Risk Management Committee (VCRMC) members **(Fig. 172)**.

Fig. 172. Interaction with the farmers' at Kurkurha village, Buxar district

4th Scientific Advisory Committee (SAC) Meeting of KVK Buxar

4th Scientific Advisory committee meeting of KVK Buxar was held on 7th July 2012 under the Chairmanship of Dr. B. P. Bhatt, Director, ICAR Research Complex for Eastern Region, Patna. The meeting reviewed, discussed and made recommendations for better location specific research and extension agenda for the KVK. A chairman has given ample research and extension guidance for the ongoing as well as future Research and Extension programmes of the Krishi Vigyan Kendra, Buxar.

Observed National Fish Farmer Day

National Fish Farmer Day was celebrated on 10th July, 2012, in which Hon'ble Animal Husbandry and Fisheries Resources Minister Shri Giriraj Singh graced the occasion as chief guest.

Workshop on Quality Fish Seed Production in Bihar

One day stakeholders workshop on Quality Fish Seed Production in Bihar was organized jointly by ICAR Complex for Eastern Region, Patna, Department of Fisheries, Govt. of Bihar and Central Institute of Freshwater Aquaculture, Bhubaneswar on 17th August, 2012. Hon'ble Minister of Animal Husbandry and Fisheries, Govt. of Bihar, Sri Giriraj Singh graced the occasion as Chief Guest. About 100 participants mostly fish farmers, hatchery owners, Department officers of the state were present (Fig. 173).

2nd QRT Meeting of the Institute

The 2nd QRT of the Institute held its first meeing on 15th September, 2012 at New Delhi. The meeting was attended by all the Hon'ble members of QRT (Dr. R.P. Singh, Chairman; Dr. N. Sarangi, Dr. Gautam Goswami, Dr. I.S. Singh, Dr. K.N. Tiwari, Dr. S.S. Randhawa, Dr. I.S. Singh, Dr. N. Parsuraman) and Member Secretary Dr. R. D. Singh. The meeding was also attended by Dr. A.K. Singh, DDG (NRM) and Dr. P.S. Minhas ADG of the NRM Division.

Fig. 173. Distribution of quality fish fingerlings to the progressive farmers by Hon'ble Minister of Animal Husbandry and Fisheries, Govt. of Bihar, Sri Giriraj Singh during the celebration of National Fish Farmer Day

XXI Meeing of ICAR Regional Committee (No. IV)

The XXI Meeting of ICAR Regional Committee-IV was organized at ICAR Research Complex for Eastern Region, Patna on 21st September, 2012 **(Fig. 174)**. The important dignatories present in the meeting include, Sri Narendra Singh, Hon'ble Minister of Agriculture, Govt.

Fig. 174. Address by Dr. S. Ayyappan, Secretary DARE & DG, ICAR during Regional Committee Meeting

of Bihar; Sri Giriraj Singh, Hon'ble Minister for Animal Resources and Fisheries, Govt. of Bihar; Dr. Mangala Rai, Agriculture Advisor to Hon'ble Chief Minister, Govt. of Bihar; Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR; all the Deputy DGs from the council. About 86 delegates from the Zone IV participated in the meeting besides the scientists from the Institute and IVRI. Dr. Ayyappan gave the presidential address and spoke about the FARMER FIRST which is going to be a major programme of ICAR during XII Plan period. The regional agricultural planning was discussed under the Chairmanship of Secretary, DARE and Director General, ICAR.

Agri-Expo 2012

The ICAR Research Complex for Eastern Region, Patna organized a three day Agri-Expo 2012 w.e.f. 11-13 October, 2012 to showcase the latest technological developments in the field of agriculture. Four ICAR institutes and about 80 firms from different parts of the country dealing in agricultural technological inputs including seeds, plant protection chemicals, fertilizers and farm implements/ machinery, package of practices of different crops' cultivation participated in the Expo, and exhibited their products **(Fig. 175)**.

Fig. 175. Inauguration of Agri Expo 2012 by Hon'ble Agriculture Minister, Govt. of Bihar, Sri Narendra Singh

Agriculture Education Day

Agriculture Education Day was celebrated on 9th November, 2012 at ICAR Research Complex for Eastern Region, Patna in which 80 students from different schools of Patna participated. The programme was consisted of field and laboratory visits, interaction with scientists followed by a lecture on climate change impacts on agriculture. A debate and quiz competition based on food security was also organized. A documentary film on activities and achievements of the Institute was also shown to the students.

Inauguration of Veterinary Clinic

Shri Tariq Anwar, Hon'ble Union Minister of State for Agriculture and Food Processing Industries, Govt. of India visited ICAR Research Complex for Eastern Region, Patna on 14th November, 2012 **(Fig. 176)**. Hon'ble Minister inaugurated newly constructed Veterinary Clinics at ICAR-RCER, Patna. An interactive session with scientists and staff of the institute was also held. Shri Tariq Anwar stressed for the need of technology transfer on large scale. Hon'ble Minister reiterated for better utilization of natural resources so as to bring the second green revolution in the region.

Fig. 176. Inauguration of Veterinary clinic of Insitute by Shri Tariq Anwar, Hon'ble Union Minister of State for Agriculture and Food Processing Industries, Govt. of India

Agri Business Camp

Agri Business Camp, Jharkhand was jointly organised by ICAR RCER, Patna, ZTM-BPD Unit (East Zone), NIRJAFT, Kolkatta and Agri Business Incubation Programme, ICRISAT, Hyderabad in collaboration with Jharkhand Chamber of Commerce and Industries (FJCCI) and Jharkhand Small Industries Association (JSIA) (Fig. 177) on 14th December 2012 with the objective to appraise the investors, entrepreneurs and potential

Fig. 177. Inauguration of Agri Business Camp at Ranchi by Sri A. K. Singh, I.A.S., Principal Secretary, Dept of Agriculture & Cane Development, Govt. of Jharkhand

investors of Jharkhand about available technologies generated at different ICAR institutes in eastern zone which can be commercialized and mechanism developed at ICAR for facilitating the process of commercialization of technologies. The meet was chaired by Sri A. K. Singh, Principal Secretary, Dept of Agriculture & Cane Development, Govt. of Jharkhand. The programme was attended by 110 participants including farmers, aspiring entrepreneurs and representatives from NGOs from Jharkhand and West Bengal. During the meeting, MOU was signed for commercialization of "Swarna Vijaya" tomato variety, developed by the Institute.

Workshops, Seminars, Symposium, Meetings, Farmers' Day etc. Organized

- Stakeholder meeting on "Strategies for agricultural development in eastern region" at ICAR-RCER, Patna on 3rd March, 2012.
- Stakeholders' Meeting with veterinary officers of Bihar was organized at ICAR-RCER, Patna in collaboration with IVRI, Izatnagar to discuss different issues on animal husbandry on 12th April, 2012.
- Second Project Advisory Committee meeting was organized at ICAR Research Complex for Eastern Region, Patna under the project "Tracking Change in Rural Poverty in Households and Village Economies in South Asia" on 23rd April, 2012.
- A meeting with the Vigilance Officer of ICAR Institutes in eastern region was held at ICAR Research Complex for Eastern Region, Patna on 3rd June, 2012. Different issues and vigilance related problems were discussed by the Director (Vigilance), ICAR, New Delhi.
- Organized a workshop on SAS sensitization under the project "Strengthening Statistical Computing for NARS"(NAIP component-I) at ICAR-RCER, Patna during 27-29 June, 2012.

- Organized a workshop on "Design Clinic Workshop" in collaboration with Makhana Processor and Development Society, Baheri in collaboration with MSME, Govt. of India and National Institute of Fashion Designing at Research Centre for Makhana, Darbhanga from 2-6 October, 2012.
- Stakeholders meeting on "Strategies for Fodder Production in Bihar" was organized at ICAR-RCER, Patna on 22nd November, 2012.

Award and Recognitions

K.M. Singh successfully completed "Management Development Programme on Leadership Development" (A Pre-RMP Programme) at NAARM, Hyderabad from 8-19 Oct., 2012.

K.M. Singh was nominated "Member of the Study Team on assessing Bihar's agricultural extension system" by CRS and Modernizing Extension & Advisory Services (MEAS) 21st Sept to 5th Oct., 2012.

K.M. Singh was nominated "Member of the Technical Advisory Committee (TAC)" for the ICAR-RCER, Patna, IRRI and CRS Collaborative project, "Improved Rice-based Rainfed Agricultural Systems (IRRAS) project", funded by the Bill & Melinda Gates Foundation.

Joydeep Mukherjee received award for best paper published in Journal of Agrometeorology (NAAS rating 6.6) for 2010 & 2011 from Association of Agrometeorologists, Anand, Gujarat.

Anil Kumar Singh, Senior Scientist (Agronomy), was awarded with "Certificate of Recognition" by Association of Plant Pathologist, Dr. PDKV., Akola in the recognition for scientific contributor published in "Journal of Plant Disease Sciences" on 30th October, 2012 on the occasions of Annual Meeting of India Pathological Society & National Symposium on Microbial Consortium Approaches for Plant Health Management held at Akola (Maharashtra).

J.P. Sharma and S. Kumar was awarded Best Research Paper Award "M.J. NARSHIGHUM MERIT" for paper on "Management of Ralstonia wilt of tomato through microbes, plant extract and combination of cake and chemicals" published in 2009 in Indian Phytopathology 62(4): 417-423 during 64th Indian Phytopathological Society Annual Meeting held at University of Hyderabad, Hyderabad on 4th Dec.2011.

Dr. Abhay Kumar Thakur, Principal Scientist (AS & PE) received Team Leader Award from Indian Society of Agricultural Engineers for significant contribution in development of Pomegranate Aril Extractor, conferred during 46th Annual Convention of ISAE and International Symposium on Grain storage, at GB Pant University of Agriculture and Technology, Pantnagar from 27-29 February, 2012.

Patents

Abhay Kumar Thakur (2012). Patent filed for "Process for preparation of dry instant soup mix from mushrooms without addition of chemical additives" (India Patent Application No.: 1196/KOL/2012).

Education and Training of Staff undertaken in India/ Abroad

India

R.C. Bharati attended a training programme on Developing Agricultural Commodity Outlook Models for Policy Analysis at NCAP, New Delhi during 15-24 March, 2012.

A.K. Singh attended NAIP sponsored training programme on Intellectual Property Rights and Biotechnology at NAARM, Hyderabad from 21-25 September, 2012.

Santosh Kumar participated in an ICAR Sponsored winter school on "Molecular Breeding Approaches for Genetic Enhancement in Oilseeds Research" held at Directorate of Oilseeds Research (DOR), Hyderabad from 01 - 21 December, 2012.

Abroad

Santosh Kumar participated in a foreign workshop-cum-training on "Marker Assisted Breeding for Drought Tolerance" held at International Rice Research Institute (IRRI), Los Banos, Philippines from 02 - 09 September, 2012.

Linkages and Collaborations in India/ Abroad

- ATMA, Darbhanga.
- ATMA, Hazaribagh.
- Bihar Agriculture Management Extension and Training Institute (BAMETI), Patna.
- Bihar Veterinary College, BAU, Patna.
- Bill and Melinda Gates Foundation/USAID / IRRI for CSISA 2 (Platform Research).
- Birsa Agriculture University, Ranchi, Jharkhand
- Central Institute of Freshwater Aquaculture, Bhubaneswar.

- Central Institute of Research on Buffalo, Hisar.
- BAIF, Patna, CIFRI Barrackpore, IWMI and IFPRI New Delhi, CPRS Patna.
- Department of Agriculture, Govt. of Bihar.
- Department of Forest, Govt. of Jharkhand.
- Directorate of Fisheries, Government of Bihar, Patna.
- Directorate of Veterinary and Animal Husbandry, Government of Bihar, Patna.
- DRMR, Bharatpur for AICRP on Mustard.
- DWR, Karnal for AICRP on Wheat.
- IIPR, Kanpur for AICRP on Pigeon pea.
- IIT, Kharagpur.
- IARI, New Delhi.
- Indian Veterinary Research Institute, Bareilly.
- Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh.
- International Livestock Research Institute.
- International Water Management Institute.
- Krishi Gram Vikas Kendra, Ranchi.
- Ministry of Water Resources, Govt. of India.
- NABARD, PRADAN, IFFCO.
- NRC on Mithun, Jharnapani, Nagaland
- NRC on Pig, Guwahati , Assam
- OUAT, Bhubaneswar.
- Rajendra Agricultural University Pusa.
- Ramakrishna Mission Ashram, Narayanpur, Chhatisgarh.
- Vaishali Small Farmer Development Agency, Vashali, Bihar.
- Rama Krishna Mission Ashram, Ranchi.
- Indian Grassland & Fodder Research Institute, Jhansi

Participation in Conference /Seminar/ Workshops/Symposia/Meetings

Abdul Haris, A.; Kumar Sanjeev; Singh R.D.; Singh S. S. and Shivani participated in 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods organized by Indian Society of Agronomy at IARI, New Delhi from 26-30 November 2012.

Bharati, R.C. participated in Scientific Advisory Committee Meeting of KVK, Arwal on 26th July, 2012.

Das, Bikash; Choudhary and Jaipal Singh attended International Conference on Climate Change, Sustainable Agriculture and Public Leadership, organized by, ICAR, NCCSD NASC at New Delhi from 7-9 February, 2012.

Das, Bikash attended 7th National Conference on KVKs at PAU, Ludhiana from 20-22 December, 2012.

Das, Bikash attended National Symposium on 'Plant Biology and its Role in Sustainable Energy Production' at Guru Ghasidas University, Bilaspur, Chhatisgarh from 17-18 March, 2012.

Dayal, S. attended Xth National Symposium on "Integrated Development of Vast Biodiversity of Indigenous Livestock for Long Term Rural Livelihood Security" held at GBPUAT, Pantnagar from 7-8 February, 2013.

Dey, A. attended Brainstorming Session on Strategies for Agricultural Development in Hill & Plateau Region at ICAR-RCER, RC, Ranchi on 24th July 2012.

Dey, A.; Gupta, J.J.; Jain, A.K.; Islam, Adlul; Kumar, Sanjeev; Kumar, Ujjwal and Shivani attended Brain Storming Session on "Water Use Potential of Flood-affected and Drought-prone Areas of Eastern India" at ICAR-RCER, Patna on 14th May 2012.

Dey, A.; Gupta, J.J.; Dayal, S.; Kumar, Pankaj; Chakrabarti, Asit and Kumari, Rajani attended Meeting on Strategies for Fodder Production in Bihar at ICAR-RCER, Patna on 22nd November 2012.

Gupta, V.K. and Singh, I.S. participated in Agri. Expo.-2012 organized at ICAR-RCER, Patna held on 10th October, 2012.

Islam, Adlul participated in the ACIAR Project Inception Workshop on "Improving Livelihoods with Innovative Cropping Systems on the East India Plateau" organized by the Australian Centre for International Agricultural Research at Ranchi from 24-25th August, 2012.

Islam, Adlul participated in the Seminar on "Agricultural Development in Hill and Plateau Region" organized by ICAR RCER and NAAS, New Delhi on 25 July 2012.

Islam, Adlul participated in the Workshop on "Climate Resilient Cropping Systems for Livelihood Improvement in the East India Plateau" organized by the Australian Centre for International Agricultural Research held at Ranchi from 27-28th April, 2012.

Khan, A.R. attended 2nd National Seminar on "Management of Salt Affected Soil and Water: Challenges of the 21st Century at CSSRI Regional Research Station, Lucknow from 16-17 March, 2012.

Khan, A.R. attended Divisional Committee Meeting to review the foreign aided projects under NRM Division at KAB II, ICAR, Pusa, New Delhi on 9th July, 2012.

Khan, A.R. attended Review and Planning Meeting for CSISA's Objective 2 (Strategic Research) at NASC Complex, Pusa, New Delhi on 1st

October, 2012.

Kumar, S.; Das, Bikash and Choudhary, Jaipal Singh attended Annual Workshop of NICRA Project at CRIDA, Hyderabad from 12-14 June, 2012.

Kumar, Sanjeev attended Biennial Workshop of AICRP-IFS, organized by PDFSR, Modipuram and Association for Coastal Agricultural Research at ICAR Res. Complex for Goa, Panji from 16-19 November, 2012.

Kumar, Sanjeev attended National Conference on "Livelihood and Environmental Security through Resource Conservation in Eastern Region of India (LESRC-2012) organized by IASWC (CSWCRTI) Res. Centre, Koraput (Odisha) at OUA&T., Bhubaneswar (Odisha) from 5-7 April, 2012.

Kumar, Sanjeev attended Workshop on Weed Managementand organized by IRRI (Phillipines) at NASC, New Delhi from 27-28 March, 2012.

Kumar, Santosh attended 47th Annual Rice Research Group Meeting, at Directorate of Rice Research, Hyderabad during 6-9 April, 2012.

Kumar, Santosh participated in a Foreign Workshop-cum-training on "Marker Assisted Breeding for Drought Tolerance" at International Rice Research Institute (IRRI), Los Banos, Philippines 02-09 September, 2012.

Kumar, Santosh participated in a Workshop on Improved Rice Based Rainfed Agriculture System in Bihar held at ICAR-RCER, Patna during 15-18 January, 2012.

Kumar, Santosh participated in an ICAR Sponsored Winter School on "Molecular Breeding Approaches for Genetic Enhancement in Oilseeds Research" at Directorate of Oilseeds Research (DOR), Hyderabad 01-21 December, 2012.

Kumar, Santosh participated in the "SAS Sensitization Workshop" organized by ICAR-RCER, Patna during 27-29 June, 2012.

Kumar, Shivendra; Das, Bikash; Maurya, Sudarshan and Choudhary, Jaipal Singh attended Training-cum-workshop on 'Real Time Pest Surveillance' at Regional Fruit Research Station, Vengurle from 2-3 February, 2012.

Kumar, Shivendra; Singh, A.K.; Thakur, A.K.; Das, Bikash; Maurya, Sudarshan and Choudhary, Jaipal Singh attended International Conference on Organic Farming for Sustainability in Horti-Agriculture , 'Jhavik', 2012 at National Horticulture Mission, Jharkhand from 8-9 November, 2012.

Maurya, Sudarshan and Choudhary, Jaipal Singh attended Workshop on Livelihood Security, Vulnerability Assessment and Simulation of Pest Dynamics in Climate Change Scenarios at Indian Agricultural Research Institute, New Delhi from 16-19 January, 2012.

Maurya, Sudarshan attended 99th Indian Science Congress, at KIIT, Bhuvneshwar, Odisha from 2-7 January, 2012.

Mukherjee, Joydeep attended a Meeting on PME Cell (presided by Secretary to DARE and DG of ICAR) at NDRI, Karnal on 8th Dec., 2012.

Mukherjee, Joydeep attended International Conference on Climate Change, Sustainable Agriculture & Public Leadership at National Agriculture Science Centre (NASC), New Delhi from 7-9 February, 2012.

Mukherjee, Joydeep attended review meeting of RFD of NRM Division of ICAR at New Delhi on 19th November, 2012.

Mukherjee, Joydeep participated in International Conference on Sustainable Agriculture held at PAU, Ludhiana from 27-29 November, 2012.

Naik, S.K. attended Global Conference on Horticulture for Food, Nutrition and Livelihood Options at Orissa University of Agriculture and Technology, Bhubaneswar from 28-31 May, 2012.

Naik, S.K. attended 8th International Symposium on Plant-Soil Interactions at Low pH at University of Agricultural Sciences, Bengaluru from 18-22 October, 2012.

Naik, S.K. attended Conference on Livelihood and Environmental Security through Resource Conservation in Eastern Region of India at Orissa University of Agriculture and Technology, Bhubaneswar from 5-7 April, 2012.

Pan, R.S. attended 5th Indian Horticulture Congress at Punjab Agricultural University, Ludhiana from 6-9 November, 2012.

Sarma, Kamal attended Workshop on ITK in Fisheries at College of Fisheries, AAU, Raha, Assam from 5-6 October, 2012.

Sharma, J.P. attended Group Workers' Meeting of AICMR at Orissa University of Agriculture and Technology, Bhubaneswar from 1-2 April, 2012.

Sharma, J.P. attended National Symposium on Blending Conventional and Modern Plant Pathology for Sustainable Agriculture at IIHR, Bengaluru from 4-6 December, 2012.

Sharma, J.P. attended National Seminar on Plant Genetic Research for Eastern and North Eastern India at ICAR Research Complex for North Eastern Region, Umian from 11-12 May, 2012.

Singh, A.K. and Minocha, Astha attended National Seminar cum Workshop on IT-mediated and Technology-driven Agricultural Development at Birsa Agricultural University, Kanke, Ranchi

from 21-22 June, 2012.

Singh, K.M. participated in "Stakeholder Consultation Meeting of CSISA Project" at ICAR RCER, Patna on 6th July, 2012.

Singh, K.M. participated in Brainstorming Session on Prioritizing Development Initiatives for Higher, Inclusive and Sustainable Agricultural Growth at NASC Complex, New Delhi on 21st Feb.,2012.

Sundaram, P.K. attended 46th Annual Convention of ISAE and International Symposium on Grain Storage at College of Technology, G. B. Pant University of Agriculture and Technology.Organised by Indian Society of Agricultural Engineering (ISAE) from 27-29 February, 2012.

Research Paper Presented in Conferences/Seminar/Symposia

Abdul Haris, A.; Bhatt, B.P. and Chhabra, Vandna (2012). Climate change impact on yield of rice varieties in Bihar. In: 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, held at IARI, New Delhi during 26-30, November, 2012.

Elanchezhian, R; Kumar, S and Singh, S.S. (2012). Growth and regeneration capacity of rice genotypes towards submergence stress under lowland flood prone ecosystem. *In:* National Seminar on Physiological and Molecular Approaches for Development of Climate Resilient Crops at Acharya N. G. Ranga Agricultural University, Hyderabad from 12-14 December, 2012.

Idris, M. (2012). Integrated Rodent Pest Management. *In:* Seminar on Promotion and Popularization of Rural Biotechnological Intervention for Development of Socio-economic in Agriculture at Bihar Sharif (Nalanda) on 27-28 September, 2012.

Islam, Adlul (2012). Understanding small watershed hydrology for managing climate variability. *In:* Workshop on Climate Resilient Cropping Systems for Livelihood Improvement in the East India Plateau organized by the Australian Centre for International Agricultural Research at Ranchi from 27-28 April, 2012.

Khan, A. R.; Singh, S.S.; Singh, R.D. and Bhatt, B.P. (2012). Improvement of crop productivity due to soil reclamation in sodicity affected canal command of Bihar. *In*: 2nd National Seminar on "Management of Salt Affected Soils and Waters: Challenges of the 21st Century" at CSSRI Regional Research Station, Lucknow on 16-17 March, 2012.

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Sangle, U.R.; Idris, M. and Singh, S.S. (2012). Production of lentil (*Lens culinaris*) decline due to wilt complex problem in rice wheat cropping system in eastern region. *In:* 3rd Global Conference on "Plant Pathology for food security", organized by Indian Society of Mycology and Plant Pathology Maharana Pratap University of Agriculture and Technology Udaipur Rajasthan from 10-13 January, 2012.

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Singh, A.K. and Kumar, P. (2012).Good Agronomic Practices (GAP) - an efficient and eco-friendly tool for sustainable management of plant diseases under changing climate.*In:* National Conference on Factors Affecting Teaching & Research and Strategy to Improve Quality in Higher Education (FATRSIQHE) at RGSC, Barkachha, Mirzapur, BHU on 28-29 Feb. 2012.

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Singh, K.M. (2012). Agricultural extension, research & development in Bihar. *In:* State Consultations on Priorities and Possibilities of Investment for Accelerated and Stabilizing Agricultural Growth in Bihar, organized by IFPRI and ICAR-RCER, Patna at Hotel Patliputra Ashok, Patna on 17th March 2012.

Singh, K.M. (2012). Agro-ecological and socio-economic characteristics of Jharkhand state *In:* Project Advisory Committee Meeting of ICAR-ICRISAT Collaborative Project Tracking Change in Rural Poverty in Household and Village Economies in Eastern India at ICAR-RCER, Patna on 23 April 2012.

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Singh, S.S.; Khan, A.R. and Bhatt, B.P. (2012). Sodic land reclamation in Gandak command of Bihar through participatory technology transfer. *In*: 2nd National Seminar on "Management of Salt Affected Soils and Waters: Challenges of the 21st Century" at CSSRI Regional Research Station, Lucknow on 16-17 March, 2012.

New Entrants, Selection, Promotion, Transfer, Retirements and Resignation

New entrants

Dr. Sulip Kumar Manjhi joined as Scientist (Fish & Fisheries) at ICAR-RCER, Patna w.e.f. 09.04.2012.

Dr. Mandhata Singh joined as Subject Matter Specialist (Agronomy) at KVK Buxar w.e.f. 27.04.2012.

Dr. Rajni Kumari joined as Scientist (Anim. Biotech.) at ICAR-RCER, Patna w.e.f. 21.05.2012

Dr. Pankaj Kumar joined as Scientist (Vet. Medicine) at ICAR-RCER, Patna w.e.f. 06.06.2012

Mr. Sharad Kumar Dwivedi joined as Scientist (Plant Physiology) at ICAR-RCER, Patna w.e.f. 09.10.2012.

Mr. Ravishankar joined as Assistant at ICAR-RCER, Patna w.e.f.27.08.2012

Selection

Dr. Nitu Singh (SMS, Hort.) KVK, Buxar, selected to the post of Assistant Professor cum Junior Scientist at Bihar Agriculture University, Sabour w.e.f. 25.09.2012.

Promotion

Dr. Ashutosh Upadhyaya promoted to Principal Scientist w.e.f. 01.01.2008

Dr. Amitava Dey promoted to Principal Scientist w.e.f. 01.01.2009

Dr. A. Abdul Haris promoted to Principal Scientist w.e.f. 30.12.2010

Dr. Abhay Kumar promoted to Principal Scientist w.e.f. 03.04.2011

Dr. Adlul Islam promoted to Principal Scientist w.e.f. 19.07.2011

Dr. Ujjwal Kumar promoted to Principal Scientist w.e.f. 01.02.2012

Dr. Atiqur Rahman promoted to Principal Scientist w.e.f. 03.02.2012

Dr. S.K. Barari promoted to T-9 w.e.f. 03.11.2004

Mr. Umesh Singh promoted to Assistant Administrative Officer w.e.f. 13.04.2012

Transfer

Mr. A.K. Singh, T-4 (Hindi Translator), transferred on 28.05.2012 from this institute to IISR, Lucknow.

Retirements

Dr. D.K. Kaushal, Pr. Scientist & Head w.e.f. 31.01.2013

Dr. P.K. Thakur, Pr. Scientist w.e.f. 28.02.2013

Sri Kishori Prasad, T-6 w.e.f. 31.01.2013

Dr. J.P. Sharma, Pr. Scientist w.e.f. 31.01.2013

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On-going Research Projects

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
1.0	**Integrated Farming System and Cropping System for Eastern Region**					
1.1	ICAR-RCER/ AICRP/ IFS/ EF/ 2010/25(i)	Development of location specific Integrated Farming System models for small and marginal farmers of Bihar	Sanjeev Kumar A. Dey, A.K. Jain, S.S. Singh, U. Kumar N. Chandra, Mohd. Idris	June 2010	March 2013	PDFSR, AICRP
1.2	ICAR-RCER/ RCM/ 2011/25(ii)	Development of makhana based Integrated Farming System models for low land eco-system	L. Kumar, I.S. Singh V.K. Gupta	July 2011	June 2014	ICAR-RCER
1.3	ICAR-RCER/ RC Ranchi/ 2011/ 25(iii)	Development of location specific Integrated Farming System models for rainfed eco-system of eastern plateau hill region	B.K. Jha, S.K. Naik, Bikash Das, A.K. Singh, R.S. Pan, J.P. Sharma, A.K. Thakur, J.S. Chaudhary	June 2011	May 2014	ICAR-RCER
1.4	ICAR-RCER/ RCMS/ 2008/ 49	Studies on irrigation and nutrient requirement of diversified cropping system in irrigated eco-system of central Bihar.	R.D. Singh, Shivani	July 2008	June 2013	ICAR-RCER
1.5	ICAR-RCER/ HARP/ 2008/ 56	Development of guava + pineapple based multi-storied cropping system under irrigated conditions of eastern plateau region.	B.R. Jana, Bikash Das	July 2008	June 2013	ICAR-RCER
1.6	ICAR-RCER/ R.C Makhana/ 2011/ 117	Dynamics of nutrients under makhana and makhana based cropping system grown in inceptisols of Bihar	I.S. Singh, V.K. Gupta L. Kumar	April 2012	March 2015	ICAR-RCER
2.0	**Resource Conservation Technology**					
2.1	ICAR-RCER/ R.C Ranchi/2011/98	Resource conservation and methods of planting in acid soil by vegetable based cropping system	B.K. Jha, S.K. Naik, A.K. Thakur, J.S. Chaudhary	June 2011	May 2014	ICAR-RCER
2.2	ICAR-RCER/ E.F./ CSISA/2009/22	Crop and resource management practices for sustainable future cereal-based systems.	S. S. Singh, A. R. Khan Mohd. Idris	July 2010	Jan. 2013	BMGF*
2.3	ICAR-RCER/ IFAD/DCR/ EF/2011/27	Accelerating RCTs adoption to improve food security and rural livelihoods while reducing adverse environmental impacts in Indo-Gangetic Plains (IFAD)	Sanjeev Kumar	June 2011	June 2013	IRRI
3.0	**Climate Resilient Agriculture**					
3.1	ICAR-RCER/ SEET/ 2011/ 112	Weather based forecasting for agricultural growth in eastern India	R.C. Bharati, K.M. Singh A. A. Haris, J. Mukherjee U.R. Sangle	July 2011	June 2014	ICAR-RCER
3.2	ICAR-RCER/ DCR/ 2011/ 115	Weather crop-pest-disease interaction studies of major crops of eastern region	J. Mukherjee, Mohd. Idris U.R. Sangle	July 2012	June 2015	ICAR-RCER
3.3	ICAR-RCER/ RC Ranchi/ 2011/29	Understanding the changes in host-pest interactions and dynamics in mango under climate change scenario (NICRA)	S. Kumar, Bikash Das, S.S. Mali, J.S. Chaudhary	Jan. 2011	Jan. 2014	NICRA
3.4	ICAR-RCER/ ICCW/2004/ 02	Impact assessment of climate change on water resources and their productivity	A. A. Haris, A. Islam	2004	2012	CRIDA
3.5	New project	Land suitability classification for different crops using remote sensing and GIS	Manibhushan, A. Upadhyaya A.K. Singh, Surajit Mondal	Jan. 2013	Dec. 2015	ICAR-RCER

4.0	**Varietal Development**					
4.1	ICAR-RCER/ DCR/ 2010/ 84	Management of abiotic stress in rice through biotechnological approaches.	Santosh Kumar, Shivani	July 2010	June 2014	ICAR-RCER
4.1(a)		Management of submergence tolerance through biotechnological approaches in rice grown in lowland ecosystem.				
4.1(b)		Genetic variability analysis and development of mapping population for drought tolerance in rice.	Santosh Kumar, S. S. Singh			
4.2	ICAR-RCER/ DCR/ 2011/ 93	Characterization and evaluation of elite genotypes and high yielding varieties of rice for aerobic condition	Santosh Kumar, S.S. Singh	July 2011	June 2014	ICAR-RCER
4.3	ICAR RCER/ FF /2011/ 30	Evaluation and development of drought tolerant rice for eastern region (STRASA Phase-II)	Santosh Kumar, S.S. Singh, Mohd. Idris, U.R. Sangle	July 2011	June 2014	IRRI
4.4	New Project	Improved Rice based rainfed agricultural system in Bihar State, India (IRRAS)	S.S. Singh, S. Kumar, A. K. Singh, U. R. Sangle	July 2012	June 2015	IRRAS
4.5 (a)	ICAR-RCER / DLWM/ 2011 /116	Varietal development of faba bean (Vicia faba L.) for nutritional security in eastern region	A. K. Singh, Santosh Kumar, U.R. Sangle, P.K. Sundaram, I.S. Singh, R.S. Pan, Janardan Jee	Sept. 2011	July 2014	ICAR-RCER
4.5(b)	New Project	Development of guidelines for the conduct of test for Distinctiveness, Uniformity and Stability (DUS) on faba bean.	A. K. Singh, Shivani, Manibhushan	April 2012	March 2014	PPV &FRA
4.6	ICAR RCER/ RC Ranchi/ 2011/ EF/ 28	Developing national repository and creating facilities for DUS testing in mango, guava and litchi (Litchi chinensis)	Bikash Das	June 2011	June 2014	PPV &FRA
4.7	ICAR-RCER/RC Ranchi/ 2010/ 83	Genetics of bacterial wilt resistance in brinjal using conventional and molecular approaches.	P. Bhavana, A. K. Singh, J. P. Sharma	2010	2014	ICAR-RCER
4.8	ICAR-RCER/ HARP/ 2006/33	Evaluation of advance breeding lines and maintenance of breeding in Solanaceous and Cucurbitaceous vegetable crops	A.K. Singh, R.S. Pan, J.P. Sharma, P. Bhavana	2006	2014	ICAR-RCER
4.9	ICAR-RCER/ HARP/ 2006/ 34	Management of plant genetic resources and improvement of leafy and underutilized vegetable crops	R.S. Pan, A.K. Singh, S. Kumar, J.P. Sharma, Bikash Das	2006	2014	ICAR-RCER
4.10	New Project	Genetic enhancement of Tomato for nematode and bacterial wilt resistance through Molecular markers	P. Bhavana, A.K. Singh, S. Maurya, J.S.Choudhary	Jan. 2013	Dec. 2017	ICAR-RCER
4.11	ICAR-RCER / HARP/ 2001/ 03	Plant genetic resource and improvement fruit and ornamental crops	Bikash Das, B.R. Jana, S. Kumar	2001	Long term	ICAR-RCER
4.12	ICAR-RCER/ RC Ranchi/ 2010/ 86	Standardization of inter stock for induction of dwarfing in vigorous mango cultivars growing under eastern under eastern plateau and hill conditions	Bikash Das, B. R. Jana	July 2010	June 2015	ICAR-RCER
4.13	ICAR-RCER/ RCM/ 2010 / 89	Collection, characterization descriptor documentation, conservation, bio-chemical evaluation, value addition and utilization of makhana	V.K. Gupta, L. Kumar	March 2011	Feb. 2013	ICAR-RCER
5.0	**Production Technologies**					
5.1	ICAR-RCER/ RC Ranchi/ 2010/ 87	Process development for production of dried products from selected fruits and vegetables.	A.K. Thakur, B.R. Jana, V. K. Gupta	July 2010	Dec 2012	ICAR-RCER
5.2	ICAR-CER / DLWM/ 2010 / 88	Evaluation of different weeding technologies for direct seeded rice – maize cropping system.	P.K. Sundram, A. K. Singh, A. Rahman	June 2011	June 2014	ICAR-RCER
5.3	ICAR-RCER/ DCR/ 2011/ 92	Optimization of methodology of transplanting and fertilizer application in transplanted maize	Sanjeev Kumar, U.R. Sangle, N. Chandra	Oct. 2011	June 2014	ICAR-RCER
5.4	ICAR-RCER/ RC Ranchi/ 2011/ 96	Evaluation of soil fertility status of acid soils of different mango orchards of eastern plateau and hill region	S.K. Naik, Bikash Das	July 2011	June 2014	ICAR-RCER
5.5	ICAR-RCER/ DC/ 2011/104	Evaluation of different production system for Carbon sequestration potential	A.Haris A., S.K. Naik, J. Mukherjee	July 2011	June 2015	ICAR-RCER

5.6	New Project	Evaluation of vegetable varieties under different irrigation methods	Shivani, A.K. Singh, A. Islam Mohd. Idris	Sept. 2012	Aug. 2016	ICAR-RCER
5.7	New Project	Development of methods for processing and extending shelf-life of selected vegetable beans	A. K. Thakur, S. Maurya R.S. Pan	Jan. 2013	Dec. 2015	ICAR-RCER
6.0	**Protection Technologies**					
6.1 (a)	ICAR-RCER/ DLWM/2011/ 120	Effect of abiotic factors on population dynamics of major insect pest in paddy-potato-onion cropping system in Bihar state	Janardan Jee, Mohd. Idris	July 2011	June 2014	ICAR-RCER
6.1 (b)	New Project	Survey and surveillance of pest complex and their natural enemies on selected horticultural crops	J.S. Chaudhary, S. Maurya	Jan 2013	Dec. 2015	ICAR-RCER
6.2	ICAR-RCER/ DCR/ 2010/ 85	Eco-biology and management of rodent fauna of rice- wheat cropping system	Mohd. Idris	July, 2010	June 2013	ICAR-RCER
6.3	ICAR-RCER/ DCR/ 2011/105	Management of wilt complex of lentil through bio-agents coupled with host resistance	U.R. Sangle, Sanjeev Kumar	Nov. 2011	Oct. 2015	ICAR-RCER
6.4	ICAR-RCER/ DCR/ 2011/114	Development of bio-insecticides module for management of gram pod borer (Helicoverpa armigera) in chickpea crop	U.R. Sangle, Mohd. Idris, Sanjeev Kumar	Dec. 2011	April 2014	ICAR-RCER
6.5	ICAR-RCER/ RC Ranchi/ 2011/110	Exploration of biocontrol agents for the management of soil borne phytopathogens in eastern plateau and hill region.	S. Maurya, S.K. Naik, U.R. Sangle	Jan. 2012	Dec. 2014	ICAR-RCER
6.6	ICAR-RCER/ RC Ranchi/ 2011/ 97	Biology, seasonal incidence and management of stink bug (Tessaratoma sp.) on litchi under eastern plateau and hill region	J.S. Chaudhary, Mohd. Idris	June 2011	June 2014	ICAR-RCER
7.0	**Land and Water Management**					
7.1	ICAR-RCER/ DLWM/ 2011/100	Crop diversification with faba bean to improve land and water productivity	A.K. Singh, Ajay Kumar	June 2011	July 2014	ICAR-RCER
7.2	ICAR-RCER/ DLWM/2011/ 94	Application of micro-irrigation in system of rice- wheat intensification for enhancing water productivity	S.K. Singh, Ajay Kumar	July 2011	June 2013	ICAR-RCER
7.3	ICAR RCER/ RC Ranchi/ EF/ NABARD / 2011/ 26	Standardization of planting geometry and growth stage based fertigation patterns for commercial cultivation of vegetables using drip irrigation system.	B.K. Jha, S.K. Naik, A.K. Singh, R.S. Pan, A. Kumar	June 2011	May 2014	NABARD
7.4	ICAR-RCER/ DLWM/ 2011/ 102	Refinement of LEWA for its better performance	Ajay Kumar, A. Upadhyaya	July 2011	June 2013	ICAR-RCER
7.5	ICAR-RCER / DLFM / 2010/ 118	Diversification of fish farming system to maximize the water productivity	B.K. Choudhary, D.K. Kaushal	April 2012	March 2015	ICAR-RCER
7.6	New Project	Standardization of water and fertilizer use efficiency of Sapota based high density inter-cropping of different fruit crops under eastern plateau and hill region	R. Jana, Bikash Das, S.K.Naik, Ajay Kumar	July 2012	June 2017	ICAR-RCER
7.7	ICAR-RCER/ DLWM/2011/ 119	Solar energy utilization in agriculture	A. Rahman, J. Mukherjee, P.K. Sundram	August 2011	July 2014	ICAR-RCER
7.8	ICAR-RCER/ DLWM/2011/121	Evaluation of developed Decision Support Tool in participatory mode	A. Upadhyaya	Jan. 2012	Dec. 2014	ICAR-RCER
8.0	**Livestock and Avian Management**					
8.1	ICAR-RCER / DLFM / 2010/ 90	Evaluation of feeds and fodders in ruminants to develop mixed ration for production of milk and meat	J.J. Gupta, A. Dey, P.K. Ray S. Dayal, D.K. Kaushal, K.M. Singh, S. Bandopadhyay	April 2011	Mar. 2015	ICAR-RCER
8.2	ICAR-RCER / DLFM / 2011/ 91	Network project: Growth performance of poultry and pig as influenced by phytase supplementation in eastern region	J.J. Gupta, A. Dey, K. Burman A. Chakrabarti	July 2011	June 2014	ICAR-RCER
8.3	ICARRCER/ DLFM / 2011/ 95	Exploring growth hormone gene for improvement of growth performance traits in Black Bengal goat	S. Dayal, P.K. Ray, S.P. Sahu	Aug. 2011	July 2014	ICAR-RCER
8.4	ICARRCER / DLFM /2011/ 99	Chronic exposure effect of Carbofuran and Chlorpyrifos in ducks and role of Vitamin C and Vitamin E in its amelioration	A. Chakrabarti S. Dayal Pankaj Kumar	Aug. 2011	July 2014	ICAR-RCER

8.5	ICAR-RCER / DLFM / 2011/ 106	Formulation of area specific mineral mixture for Bihar based on soil-plant-animal continuum	A. Dey, J.J. Gupta, P.K. Ray Manoj Kumar, Bipin Kumar S.K. Naik	Aug. 2011	July 2015	ICAR-RCER
8.6	ICAR-RCER/ DLFM/ 2010/ 107	Field bailing of crop residues for animal feeding	A. Dey, A. Rahman, Dev Karan	Aug. 2011	July 2014	ICAR-RCER
8.7	New Project	DBT Twining Programme on Elucidating the mechanisms involved in higher feed conversion efficiency of bovine species by expression of the genes regulating mitochondrial proton leak kinetics	A Dey, S.Dayal	Jan. 2013	Dec. 2015	DBT
8.8	ICAR-RCER/ DLFM/ EF/ 2011/ 31	Network project on Buffalo improvement	S. Dayal, A. Dey, A. Chakrabarti, P.K. Ray	June 2012	Dec. 2016	CIRB, Hissar
8.9	ICAR-RCER/ DLFM/ 2011/ 109	Adaptability and management study of rabbit in Bihar	A. Chakrabarti, J.J. Gupta, P.K. Ray	Jan. 2012	Dec. 2014	ICAR-RCER
8.10	New Project	Evaluation of nutraceuticals supporting therapy for subclinical mastitis in peri-urban cattle	Pankaj Kumar, J.J. Gupta, S.Dayal, S. Kumar, R.R.Kumari, P. Kumar	Feb. 2013	Jan. 2016	ICAR-RCER
8.11	New Project	Serological epidemiology of major viral pathogen of caprine in bihar	Pankaj Kumar, R.K.Roy, K.K.Rajak, Manoj Kumar, P. Shekhar, P. C. Chandran	March 2013	Feb. 2016	ICAR-RCER
8.12	New Project	Health monitoring and disease surveillance of farm animals	Pankaj Kumar, P. C.Chandran Purushottam Kaushik Ajit Kumar, Sanjiv Kumar, G.D.Singh	March 2013	March 2015	ICAR-RCER
8.13	New Project	Study of prolificacy genes in Black Bengal goat by molecular methods	Rajni Kumari, S. Dayal, A. Chakrabarti, S.Kumar	Aug. 2012	July 2015	ICAR-RCER
8.14	ICAR-RCER / DLFM / 2010/ 103	Adoptability and management study for poultry species in Bihar (Turkey, Quail and Vanaraja)	A. Chakrabarti, J.J. Gupta, P.K. Ray	April 2012	March 2015	ICAR-RCER
9.0	**Fisheries Management**					
9.1	ICAR-RCER/ DLFM/ 2011/ 101	Breeding, rearing and culture of Magur (Clarius batrachus) for eastern region	B.K. Choudhary, D.K. Kaushal K. Sarma,	June 2011	June 2014	ICAR-RCER
9.2	New Project	Feed formulation for production of quality fish seed from locally available feed ingredients	K. Sarma, A Dey, B.K.Choudhary, U. Kumar	Jan. 2013	Dec. 2015	ICAR-RCER
10.0	**Socio-economic Research**					
10.1	ICAR-RCER/ SEET/ 2011/ 108	Impact assessment of adopted technologies	N. Chandra, R.C. Bharati, A. K. Singh, P.K. Thakur	July 2011	July 2014	ICAR-RCER
10.2	ICAR-RCER/ SEET/ 2011/ 111	Risk proneness of major crops of eastern India	R.C. Bharati, K.M. Singh, N. Chandra	July 2011	June 2014	ICAR-RCER
10.3	ICAR-RCER/ E.F/2010/ 23	Tracking change in rural poverty in village and household economics in south Asia	K. M. Singh, M.S. Meena, A. Kumar, A.K. Jha, R.K.P. Singh	Jan. 2010	April 2014	BMGF*
10.4	New Project	Technology out-scaling for sustainable food production and livelihood improvement	Ujjwal Kumar, K. Sarma A. Haris A., A. Dey B.K. Chaudhary	Sep. 2012	Aug. 2015	ICAR-RCER

*BMGF - Bill & Melinda Gates foundation

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Publications

Research Papers

National

A., Abdul Haris; Biswas, S.; Chhabra, V.; Elanchezhian, R. and Bhatt, B.P. (2013). Impact of climate change on wheat and winter maize over a sub-humid climatic environment. *Current Science,* **104**(2): 206-214.

A., Abdul Haris; Chhabra, V. and Biswas, S. (2011). Trends in paddy production and productivity in the Gangetic Plains of Bihar as influenced by rainfall. *Agricultural Situation in India,* LXVIII **(7)**: 323-327.

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Chandran, P.C.; Dey, A.; Pandian, S.J.; Barari, S.K. and Kaushal, D.K. (2012). Red Purnia cattle-an unexplored indigenous germplasm. *Indian Journal of Animal Sciences,* **82**: 1594-1597.

Chaudhary, J.S.; Kumari, A.; Das, Bikas; Maurya, S. and Kumar, S. (2012). Diversity and population dynamic of fruit flies species in methyl eugenol based parapheromone traps in Jharkhand region of India. *The EcoSCAn*, **1**: 57-60.

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Doley, S.; Shakuntala, I.; Basumatari, R.; Gupta, J.J. and Kumar, S. (2012). Effect of herbal powder as feed additives on the performance and serum cholesterol level in broiler chicken. *Indian Journal of Animal Production and Management*, **28**(1-2): 37-39.

Elanchezhian, R.; A., Abdul Haris; Biswas, S. and Chhabra, V. (2012). Simulation of yield and its component traits of rice (*Oryza sativa* L) varieties grown in Indo-Gangetic Plains of Bihar under projected climate change. *Indian Journal of Plant Physiology,* **17**(3&4): 195-202.

Jyoti, K.; Naik, S.K.; Mandal, M. and Das, D.K. (2012). Performance of different sources of sulphur on yield and quality of rapeseed. *J. Ind. Soc. Soil Sci.*, **60**(3): 251-257.

Kaur, Prabhjyot; Singh, Harpreet; Kingra, P.K. and Mukherjee, J. (2012). Mustard model as an agronomic management tool for oilseed *Brassica* cultivation in irrigated plains of Punjab state. *J. Oilseed Brassica,* **3**(2): 99-110.

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Dr. A.R. Khan, Pr. Scientist (Soil Phy.)
Dr. Md. Idris, Sr. Scientist (Entomology)
Dr. R. Elanchezhian, Sr. Scientist (Plant Physiology)
Dr. Sanjeev Kumar, Sr. Scientist (Agronomy)
Dr. J. Mukherjee, Sr. Scientist (Agri. Met.)
Dr. U.R. Sangle, Sr. Scientist (Plant Pathology)
Dr. Santosh Kumar, Scientist (Plant Breeding)

Technical Officer

Sh. Anil Kumar, Technical Officer (T-5)

Division of Livestock and Fishery Management

Scientists

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Dr. Kamal Sharma, Pr. Scientist (Fish and Fishery Science)
Dr. A. Dey, Pr. Scientist (Animal Nutrition)
Dr. A. K. Jain, Sr. Scientist (Fish and Fishery Science)
Dr. S. Dayal, Sr. Scientist (Animal Gen. & Breeding)
Dr. Asit Chakrabarti, Sr. Scientist (LPM)
Dr. B.K. Chaudhary, Scientist (Fish & Fishery Science)
Dr. Rajni Kumari, Scientist (Animal Biotechnology)
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Technical Officers

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Division of Socio-Economics and Extension

Scientists

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Dr. P. K. Thakur, Pr. Scientist (Agril. Extn)
Dr. Abhay Kumar, Pr. Scientist (Agril. Stat.)
Dr. Ujjwal Kumar, Pr. Scientist (Agril. Extn.)
Dr. N. Chandra, Sr. Scientist (Agril. Econ..)
Dr. R.C. Bharati, Sr. Scientist (Agril. Stat.)
Dr. M.S. Meena, Sr.Scientist (Agril. Extn.)

Technical Officers

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Sh Sanjay Rajput, Technical Officer (T-5)

Performance Monitoring and Evaluation Cell

Dr. R.D. Singh, Pr. Scientist (Agron.) and In-charge
Dr. Abdul Haris A., Pr. Scientist (Agro.)
Dr. Adlul Islam, Pr. Scientist (SWCE)
Dr. (Mrs) Shivani, Sr. Scientist (Agron..)

Technical Officer

Sh. Kishan Singh, Technical Officer (T-7-8)
Sh. Sarfaraj Ahmad, Prog. Asstt. (Computer)

Farm Section

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Sh. Hari Shankar, Technical Officer (T-7-8)
Sh. R.K. Tiwari, Technical Officer (T-5)

Workshop and Estate Section

Sh. M.L.Swarnkar, Workshop Engineer (T-7-8)

ICAR RCER, Research Centre, Ranchi

Scientists

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Dr. J.P. Sharma, Pr. Scientist (Plant Pathology)
Dr. A.K. Singh, Pr. Scientist (Horticulture)
Dr. R.S. Pan, Pr. Scientist (Horticulture)
Dr. A.K. Thakur, Pr. Scientist (AS & PE)
Dr. B.K. Jha, Sr. Scientist (Horticulture)
Dr. Bikash Das, Sr. Scientist (Horticulture)
Dr. S. K. Naik, Sr. Scientist (Soil Sci.-Soil Chemistry/ Fertility/Microbiology)
Dr. Sudarshan Maurya, Sr. Scientist (Plant Pathology)
Dr. B.R. Jana, Scientist (Horticulture)
Dr. (Mrs.) P. Bhavana, Scientist (Plant Breeding)
Dr. Jaipal Singh Choudhary, Scientist (Entomology)

Technical Officers

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Sh. D.K. Sah, Technical Officer (T-6)
Sh. Paul Sanjay Sircar, Technical Officer-Computer (T-6)
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Sh. Chandrakant, Technical Officer (T-5)
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Sh. M.K. Pandey, Technical Officer- Library (T-5)
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Sh. Chandrashekher Prasad, Technical Officer (T-5)
Sh. Birendra Prasad Srivastava, Technical Officer (T-5)
Sh. Pradeep Kumar Singh, Technical Officer (T-5)
Sh. Suresh Kumar, Technical Officer (T-5)

ICAR RCER, Research Centre Makhana, Darbhanga

Dr. V.K.Gupta, Pr. Scientist (Plant Breeding) & Head
Dr. Lokendra Kumar, Sr. Scientist (Plant Breeding)
Dr. I.S. Singh, Sr. Scientist (Soil Science)

ICAR RCER, Krishi Vigyan Kendra, Buxar

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Dr. Deokaran, SMS (Soil Sci.)
Dr. Ramakrishna Roy, SMS (Animal Sci.)
Dr. (Mrs.) Nitu Kumari, SMS (Hort.)
Mr. Ramkewal, SMS (Plant Protection)
Dr. Mandhata Singh, SMS (Agron.)

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