वार्षिक प्रतिवेदन
Annual Report
2013-14

भाकृअनुप
ICAR

ICAR Research Complex for Eastern Region

ICAR Parisar, P. O. : Bihar Veterinary College
Patna-800 014 (Bihar)

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Preface

It gives me immense pleasure to bring out the 13th Annual Report of ICAR Research Complex for Eastern Region, Patna. The institute undertakes multi-commodity and multi-disciplinary research for management of natural resources and to enhance the productivity of agricultural production systems in diverse agro-climatic zones of Eastern States.

During the reported period, the research, extension and agricultural development activities continued to gain momentum. For achieving the goal of food and nutritional security alongwith water conservation, emphasis is being given on rainwater harvesting, water productivity, management of fallow land, varietal development for stress condition, weed management, ground water recharge, rehabilitation of waterlogged areas, conservation agriculture, restoration of degraded lands and cropping patterns. Different models of integrated farming systems have been developed for rainfed, irrigated and waterlogged situations which have been found ecologically and economically viable.

First ever variety of makhana – Swarna Vaidehi and 6 varieties of vegetable crops, i.e., Swarna Anmol of Tomato, Swarna Praphulya of chilli, Swarna Atulya of capsicum, Swarna Sneha of bottle gourd, Swarna Yamini of bitter gourd and Swarna Sawani of ridge gourd-satputia have been released through Institute Variety Release Committee during the year under report. To strengthen the plant genetic resource management, promising genotypes of different fruits like mango, litchi, bael, sapota and improved lines of makhana, solanaceous vegetables and cucurbits have been identified and maintained. In the field of agro-diversity conservation, 230 germplasm of wild edibles including tuber crops have been collected from Chhattisgarh, Jharkhand, Odisha and West Bengal. Rice genotypes for drought as well as submergence stress and advance breeding genotypes of wheat for rainfed lowland ecosystem have also been evaluated. Further, 4.2 t of vegetable seed, 51000 nos. of quality planting material of various fruits and vegetables and 5.2 t of mushroom spawn have been produced.

Breeding of Magur and Labeo bata have been successfully completed. Different feeding experiments on poultry, pig, rabbit, goat, cow and buffalo have been conducted during this period. More than 1000 Artificial insemination (AI) have been performed in non-descript buffalo with elite Murrah germplasm.

The institute has published 89 nos. of research papers in the journal of national and international repute, 5 books, 11 book chapters, 02 training manuals, 03 technical bulletins, 04 extension bulletins and 33 popular articles.

I acknowledge the consistent support, keen interest and guidance received from Dr. S. Ayyapan, 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. Sikka, DDG (NRM) is duly acknowledged. I am equally thankful to Dr. S. K. Chaudhari, ADG (Soil & Water Management) ICAR for their 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 Dr(s). R. D. Singh, A. Dey, Shivani, Ujjwal Kumar, Kamal Sarma and secretarial assistance by Sarfaraj Ahmad in bringing out the report is also appreciated.

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

Contents

1. Executive Summary

- Ninety six rice entries comprising of elite genotypes and high yielding varieties of different duration were evaluated under aerobic condition and 8 rice genotypes were found promising for aerobic situation (productivity 2.18 to 4.62 t/ha).
- Forty two rice genotypes were evaluated for drought stress at reproductive stage. Rice genotypes *viz.*, IR 88964-24-2-1-4 (4.73 t/ha), IR 88966-43-1-1-4 (4.33 t/ha) and IR 88964-11-2-2-3 (4.07 t/ha) under AYTGT 120 trial and IR 88867-4-1-1-4 (4.76 t/ha) and IR 88867-9-1-1-4 (4.55 t/ha) under AYT 100-120 trails showed tolerance to water stress (drought) condition at reproductive stage as compared to check varieties – Lalat, IR64, Swarna, BPT 5204, Rajendra Sweta, MTU 1010 and Sahbhagi.
- Ten rice genotypes have been evaluated under rice-sugarcane cropping system at Harinagar, West Champaran (Bihar). Rice genotypes *viz.*, IR83373-B-B-25-3 (5.32 t/ha), IR83373-B-B-24-3 (4.54 t/ha), IR83387-B-B-110-1 (4.31 t/ha) IR84895-B-127-CRA-5-1-1(4.67 t/ha), IR83376-B-B-24-2 (3.89), Sahbhagi (4.60 t/ha) and Shusk Samrat (4.23 t/ha) have performed better than existing recommended rice varieties of this region.
- Application of tank mixture spray of Bispyribac + Ethoxysulfuron at 16-18 DAS has resulted in maximum yield (5.1 t/ha) and weed control efficiency (82.7%) in direct seeded rice. Tank mixture combination of Bispyribac + Azimsulfuron ranked second for rice yield (4.7 t/ha) and weed control efficiency.
- Practicing direct seeded rice (DSR) could save an amount of ₹ 10,400/ha followed by ₹ 6,700/ha in unpuddled mechanical transplanted rice (MTR) compared to total expenditure of ₹ 25,300/ha in puddled transplanting of rice (PTR). Further, MTR produced 34.4% higher yield over DSR (3.2 t/ha).
- Thirty advance breeding genotypes of wheat were evaluated for rainfed lowland ecosystem of eastern region. Wheat genotypes – NW5054 (5.42 t/ha), RAJ 4250 (5.36 t/ha), HD3076 (5.11 t/ha) and HD3118 (5.09 t/ha) were identified promising as compared to check varieties HD 2733 (4.41 t/ha), HI 1563 (4.36 t/ha), PBW 343 (4.34 t/ha) & PBW 373 (3.87 t/ha).
- Performance of wheat genotypes (C306, HD 2967, PBW 550 and HD 2733) under predicted climate change (elevated CO_2, 475 ppm) showed that elevated CO_2 has positive effect in terms of more grain numbers (50.3 nos/panicle compared to 44.6 nos/panicle in control), percentage of filled grains (94.6% compared to 94.03% in control) and grain yield (4.06 t/ha compared to 2.86 t/ha in control).
- In an experiment conducted on carbon stock assessment in different cropping system, potential carbon addition was maximum in rice-maize sequence (6.93 t/ha) followed by rice-wheat (6.2 t/ha) and rice-lentil sequence (5.27 t/ha).
- Agri-horti crops + fish + cattle + duck integration under 2 acre IFS model fetches a net return of ₹ 2,34,953/annum, i.e., ₹ 643/day.
- Agri-horti crops + goat + poultry + mushroom integration under 1 acre IFS model fetches a net return of ₹ 1,39,538/annum, i.e., ₹ 381/day.
- Centre opening of mango trees in the month of August was found to be an effective adaptation strategy for minimization of infestation of mango hoppers. Among 100 screened genotypes of mango, Mulgoa Hill, Himayuddin, Sammar Bahist Chausa and Lat Sinduria were found resistant against shoot gall psylla.
- During the period under report, 5 varieties of vegetable crops, (Swarna Anmol– Tomato hybrid for protected cultivation; Swarna Praphulya– Chilli; Swarna Atulya– Capsicum; Swarna Sneha– Bottle gourd; Swarna Yamini– Bitter gourd and Swarna Sawani– Ridge gourd– Satputia) have been released through Institute Variety Release Committee.

- "Swarna Vaidehi" first ever variety of makhana (*Euryale ferox* Salisb.) has also been developed and released by Institute Variety Release Committee with production potential of 3.0 t/ha compared to 1.4 - 1.6 t/ha in traditional cultivars.
- Five brinjal genotypes (HAB-905, IC-545931, IC-545941, IC-545901, IC261786) were found resistant to bacterial wilt and are being used in the crossing programme. Similarly, tomato genotypes– EC-596747, HAT-296, HAT-305 and Swarna Lalima were found resistant for bacterial wilt, and HAT-310 and HAT-311 for root knot nematode.
- Demonstration of low poly tunnel off-season cultivation of bottle gourd in winter resulted in early harvest of produce in February-March with the maximum net income of ₹ 1571/- from one decimal (40 m^2) area. Cultivation of oyster mushroom also found economically most viable in tribal dominated areas.
- More than 230 germplasm of wild edibles including tuber crops *viz.*, elephant foot yam, taro, yams, giant taro, cassava, sweet potato, arrowroot and wild musk melon have been collected from the surveys undertaken in Chhattisgarh, Jharkhand, Odisha and West Bengal during the period under report.
- The ridge and furrow planting method was found to be the superior methods of planting cauliflower. Further, use of plastic mulch in ridge and furrow method showed maximum yield of 35.79 t/ha.
- The exchangeable Al content in acidic soils was low to medium [0.31-1.08 cmol (p+)/kg] status among the mango orchards of 1-3, 4-5 and 6-7 years in Jharkhand. The total acidity of the acidic soils of different mango orchards of Jharkhand varied from 0.88-2.34 cmol (p+)/kg.
- Two year old orchard of guava had highest organic carbon stock in soils (10.77 t/ha), followed by litchi (10.16 t/ha). Whereas in 4 year old orchard, the organic carbon stock was highest in mango orchard (12.58 t/ha) followed by litchi (11.38 t/ha) and guava (10.78 t/ha) before rainy season. However, after rainy season, highest organic carbon stock was found in litchi orchard (10.87 t/ha) and least in mango (10.36 t/ha).
- Among various diversified cropping systems, rice-tomato-bottle gourd, rice–cabbage–cowpea, rice-coriander-ladies finger and rice–potato–onion have been found the most promising cropping systems under irrigated ecosystem.
- During the period under report, more than 1000 nos of artificial insemination (AI) were performed in non-descript buffalo with elite Murrah germplasm.
- Supplementation of phytase enzyme @ 20 g/100 kg feed improved average daily gain by 2.25% and feed conversion ratio by 5.62% over control group in broiler chicken.
- Feeding of Total Mixed Ration (TMR) increased milk yield by 19.5% and dry matter and crude protein digestibility by 12.43 and 42.26%, respectively in dairy cows.
- Feeding of leguminous fodder (ground nut, soybean and rice bean) has saved 75-80% of concentrate in broiler rabbit.
- Experiment on round the year fodder production with multicut sudan and cowpea/rice bean in *kharif* and barseem and oat in *rabi* season, revealed that a total biomass yield of 67.90 and 51.99 t were produced from one ha of land during *kharif* and *rabi* season respectively, which was sufficient to meet the fodder requirements of 14 crossbred cows round the year.
- Screening of serum samples of goats from Bihar for three viral antibodies (PPR, CAE and BT) indicated that there was no prevalence of Lenti virus antibody in goat and all the samples tested were negative for CAE antibody. However, prevalence of PPR and blue tongue was recorded at 34.07 and 14.01%., respectively.
- Induced breeding of Magur recorded 93.16% fertilization, 55.10% hatching and 21.55% survival (spawn to fry).
- Breeding of *Labeo bata* has been successfully completed with hatching percentage varying between 39.67 and 84.00%. Ovaprim at the dose of 0.3 ml/ kg for female and 0.1 ml /kg for male was found most effective.
- Rice-fish integration resulted into fish yield of 1.62-1.86 t/ha of rohu and catla with a stocking density of 10,000 yearlings/ha.
- During the year under report, a total of 183 training programs, 22 Front Line Demonstrations, 13 On Farm Trials and 6 Farmers' Fair have been conducted for the farmers and the state Government officials.
- The institute also organized Agri-Summit 2013 – A Step towards Second Green Revolution and Regional Chapter meet on IPR issue in Agriculture at Patna and Ranchi.

2. 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, agro-forestry, 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 2013-2014 of the complex is presented below (Table 1).

Table 1. Financial allocation and expenditure during the year 2013-14 (₹ in Lakhs)

Head of accounts	Budget allocation		Actual expenditure	
	Plan	Non-plan	Plan	Non-plan
Establishment charges	0.00	1520.00	0.00	1437.71
T. A.	24.56	10.00	24.55	10.00
HRD	1.01	0.00	1.01	0.00
Works	12.90	0.00	12.90	0.00
Other charges	276.53	712.56	276.50	644.60
Total	315.00	2242.56	314.96	2092.31

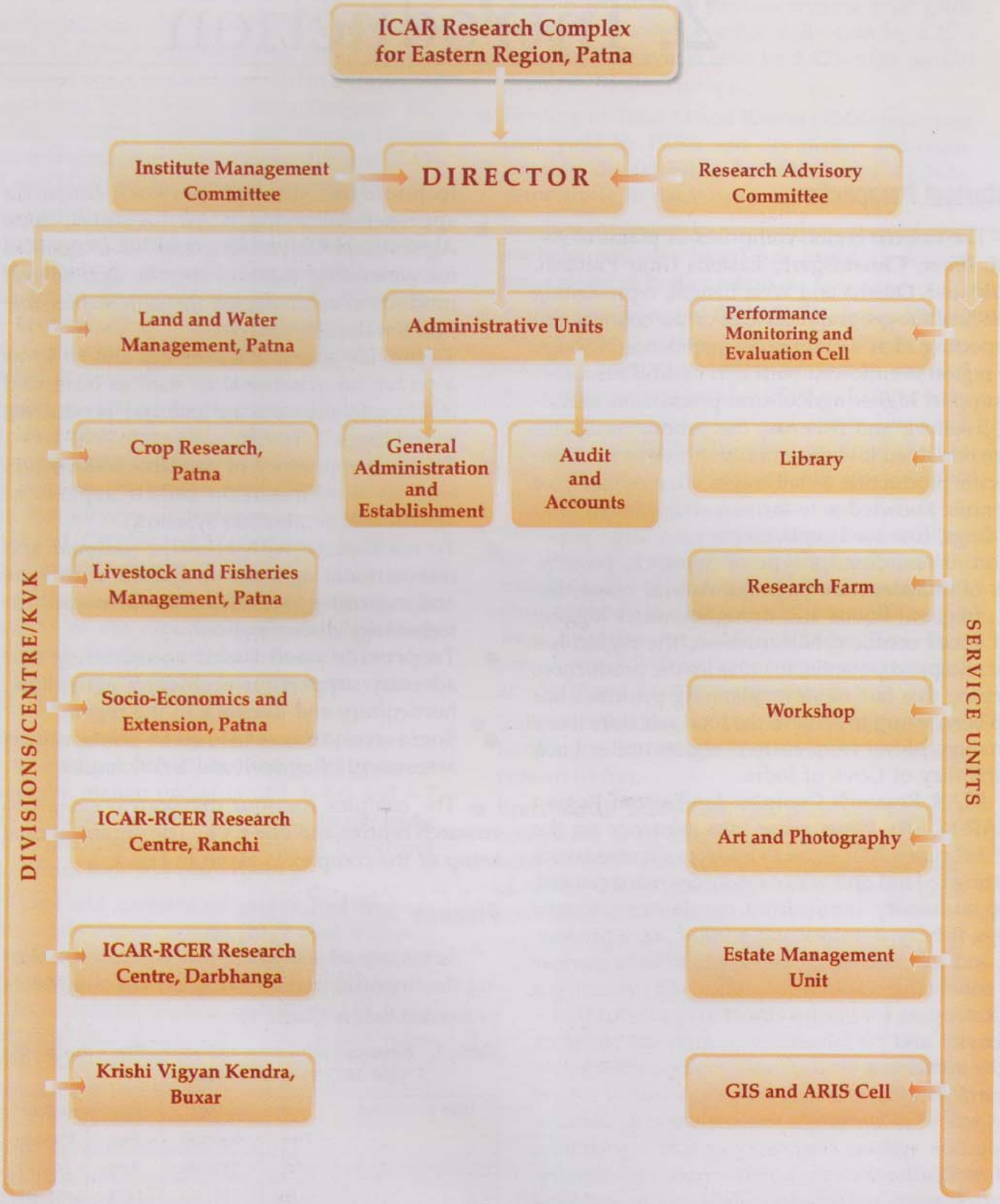


Fig. 1. Organogram of ICAR Research Complex for Eastern Region, Patna.

3. Wheather

Temperature, humidity, rainfall, wind speed, wind direction, solar radiation, soil temperature and leaf wetness in hourly interval was recorded at Patna and Ranchi.

At Patna total annual precipitation received in 2013 was recorded to be 844.7 mm which was below normal. The distribution of rainfall over time and intensity in the rainy season was very erratic. The monsoon rainfall (June-September) was very low (575 mm) as compared to normal (951.9 mm). Except September, all other monsoon months received lower rainfall than the normal (Fig. 2). During the months of October and February higher rainfall was received in comparison to their normal. The year experienced 45 rainy days (rainfall < 2.5 mm) with a highest in August (11 days). The annual pan evaporation was 1481.8 mm.

Mean monthly maximum temperature varied from 36.3°C in May to 19.7°C in January while the mean monthly minimum temperature varied between 27.1°C in July to 7.7°C in January (Table 2). The average relative humidity and sunshine hrs

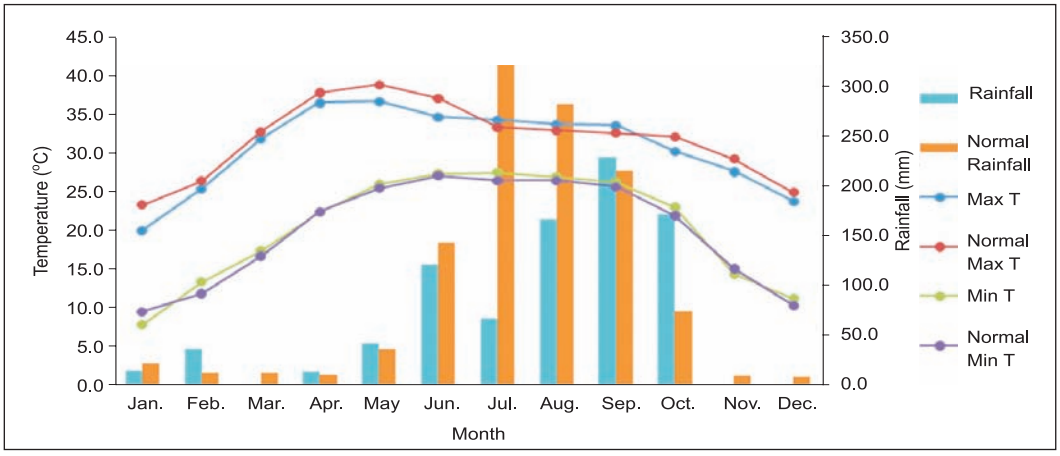


Fig. 2. Monthly variation of temperature and rainfall in Patna.

Table 2. Monthly meteorological data of Patna 2013

Month	Temperature (°C)				Avg RH (%)	Avg. sunshine (hrs/day)	Total rainfall (mm)		Rainy days	Pan evaporation (mm)
	Max.	Normal	Min.	Normal			Observed	Normal		
January	19.7	23.0	7.7	9.3	70.4	2.3	13.0	20.4	1	36.8
February	25.0	26.1	13.1	11.6	70.6	5.9	35.2	11.1	2	76.7
March	31.5	32.4	17.1	16.4	56.1	7.7	0.0	11.4	0	161.7
April	36.1	37.4	22.1	22.1	49.2	6.5	12.2	9.0	2	245.0
May	36.3	38.4	25.6	25.1	63.4	5.4	40.2	35.6	2	247.8
June	34.3	36.7	27.0	26.7	74.1	3.9	119.3	141.0	6	151.2
July	33.9	32.9	27.1	26.1	76.7	4.5	65.1	319.0	7	132.4
Aug	33.3	32.5	26.5	26.1	76.5	5.0	163.8	279.3	11	148.2
September	33.2	32.2	26.0	25.3	76.5	6.0	226.8	212.6	9	115.4
October	29.9	31.7	22.7	21.6	79.3	4.5	169.1	72.3	5	78.1
November	27.3	28.9	14.1	14.8	67.5	5.1	0.0	8.2	0	54.2
December	23.4	24.6	10.9	10.1	71.9	2.7	0.0	7.4	0	34.3
Annual	30.3	31.4	20.0	19.6	69.4	5.0	844.7	1127.3	45	1481.8

for the year was 69.4% and 5.0 hours, respectively.

Mean monthly maximum temperature varied from 37.7°C in May to 19.3°C in December at Ranchi (Table 3). Similarly, mean monthly minimum temperature ranged from 24.9°C (in June) to 7.5°C (in December). Relative humidity was maximum in August (91.4%) and minimum in December (68.2%). The total annual precipitation was 1016 mm. Ranchi received 38, 35 and 58% less rainfall in July, August and September, respectively. However, October had almost double rainfall than normal (Fig. 3).

Table 3. Monthly variation of temperature and rainfall during 2013 at ICAR RCER, Research Centre, Ranchi

Month	Temperature (°C)				Average relative humidity (%)	Total rainfall (mm)		Rainy days
	Maximum	Normal	Minimum	Normal		Observed	Normal	
January	23.8	23.0	8.4	10.0	85.9	0.0	20.5	0
February	25.7	25.8	12.0	12.6	83.9	34.0	25.7	3
March	32.4	31.2	15.8	17.0	80.1	6.0	18.9	1
April	35.4	35.5	20.2	21.4	73.6	24.0	41.2	4
May	37.7	37.2	23.9	23.6	86.3	24.0	58.5	4
June	30.7	33.5	24.9	23.7	89.9	205.0	216.3	12
July	24.9	29.3	24.7	22.7	90.1	209.0	337.9	13
Aug	28.6	28.8	23.6	22.5	91.4	211.0	326.8	13
September	29.6	29.1	24.4	21.8	90.8	113.0	273.2	9
October	26.8	28.5	20.8	19.0	89.7	190.0	99.7	11
November	26.9	25.9	12.2	14.0	86.0	0.0	16.0	0
December	19.3	23.2	7.5	10.2	68.2	0.0	6.1	0
Annual	28.5	29.2	18.2	18.2	84.7	1016.0	1440.8	70

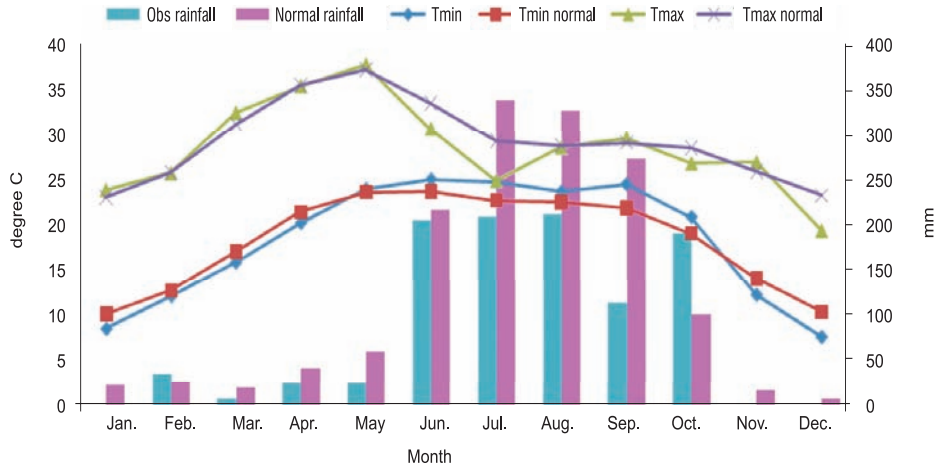


Fig. 3. Monthly variation of temperature and rainfall in Ranchi

4. Climate Change

Modeling the performance of few major cropping system in eastern India in the light of projected climate change (NAIP Comp-4)

Open Top Chamber (OTC) experiment

A study was conducted in OTCs with four wheat genotypes (C306, HD 2967, PBW 550 and HD 2733) during rabi season 2012-13. Response of these wheat varieties were observed at 25% higher CO_2 concentration (475 ppm) than control (with ambient CO_2) in OTC.

Wheat grown under elevated CO_2 produced significantly more grain yield than open field condition (Table 4). However, ambient CO_2 and open field condition performed statistically at par. The percentage of filled grains was also significantly greater in the elevated treatment (Table 4).

Table 4. Yield and yield contributing traits of wheat in OTC and open field condition in *rabi* 2012-13

Cultivar	Treatment	Height (cm)	Duration (days)	Panicle length (cm)	Grains / panicle	1000 grain weight (gm)	Spi kelet sterility	Grain yield (t/ ha)
C-306	Elevated CO_2	92.0	127	13.5	51	37.8	6.8	3.9
	Ambient CO_2	85.0	124	10.5	46	35.2	6.5	2.9
	Open	88.0	121	11.2	48	36.9	6.2	3.1
	LSD 0.05	2.1	2.5	1.8	1.9	1.3	0.4	0.5
HD 2967	Elevated CO_2	96.0	132	14.6	51	51.6	5.4	4.2
	Ambient CO_2	88.0	127	11.1	44	42.7	4.9	2.9
	Open	91.0	126	12.4	46	45.3	4.7	3.3
	LSD 0.05	2.3	1.5	1.3	1.7	1.8	1.5	0.9
PBW550	Elevated CO_2	90.0	127	12.6	49	43.8	6.2	4.1
	Ambient CO_2	83.0	128	10.5	44	40.1	6.5	2.8
	Open	85.0	124	11.7	46	41.4	5.8	3.2
	LSD 0.05	1.4	1.5	1.2	2.5	2.6	0.7	0.6
HD2733	Elevated CO_2	83.0	136	14.5	60	51.2	3.2	5.1
	Ambient CO_2	77.0	133	12.8	52	47.1	3.9	3.9
	Open	79.0	132	13.6	57	48.6	3.5	4.5
	LSD 0.05	1.3	1.6	1.1	2.4	2.0	0.8	0.6

Understanding the changes in host-pest interactions and dynamics in mango under climate change scenarios

For assessing the changes in host-pest interaction and population dynamics of mango pests in respect to changing climate scenarios, real time pest surveillance data of insect pests and diseases along with phenological parameters were recorded at six centres from major mango growing regions of India. Analysis of RTPS data indicated that under Chotanagpur plateau and hill region conditions, the late onset of powdery mildew disease on panicles was observed. This may be due to rainfall at the time of disease proliferation (40 mm in 7th SMW). Rainfall at the time of flower initiation also resulted in severe infestation of mango hoppers, thrips and blossom blight in panicles in 2013. Outbreak of leaf webber and leaf cutting weevil (*Deporaus marginatus*) were observed on old (25-30 year old) and young plants, respectively. This was due to concurrent emergence of new flushes in response to irregular and late cessation of monsoon. In Lucknow and adjoining areas (5th agro-climatic zone), severe cold with frost during 9th and 10th January, 2013 was experienced where minimum temperature was below zero (-0.2 to-1.2°C) at Amausi and Rehmankehra observatories (26° 54.53′ N, 80° 46.56′ E, 107.5 MASL). This was the lowest of last 40 years. As a result of this extreme weather, nearly 100% leaf necrosis with 5-20 cm top dead terminal shoots was recorded. Infested trees were also more prone to infection of *Botyodiplodia theobromae* which caused further loss in yield. Higher rain during February, 2013 (>200mm) caused severe incidence (85%) of blossom blight with severity ranging from 5 to 20% as compared to 20% incidence in 2012 in Lucknow region (Fig. 4).

Fig. 4. Blossom blight in 5th agro-climatic zone due to rain in February, 2013

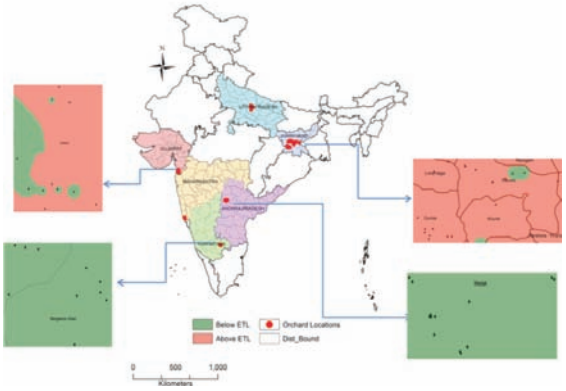


Fig. 5. Leaf hopper population status on 100% flowering stage in 2012 in different locations of India based on ETL

Under Gujarat conditions, mango hopper on flower panicles was the major pest with highest population (25/panicle) in first week of November, 2012 on Alphonso variety of mango. The population exhibited significant positive correlation with maximum temperature and sun shine. Apart from mango hoppers, shoot borers, powdery mildew and anthracnose were recorded as major insect pests and diseases in the region. In Konkan region of Maharashtra, mango hopper species, *Idioscopus nitidulus* was the major hopper species as compared to *I. nagpurensis*. Thrips incidence was severe in the month of December to January due to suitable range of maximum temperature in the region (17°C to 22°C). In northern Telangana region of Andhra Pradesh, outbreak of leaf webber (almost 100 webs/tree) and hairy caterpillars (*Euproctis fraterna, Porthesia scintillans*) on panicles (2.6 larvae/inflorescence) and leaves were observed during the year 2012-2013. This outbreak may be attributed to irregular and late cessation of rainfall. In Deccan (Karnataka) Plateau, increased emergence of new vegetative flushes during January-February resulted in infestation of shoot borer in panicles (emerging in January-February).

Hot spot mapping of pests

Based on the RTPS data collected, representative hot-spot maps for mango hopper and powdery mildew at 100% flowering stage have been generated indicating the pest scenario below or above ETL (Fig. 5).

For molecular characterization of mango hopper, *Amritodus atkinsoni* based on mitochondrial *cytochrome oxidase I* (*COXI*), nucleotide sequence have been submitted in NCBI and accession number have been obtained as KC513458 to KC513474.

Models for forewarning of pest/diseases

Based on three years data of hopper population, host plant phenology and weather parameters, a forecasting model for prediction of mango hopper population was developed. The simple regression model was best fitted with weather and phenological data ($R^2 = 0.60$ and VIF = 2.47) as compared to weather alone ($R^2 = 0.18$) or phenological parameters ($R^2 = 0.42$). Thus, the simple linear regression model derived for weather and phenological stage had the strongest relationship with hopper population per panicle or per sweep.

Prediction of future pest scenarios using different approaches

An attempt was made to understand the influence of climate change on potential population fluctuation of fruit flies in Lucknow region based on historical data. Prediction of the potential population dynamics of fruit flies was done for different time frames (2030, 2050, 2070 and 2090) under the A2B climate change scenario using regression equation (Fig. 6). The model predicted

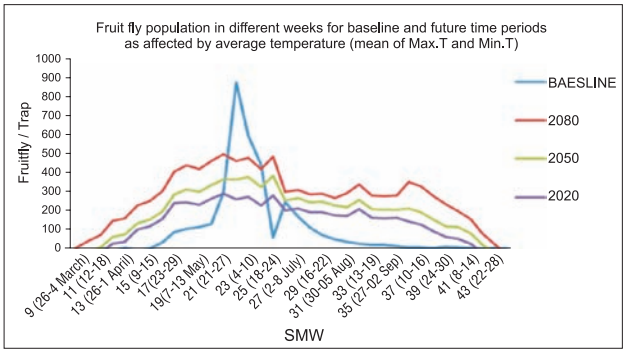


Fig. 6. Predicted fruit fly population using HadCM3 A2a scenarios based on average temperature

an overall gradual increase in time of fruit flies infestation period.

Adaptation strategies for pest management of mango pests under changing climate scenarios

Centre opening of mango trees in the month of August by removal of central leader branch 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 (Fig. 7).

Data on pest and diseases incidence on 100 mango genotypes along with phenological and weather parameters showed that the mango genotypes Mulgoa Hill, Himayuddin, Sammar Bahist Chausa and Lat Sinduria were resistant against shoot gall psylla.

Fig. 7. Centre opening for minimizing the risk of insect and pests

5. Cereals

■ RICE

Characterization and Evaluation of Elite Genotypes and High Yielding Varieties of Rice for Aerobic Condition

Ninety six rice genotypes comprises of early, medium and late duration were evaluated during *kharif* 2013 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. In the aerobic field, surface irrigation of 5 cm was applied twice a week. Further, irrigation was given at 2-3 days intervals during reproductive stage. Twenty rice genotypes were identified which showed better performance under aerobic condition as compared to check varieties. Grain yield of different genotypes varied from 2.18 to 4.62 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 are given in Table 5. These lines performed significantly better than check varieties IR 36, IR64, MAS 26, Rasi and Sahbhagi (Fig. 8). Hence these lines can be better utilized for water limited areas.

Table 5. Performance of advanced breeding rice genotypes under aerobic condition

Name of Rice genotypes	DFF (Days of 50% flowering)	Plant height (cm)	Tiller no./m^2	Panicle length (cm)	Test weight (g)	Yield (t/ha)	Harvest Index
IR 77298-14-1-2-130-2	86	113	298	28.8	32	4.08	0.36
IR 84899-B-179-16-1-1-1	94	109	297	26.8	28	4.27	0.35
IR 84899-B-179-13-1-1-1	82	108	314	27.2	28	3.88	0.35
IR 83920-B-B-277-2-1-1-1	92	99	292	28.0	34	4.21	0.37
IR 84887- B-156-17-1-1	84	111	289	25.8	26	3.69	0.37
IR 84887-B-158-7-1-1-4	88	110	282	26.6	26	4.53	0.37
IR 83929-B-B-291-3-1-1	90	118	304	28.7	28	4.62	0.35
IR 83927-B-B-278-5-1-1-1	95	112	318	27.2	34	4.40	0.37
IR 84900-B-151-27-1-1	85	112	264	29.4	32	3.77	0.35
IR 84899-B-183-20-1-1-1	95	118	280	27.6	36	3.65	0.34
IR 84898-B-168-24-1-1-1	84	105	262	28.5	32	3.39	0.34
IR 83383-B-B-129-4-78-1	90	113	265	27.1	32	3.64	0.32
IR 82639-B-B-3-3-164-4	84	109	249	27.3	26	4.11	0.33
IR 82635-B-B-75-2-219-2	93	113	316	25.3	28	4.21	0.35
IR 83376-B-B-147-3-69-1	86	112	306	24.7	30	3.77	0.33
IR 83929-B-B-291-2-1-1-2	97	116	247	26.7	32	4.19	0.32
IR 84899-B-185-8-1-1-2	88	95	251	25.5	30	4.06	0.31
IR 84899-B-184-2-1-1-1	93	102	257	26.6	34	3.51	0.33
IR 84899-B-183-6-1-1-2	97	103	217	26.2	22	3.92	0.32
IR 84898-B-165-9-1-1	90	119	247	28.5	32	4.03	0.30
IR 84899-B-185-8-1-1-1	88	99	256	27.5	30	4.26	0.36
IR 64	89	111	223	25.3	32	2.32	0.25
IR36	88	105	211	23.4	26	2.18	0.25
MAS 26	90	99	255	25.1	28	2.72	0.24
Rasi	78	88	232	26.1	32	2.41	0.16
Sahbhagi	89	110	263	27.0	34	2.84	0.31
Mean	89	108	269	26.8	30.1	3.72	0.32

Fig. 8. Evaluation of advanced breeding population under aerobic field condition

Evaluation and Development of Drought Tolerance Rice for Eastern Region (STRASA Phase-2)

Drought stress is a major constraint for rice (*Oryza sativa L.*) production and yield stability in rainfed ecosystem. Most of the high-yielding varieties-IR36, IR64, Swarna, and Sambha Mahsuri grown

in rainfed areas are bred for irrigated ecosystems, and thereby susceptible to drought. Because of the absence of high-yielding good-quality drought-tolerant varieties, farmers in the rainfed ecosystem continue to grow these varieties. Keeping this fact in view, 42 rice entries, received from IRRI along with some local varieties were evaluated under two treatment, i.e., reproductive stage stress condition and non-stress (irrigated). Fifty five days old seedlings were subjected 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. Morpho-physiological data related to drought tolerance were recorded. Some breeding lines showed better drought tolerance under field stress as compared to check varieties (Fig. 9). Grain yield varied from 2.47-7.48 t/ha and 1.26-4.76 t/ha under non stress (Irrigated) and stress (Rainfed) condition, respectively. The relative water content (RWC), chlorophyll content, and leaf area index were also recorded. The RWC values of advance breeding lines varied from 49-68%. Rice genotypes IR 88964-24-2-1-4, IR 88966-43-1-1-4, IR 88964-11-2-2-3, IR 84895-B-127-CRA-5-1-1, IR 88906-27-1-1-1 and IR 88836-4-1-4-2 under AYTGT 120 trial (Table 6) and IR 88867-4-1-1-4, IR 88867-9-1-1-4, IR 87651-26-1-1-3, IR 87638-10-1-1-3, CR 2732-2-2-1-2-1, IR 88963-3-7-2-4, IR 88864-2-1-1-3, CRR 632-34-1, REWA 842 and CRR 611-8-3-1 under AYT 100-120 trails (Table 7) performed better and showed tolerance under water stress (drought) condition at reproductive stage as compared to check varieties (Lalat, IR64, Swarna, BPT 5204, Rajendra Sweta, MTU 1010 and Sahbhagi).

Table 6. Performance of promising genotypes of AYTGT-120 days under water stress condition

Name of rice genotypes	Days to 50% flowering	Plant height (cm)	Panicle no./ hill	Biomass (dry wt.)/ hill (g)	Grain yield (t/ha)		Harvest Index
					Stress	Non-stress	
IR 88964-24-2-1-4	79	109.0	13.3	43.96	4.73	7.16	0.34
IR 88966-43-1-1-4	75	117.0	11.7	45.73	4.33	5.62	0.35
IR 88964-11-2-2-3	77	115.0	9.3	44.12	4.07	6.34	0.28
IR 84895-B-127-CRA-5-1-1	79	123.0	11.7	41.53	3.80	6.65	0.29
IR 88906-27-1-1-1	80	121.0	12.0	40.76	3.73	6.10	0.32
IR 88836-4-1-4-2	74	118.0	11.3	42.33	3.62	6.32	0.35
Lalat	81	112	9.3	28.7	2.42	6.06	0.23
Swarna	103	104	10.0	29.8	1.26	6.27	0.17
Sambha Mahsuri	109	102	8.7	31.1	1.30	5.49	0.12
Rajendra Sweta	98	96	7.3	33.7	1.47	4.98	0.15
Mean	84	114	10.4	41.2	2.58	6.03	0.27
CV (%)	5.90	4.54	10.31	13.22	12.98	6.47	10.7
LSD (5%)	8.09	8.48	1.14	9.65	0.68	0.80	0.008

Table 7. Performance of promising genotypes of AYT 100-120 days under water stress condition

Name of entries	Days to 50% flowering	Plant height (cm)	Panicle no./ hill	Biomass (dry wt.) / hill (g)	Grain yield (t/ha)		Harvest Index
					Stress	Non-stress	
IR 88867-4-1-1-4	73	92	11.7	36.73	4.76	6.19	0.44
IR 88867-9-1-1-4	75	87	9.5	35.63	4.55	5.97	0.47
IR 87651-26-1-1-3	74	106	11.4	42.33	4.46	5.60	0.45
IR 87638-10-1-1-3	84	114	10.3	36.77	4.21	7.48	0.37
CR 2732-2-2-1-2-1	79	101	11.7	29.66	3.86	5.85	0.41
IR 88963-3-7-2-4	74	98	9.9	36.43	3.74	5.94	0.46
IR 88864-2-1-1-3	76	91	9.1	34.46	3.51	5.17	0.45
CRR 632-34-1	70	91	11.4	28.03	3.50	4.37	0.42
REWA 842	74	103	9.8	31.33	3.23	5.10	0.39
CRR 611-8-3-1	74	107	11.5	37.91	3.32	5.09	0.37
Lalat	83	103	10.5	35.08	2.69	6.31	0.38
MTU1010	74	109	11.6	38.46	3.04	4.78	0.46
IR64	73	95	10.2	32.72	2.04	5.40	0.40
Sahbhagi	76	109	9.5	28.82	2.87	4.86	0.46
Mean	78	102	10.49	34.45	3.13	5.74	0.42
CV (%)	1.89	3.95	4.64	15.43	12.45	3.95	9.95
LSD (5%)	2.47	6.60	3.26	4.45	0.68	0.70	0.06

Fig. 9. Screening of rice genotypes under drought stress condition

Development of Management Practices for Drought Tolerant Genotypes in Rainfed Agricultural System in Bihar (IRRAS)

Six drought tolerant genotypes *viz.*, Abhishek, CR Dhan 40, Shusk Samrat, IR84899-B-183-CRA-19-1, IR83387-B-B-40-1 and IR82870-11 were evaluated

under rainfed ecosystem. The main objective of this experiment was to develop, validate, refine and demonstrate 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 these rice genotypes used in this study were evaluated under different management practices such as SRI vs. best management practices (BMP); puddle vs. un-puddled transplanting field; and weed management. Sahbhagi, a drought tolerant variety, was also evaluated under different management practices (Fig. 10).

Fig. 10. Evaluation of of rice varieties under different management practices

Grain yield of rice was significantly higher in unpuddled transplanted plots (1.72 t/ha) as compared to puddled transplanting (1.53 t/ha) under rainfed ecology. Results indicated that the maximum grain yield was attained by the genotype Abhishek under unpuddled transplanted (2.60 t/ha) and puddled transplanted (1.95 t/ha) conditions, respectively. Similarly, Abhishek produced maximum straw yield under both planting methods. However, lowest grain yield (1.05 t/ha) was found in genotype IR 82870-11 under puddled transplanting. Interaction of establishment methods and genotypes indicated that highest B:C ratio (1.86) was recorded in Abhishek when it was grown under unpuddled transplanted condition. Abhishek performed poor in puddled transplanted rice (PTR), however, it was still better than all other varieties with B:C ratio of 1.34.

Grain yield or rice was significantly higher in weed free plots (2.90 t/ha) as compared to partial weeded plots (2.37 t/ha).Weed population (72.0) and weed biomass (175.5 g/m^2) were significantly higher in partial weeded plots than in relatively weed free plots (42.8 and 71.8 g/m^2) at 60 DAS. The corresponding figures at harvest were 159.1 and 374.8 g/m^2 in partially weeded and 94.6 and 156.0 g/m^2 in relatively weed free condition. Whereas, weed dry biomass was 330.5 and 183.4 g/m^2 in plots with IR 83387-B-B-40-1 and in IR 84899-B-183-CRA-19-1, respectively. Data on interaction indicated that IR 84899-B-183-CRA-19-1 proved superior under weed free environment and produced 3.06 t/ha grain yield, while IR 82870-11 performed better under partially weeded condition (2.54 t/ha).

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

The mapping population derived from diverse parents IR64 and IR55419-04, comprising of 196 F_4 recombinant inbred lines (RILs) were evaluated under moisture stress environment during *kharif* 2013-14 alongwith parents. Water stress was imposed at reproductive stage (55 days old plants) by withholding irrigation for one month and beyond till the susceptible checks showed permanent wilting (Fig. 11). During the reproductive stage (stress period), soil moisture content status was monitored through periodical soil sampling at 30 cm soil depth after suspension water. Depth of water table was also monitored during the stress period. Observations of yield and yield contributing traits were recorded on ten randomly selected plants per lines per replication for the traits, i.e., Days to 50% flowering (DFF), panicle length, tiller number, plant height, total biomass, test weight and grain yield were recorded (Table 6). Drought related data such as leaf rolling, tip drying, relative water content, total dry matter were also recorded. The F_5 seeds were collected for further study. The screening of mapping population (RILs) showed that 119 recombinant inbred lines were found tolerant to drought stress at reproductive stage. Further confirmation of submergence tolerance was based on the use of polymorphic SSR markers (RM327, RM263, RM250, RM264, RM26, RM510,

Fig. 11. F_4 breeding population under water stress (drought) field condition.

RM3, RM9, RM5, RM14, RM246, RM561, RM 208, RM37, RM218, RM35 and RM520) linked to moisture stress (drought) (Fig. 12).

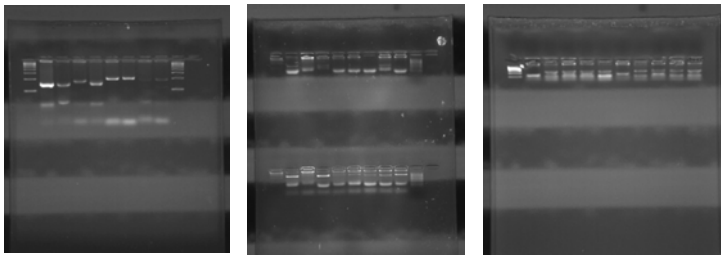


Fig. 12. Molecular profile of parents and F_3 breeding population for drought tolerance with SSR Markers (RM 14, RM 250, RM520 and RM 9)

Development of Mapping Population (RILs) for Submergence Stress Tolerance in Rice Grown in Rainfed Lowland Ecosystem

The mapping population derived from diverse parents IR64 and FR13A, comprising of 217 F4 recombinant inbred lines (RILs) were evaluated under submergence stress environment during *kharif* 2013 alongwith parents. Stress was imposed on vegetative stage (25 days old seedling) for two weeks (Fig. 13). Agro-morphological and physiological characters *viz.,* Days to 50% flowering (DFF), panicle number, tiller number, plant height, total biomass, test weight and grain yield were recorded. The mapping population significantly differed for all the traits studied. The days to 50% flowering ranged from 88 to 119 days whereas, plant height ranged from 108 to 156 cm, tiller number 9 to 18 per hill and grain yield 7.35 to 11.69 kg/m^2 among breeding populations (Table 8). The screening of mapping population showed that 138 recombinant inbred lines were found tolerant to submergence for 10 days. Further confirmation of submergence tolerance was based on the use of polymorphic SSR markers (RM 553, RM 5515, RM 257, RM 410, RM 552, RM 222, RM 5349, RM 28755 and RM 216) linked to different submergence related characteristics (Fig. 14).

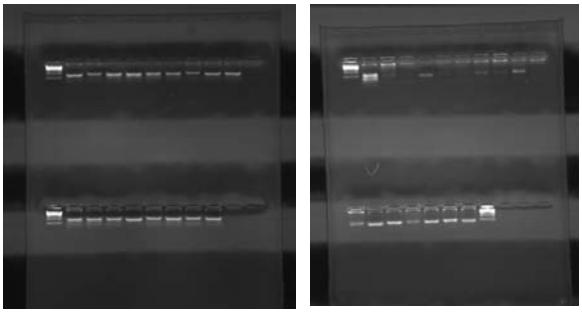


Fig. 14. Molecular profile of parents and F_3 breeding population for submergence tolerance with SSR Markers (RM410, RM 553 and RM 5515)

Table 8. Range in different agro-morphological traits among F_4 materials generated for submergence and drought tolerance in rice

Traits	F_4 mapping population (Submergence)		F_4 mapping population (Drought)	
	Mean	Range	Mean	Range
DFF (Days to 50% flowering)	94.6	88-119	86.3	76-97
Plant height (cm)	119.9	108-156	98.6	87-125
Panicle length (cm)	27.3	23-30.5	25.6	22-32
Tiller no/ plant	13.0	9-18	11.3	8-17
Biomass (g)/ plant	134.7	109-216	97.4	83-123
Grain yield (g)/ m^2	994.0	735-1169	733.0	564-1092
Leaf area (cm^2)	877.0	562-1681	648.0	492-1366
Test weight (g)	21.69	20.6-22.5	21.3	18.7-23.8
Total grain/panicle	146.4	132-184	138.7	94-212
Grain sterility (%)	26.40	14.3-44.2	11.49	3.48-21.78
Survival %	63.0	32-87	—	—

Varietal evaluation of wheat and lentil under different tillage practices

To see the effect of establishment methods of rice on the performance of *rabi* crop, five wheat and lentil varieties were evaluated during *rabi* season. In rainfed system, un-puddled rice field produced higher wheat and lentil yield (3.25 and 1.44 t/ha, respetively to wheat and lentil) over puddled rice field (3.13 & 1.39 t/ha accordingly to wheat and lentil) (Table 9). In puddled transplanted rice field,

Fig. 13. F_4 breeding population under water stress (submergence) field condition

Table 9. Effect of tillage practices on grain yield (t/ha) of wheat and lentil varieties under rice based cropping system

Wheat varieties	Puddled transplanted field		Un-puddled transplanted field	
	CT	ZT	CT	ZT
PBW 343	3.13	2.98	3.15	3.14
HD 2733	3.06	3.38	3.20	3.39
HD 2824	2.94	3.14	3.19	3.48
HI 1563	3.31	3.01	3.31	3.30
PBW 373	3.24	3.10	3.20	3.19
Mean	3.14	3.12	3.21	3.30
Lentil varieties				
Arun	1.19	1.11	1.18	1.26
PL 406	1.46	1.34	1.48	1.48
Mallika	1.52	1.47	1.51	1.51
Pusa Vaibhav	1.53	1.45	1.52	1.53
Shivalik	1.47	1.36	1.47	1.53
Mean	1.43	1.35	1.41	1.46

CT= Conventional tillage, ZT= Zero tillage

conventional tillage gave higher wheat (3.14 t/ha) and lentil (1.43 t/ha) yield over zero tillage (3.12 and 1.35 t/ha, respetively, to wheat and lentil). Performance of wheat variety HI-1563 (3.39 t/ha) was found best under conventional tillage, whereas HD-2733 (3.37 t/ha) performed better under zero tillage environment. Performance of lentil variety Pusa Vaibhav (1.53 t/ha) was found best under conventional tillage, whereas Mallika and Pusa Vaibhav performed equally good (1.49 t/ha for both the varieties) under zero tillage.

WHEAT

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

Thirty advanced breeding lines of wheat comprising of timely sown and late sown genotypes were evaluated under rainfed ecosystem (Fig. 15). The recommended farming practices like seed rate, fertilizers, irrigation etc. were adopted. Yield and yielding attributes of different genotypes were regularly monitored and recorded (Table 10). Wheat genotypes *viz.*, NW5054, RAJ 4250, HD3076, HD3118 and HD3117 were identified promising as compared to check varieties HD 2733, HI 1563, K307, PBW 343 & PBW 373.

Fig. 15. Screening of wheat genotypes under rainfed condition

Table 10. Yield and yielding attributes of promising wheat genotypes

Genotypes	Code	EVV	DFF (days)	Height (cm)	Test weight (g)	Grain yield (t/ha)
Improved						
PBW661	NE-TS-10	1	81	103	48.4	4.91
HD3076	NE-TS-11	3	82	110	49.33	5.11
NW5054	NE-TS-12	1	91	115	46.0	5.42
WH1137	NE-TS-15	1	84	99	44.5	4.86
RAJ 4250	NE-LS-05	3	70	91	39.7	5.36
HD3118	NE-LS-09	1	71	99	39.3	5.09
HD3117	NE-LS-12	1	76	102	34.5	5.06
PBW 688	NE-LS-14	3	69	99	39.1	4.87
Check						
HD2733	NE-TS-01	3	91	97	45.21	4.41
HI1563	NE-LS-04	3	68	98	36.7	4.36
PBW 343	PBW 343	3	85	99	42.53	4.34
PBW 373	PBW 373	5	77	93	37.18	3.87
K307	NE-TS-07	3	90	101	43.2	4.47
DBW 39	NE-TS-08	5	89	92	41.7	4.26
DBW 14	NE-LS-08	5	67	89	34.7	4.05

EVV = Early Vegetative Vigour; DFF = Days of 50% flowering

Effect of irrigation frequency at varying soil depth on productivity of wheat in Bihar plains

Scheduling irrigation of wheat based on soil water tension can help in increasing irrigation water productivity through avoiding water deficit stress and excess irrigation. However, there are no rigorously determined guidelines on what depth to place the tensiometers, nor the optimum irrigation threshold. Therefore, a series of experiments was conducted to evaluate the effects of irrigation threshold and measurement depth on wheat yield, irrigation water use and water productivity.

Maximum irrigation water was applied in plots where the tensiometer was set at 20 kPa. However,

as the depth of tensiometer increased beyond 20 cm, required amount of irrigation water decreased. This may be due to presence of more moisture in lower strata of soil (35-50 cm) as compared to above layer. From Table 11 and 12 it may be inferred that crop receiving 22.5 and 26.67 cm water produced significantly higher grain yield (4.10, 4.0 and 3.90 t/ha) over other irrigation treatments. The treatment p_1d_1 where 35.6 cm irrigation water was applied, resulted into lower yield (2.82 t/ha). Similarly in case of deficit irrigation (less than 22.5 cm) the yield showed a decreasing trend.

Table 11. Wheat grain yield (t/ha) as affected by irrigation applied at different depth and pressure of tensiometer

Pressure (P)	Depth of tensiometer (D)			
	d_1 (20 cm)	d_2 (35 cm)	d_3 (50 cm)	Mean
p_1 (20 kPa)	2.82	4.0	3.90	3.57
p_2 (35 kPa)	4.10	3.35	2.92	3.46
p_3 (50 kPa)	3.15	2.82	2.60	2.86
Mean	3.36	3.39	3.14	

C.D (P=0.05) for D : 0.23, C.D (P=0.05) for P : 0.23, C.D (P=0.05) for PXD : 0.40

Table 12. Applied irrigation water (cm) as affected by depth and pressure of tensiometer

Pressure	Depth of tensiometer			
	d_1 (20 cm)	d_2 (35 cm)	d_3 (50 cm)	Mean
p_1 (20 kPa)	35.60	26.67	22.50	28.26
p_2 (35 kPa)	22.50	15.00	11.67	16.39
p_3 (50 kPa)	12.50	10.83	8.87	10.73
Mean	23.53	17.50	14.35	

Irrigation water productivity increased with increase in the depth and pressure of tensiometer. The highest WPI (1.809 kg/m^3) was achieved under deficit irrigation (8.87 cm) with least grain yield (2.6 t/ha). The lowest WPI (0.686 kg/m^3), was obtained with the application of highest irrigation amount (35.6 cm) producing 2.82 t/ha grain yield. The highest grain yield (4.1 t/ha) was, however, obtained with a water productivity of 1.464 kg/m^3 (Table 13).

Table 13. Irrigation water productivity (kg/m^3)

Pressure	Depth of tensiometer			
	d_1 (20 cm)	d_2 (35 cm)	d_3 (50 cm)	Mean
p_1 (20 kPa)	0.686	1.243	1.393	1.107
p_2 (35 kPa)	1.464	1.634	1.701	1.600
p_3 (50 kPa)	1.750	1.727	1.809	1.762
Mean	1.300	1.535	1.634	

C.D (P = 0.05) for D : 0.24, C.D (P = 0.05) for P : 0.24, C.D (P = 0.05) for PXD : 0.41

6. Pulses

Crop Diversification with Faba bean to Improve Land and Water Productivity

A field experiment was conducted in randomized block design (RBD) replicated thrice 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 evaluated under rainfed (I_1) and irrigated (I_2) condition especially during *rabi* season.

Rabi (2012-13)

Sole cropping of faba bean during *rabi* season showed seed yield of 3.85 to 4.01 t/ha in irrigated situation whereas under rainfed condition, it varied from 1.47 to 1.81 t/ha (Fig. 16). Performance of faba bean under intercropping system ranged between 1.31 and 2.01 t/ha in irrigated condition, whereas, under rainfed condition, it varied between 0.91 and 1.12 t/ha (Table 14).

Faba bean as a sole cropping

Faba bean+Maize intercropping

Faba bean + Lentil intercropping

Faba bean + Potato intercropping

Fig. 16. Faba bean and other intercrops crops in *rabi* 2012 under faba bean based crop diversification

Table 14. Faba bean performances under different cropping system

Cropping system	Faba bean seed yield (t/ha)	
	Irrigated	Rainfed
Sole cropping		
Rice–faba bean–ladies finger (CS_1)	3.85	1.47
Rice–faba bean–green gram (CS_2)	4.01	1.81
Intercropping		
Rice–faba bean+potato-cowpea (CS_3)	1.71	1.04
Rice–faba bean+maize (cob)–green gram (CS_4)	1.31	0.91
Rice–faba bean+lentil–green gram (CS_5)	2.01	1.12

Potato had maximum yield as intercrop with faba bean. Lentil, however, exhibited minimum yeild under irrigated and rainfed condition (Table 15).

Table 15. Performances of intercrops during *rabi* season under faba bean based cropping system

Cropping system	Name of intercrop	Inter crop yield (t/ha)	
		Irrigated	Rainfed
Rice–faba bean+potato–cowpea (GP)(CS_3)	Potato	22.7	12.3
Rice–faba bean+maize (cob)–green gram (CS_4)	Maize	61.3	28.1
Rice–faba bean+lentil–green gram(CS_5)	Lentil	1.05	0.57

Summer

During summer season, all the crops were raised with assured irrigation. Third crop in cycle were ladyfinger and cowpea for vegetable purpose and green gram for dry seed consumption (Fig. 18). As intercrop, cowpea produced higher yield (7.61 t/ha) followed by lady finger (7.24 t/ha). In case of green gram, seed yield ranged between 1.61 in the plots of rice–faba bean + lentil– green gram (CS_5) to 1.74 t/ha, under rice–faba bean–green gram (CS_2) cropping systems, respectively (Table 16).

Table 16. Performances summer crops under faba bean based cropping system

Cropping system	Intercrops	Yield (t/ha)
Rice–faba bean–ladies finger (CS_1)	Ladies finger	7.24
Rice–faba bean–green gram (CS_2)	Green gram	1.74
Rice–faba bean+potato–cowpea (GP) (CS_3)	Cowpea (GP)	7.61
Rice–faba bean+maize (cob)–green gram (CS_4)	Green gram	1.65
Rice–faba bean+lentil– green gram (CS_5)	Green gram	1.61

GP = green pod

Ladies finger under CS_1 cropping system

Ladies finger at flowering stage

Cowpea under CS_3 cropping system

Green gram under CS_2 cropping system

Fig. 17. Ladies finger, green gram and cowpea in summer 2013 in faba bean based crop diversification

Rice performance under cropping system

Medium duration rice (cv. Rajendra Sweta) was taken during *kharif* 2013 under irrigated conditions. Maximum (126.4cm) plant height of rice was recorded with the cropping system (CS_5) in which rice-faba bean+lentil-green gram (GF) were taken. Similarly LAI ranged between 5.69 to 5.93 (Table 17). Number of panicle per m^2 and grains/ panicle ranged between 271.4 to 283.4 and 192.2 to 201.6, respectively.

Table 17. Rice growth and development, yield attributes and yields during 2013

Cropping System	Plant height (cm)	Water productivity (kg/m^3)	Harvest Index (%)	Grain (t/ha)
Rice–faba bean–ladies finger (CS_1)	123.3	2.16	0.41	6.25
Rice–faba bean– green gram (CS_2)	125.4	2.14	0.42	6.45
Rice–faba bean+potato–cowpea (GP) (CS_3)	125.2	2.14	0.42	6.41
Rice–faba bean+maize (cob)–green gram (CS_4)	124.3	2.15	0.41	6.41
Rice–faba bean+lentil–green gram(CS_5)	126.4	2.17	0.42	6.68
CD (P=0.05)	NS	NS	NS	NS

Grain yield ranged from 6.25 to 6.68 t/ha. Maximum paddy production was recorded in rice–faba bean+lentil-green gram (CS_5). Irrigation water productivity ranged between 2.14 to 2.17 kg/m^3 (Fig. 18).

Fig. 18. Rice crop in *kharif* 2013 under faba bean based crop diversification

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

Seven accessions of faba bean germplasm were deposited to National Gene Bank NBPGR, New Delhi along-with proper National Identification Numbers, i.e., Indigenous Collection Numbers.

Pusa Sumit, a national check took maximum number of days (9.5) to attain 50% germination. Germination per cent of all the tested genotype ranged in between 80 to 85. Maximum plant height (84.5 cm) was recorded in genotype VFBP201302 and minimum (72.3 cm) in case of Pusa Sumeet. Days to first flowering, i.e., anthesis also varied according to the length of lifecycle of genotype. Minimum duration (51.7 days) was taken by genotype VFBP201304 attain flowering. The check variety took 11 more days to mature than the developed line VFBP201304 (Table 18).

Table 18. Growth of developed vegetable type faba bean lines

Promising lines	Days to 50% germination	Germination (%)	Pant height (cm)	Days to anthesis	Days to maturity
VFBP201302	9.0	80	84.5	53.5	94.5
VFBP201304	8.5	85	74.5	51.7	87.5
VFBP201306	8.5	85	77.9	53.5	95.5
*Pusa Sumeet	9.5	80	72.3	57.2	98.5
LSD (P= ± 0.05)	0.50	NS	3.5	2.1	4.6

*National check

Yield attributing character, pod yield and seed yield were recorded for all the three developed lines as well as for check variety (Table 19). Numbers of pods were minimum (98.4) in Pusa Sumeet to maximum (127.5) in developed line VFBP201306. However, pod lengths varied in between 6.14 to 6.52

cm (Table 19). Minimum time taken (days to first pod picking) ranged from 63.5 for developed line VFBP201302 to 69.5 in case of Pusa Sumeet. Numbers of seed per pods varied narrowly in between 5.1 to 5.6. Green pod yield (t/ha) ranged in between 18.92 (Pusa Sumeet) to 23.54 (VFBP201302). All the developed lines yielded higher and found superior to Pusa Sumeet (check variety). Similar trend was also observed in case of grain yield and it ranged in between 29.7 to 36.9. However, 100 seed weight did not vary significantly.

Table 19. Yield attribution of developed vegetable type faba bean lines

Name of line /variety	Pods / plant	Green pod yield (t/ha)	First pod picking (days)	Grain yield (t/ha)
VFBP201302	112.7	23.54	63.5	3.69
VFBP201304	123.4	21.51	65.5	3.57
VFBP201306	127.5	22.64	66.5	3.61
*Pusa Sumeet	98.4	18.92	69.5	2.97
LSD (P< 0.05)	4.21	1.19	2.3	0.25

*National check

In vitro Evaluation of *Trichoderma* Isolates against Wilt Complex Pathogen of Lentil

Fusarium oxysporum f. sp. *lentis* (non volatile effect)

Thirty isolates of *Trichoderma* spp. (referred herein as T_1-T_{30}). The data were recorded at 2, 6 and 12 days after incubation (Table 20 & Fig. 19). At the end of 12 days of incubation, out of ten *T. harzianum* isolates tested, seven (T_{10}, T_{17}, T_{18}, T_{20}, T_{22}, T_{23} and T_{25}) were found to provide 100% inhibition, whereas isolate T_1 has moderate inhibitory effect

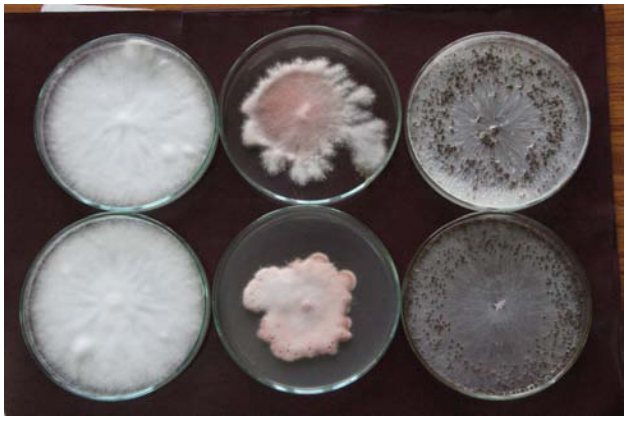


Fig. 19. Culture features of pathogen on PDA 1. *Fusarium oxysporum* f. sp. lentis (Nos. 1, 2, 3, 4 plates in different locations of wilted lentil plants) and Nos. 5 & 6 initially rotted plants due to *Sclerotium rolfsii*

Table 20. Effect of different *Trichoderma* spp. isolates on radial growth of *Fusarium oxysporum* f.sp. *lentis*

Isolate	Per cent inhibition			
	Days after inoculation (DAI)			
	2	6	12	Overall
	Mean	Mean	Mean	Mean ± SD
T. harzianum	20.37 abcde	45.21 bcd	62.67 d	62.96 ± 2.56
T. harzianum	6.48 defgh	28.77 ghij	13.33 ghi	40.74 ± 21.02
T. viride	15.74 bcdef	30.14 fghij	6.67 jkl	40.30 ± 25.48
T. viride	13.89 cdef	35.62 defgh	1.78 m	39.56 ± 28.45
T. viride	9.26 cdefg	26.71 hij	-12.00 n	32.30 ± 33.58
T. viride	1.85 efgh	21.23 jk	8.89 ijk	37.19 ± 21.73
T. hamatum	0.00 fgh	26.71 hij	0.89 m	36.15 ± 26.49
T. viride	10.19 cdefg	35.62 defgh	5.33 klm	40.15 ± 26.14
T. viride	16.67 abcdef	33.56 efghi	1.33 m	39.41 ± 28.65
T. harzianum	27.78 abc	45.21 bcd	100.00 a	76.59 ± 17.68
T. viride	16.67 abcdef	28.77 ghij	5.33 klm	39.70 ± 25.94
T. hamatum	12.96 cdef	36.99 defgh	3.56 lm	40.30 ± 28.14
T. viride	21.30 abcd	46.58 bcd	100.00 a	75.85 ± 18.34
T. reesei	16.67 abcdef	42.47 bcde	35.11 e	52.59 ± 13.63
T. viride	0.00 fgh	28.77 ghij	9.78 hijk	38.52 ± 21.97
T. hamatum	22.22 abcd	38.36 cdefg	10.67 hij	44.44 ± 25.43
T. harzianum	-11.11 hi	15.07 k	100.00 a	66.22 ± 25.79
T. harzianum	35.19 a	100.00 a	100.00 a	89.63 ± 16.02
T. reesei	14.81 cdef	23.29 ijk	15.56 g	41.63 ± 19.96
T. harzianum	22.22 abcd	41.10 bcdef	100.00 a	74.81 ± 18.97
T. harzianum	11.11 cdefg	46.58 bcd	79.56 b	67.41 ± 10.29
T. harzianum	34.26 ab	52.05 b	100.00 a	79.11 ± 15.69
T. harzianum	-1.85 fghi	28.08 ghij	100.00 a	68.15 ± 25.30
T. reesei	9.26 cdefg	31.51 efghij	71.11 c	61.04 ± 9.09
T. harzianum	-7.41 ghi	49.32 bc	100.00 a	74.22 ± 20.35
T. viride	12.96 cdef	41.10 bcdef	100.00 a	73.33 ± 20.13
T. piluliferum	5.56 defgh	15.07 k	13.78 gh	37.78 ± 19.52
T. viride	6.48 defgh	23.29 ijk	23.11 f	43.41 ± 15.78
T. viride	-20.37 i	28.77 ghij	16.89 g	41.33 ± 18.68
T. virens	16.67 abcdef	38.36 cdefg	17.78 g	45.93 ± 21.20
CD at 5%	18.77	11.63	4.52	

Means followed by the same letter are not significantly ($p < 0.05$) different.

(62.67% inhibition). In all these cases there was 100% inhibition by *T. harzianum*, the antagonist also grew over the pathogen's mycelium causing lysis. Microscopic examination indicated that the mycelium of the *F. oxysporum* f. sp. *lentis* was partially or completely degraded by *T. harzianum*. T_{10}, T_{18}, T_{22} and T_{23} isolates completely degraded the pathogen. Trend of inhibition observed at 2 and 6 days after inoculation was similar to the one observed after 12 days of incubation.

Out of the twelve *T. viride* isolates tested, only two isolates *viz.*, T_{13} and T_{26} showed 100% inhibition of the pathogen. Microscopic examination revealed that there was partial to complete mycelium degradation of the pathogen by the antagonists.

Fusarium oxysporum f. sp. *lentis* (Volatile effect)

Out of the ten *Trichoderma harzianum* isolates, T_{20} showed high per cent of inhibition whereas T_1, T_2, T_{10}, T_{18}, T_{22} and T_{23} isolates showed less or moderate inhibition. Isolates T_{17}, T_{21} and T_{25} showed only a slight inhibitory effect. In case of *T. viride*, T_3, T_{13} and T_{28} isolates showed moderate inhibition of the pathogen and isolates T_{26} showed least effect on growth of the pathogen (Table 21).

Out of three *T. hamatum* isolates, two *viz.*, T_{12} and T_{16} had less effect and T_7 had negative growth inhibition of the pathogen, thereby suggesting that this isolate of *Trichoderma* promoted the growth of pathogen. Out of three isolates of *T. reesei*, two isolates, T_{14} and T_{24} had moderate effect and T_{19} had the least effect on growth of the pathogen. *T. virens* had less inhibitory effect.

Table 21. Effect of volatile metabolites of different *Trichoderma* spp. isolates on radial growth of *Fusarium oxysporum* f. sp. *lentis*

Isolate	Percent inhibition			
	Days after inoculation (DAI)			
	2	6	12	Overall
	Mean	Mean	Mean	Mean ± SD
T. harzianum	25.69 bcd	35.95 abc	41.70 abcd	34.45 ± 16.83
T. harzianum	4.59 fghij	28.10 bcdefg	33.63 bcde	22.11 ± 21.53
T. viride	16.51 bcdefgh	28.10 bcdefg	50.67 abc	31.76 ± 16.55
T. viride	-0.92 ij	24.18 bcdefgh	27.80 bcde	17.02 ± 21.17
T. viride	6.42 fghij	12.42 cdefghij	35.43 bcde	18.09 ± 13.71
T. viride	13.76 bcdefghi	16.99 cdefghij	20.18 cdef	16.98 ± 19.04
T. hamatum	8.26 efghij	-3.92 hij	-31.84 hij	-9.17 ± 18.11
T. viride	12.84 cdefghi	4.58 defghij	29.60 bcde	15.67 ± 11.67
T. viride	1.83 ghij	16.34 cdefghij	37.67 bcde	18.61 ± 18.82
T. harzianum	17.43 bcdefgh	16.99 cdefghij	45.29 abcd	26.57 ± 14.21
T. viride	18.35 k	8.50 ij	15.70 fghi	14.18 ± 9.30
T. hamatum	6.42 ijk	13.07 j	7.85 j	25.78 ± 35.21
T. viride	16.51 bcdefgh	33.99 abcd	58.74 ab	36.42 ± 18.83
T. reesei	30.28 ab	29.41 bcdef	50.67 abc	36.79 ± 24.75
T. viride	19.27 bcdef	24.18 bcdefgh	14.80 cdefg	19.42 ± 7.55
T. hamatum	18.35 bcdefg	13.07 cdefghij	9.42 defg	13.61 ± 9.75
T. harzianum	8.26 efghij	0.65 fghij	3.59 efgh	3.73 ± 13.21
T. harzianum	28.44 abc	9.80 cdefghij	37.22 bcde	25.15 ± 15.18
T. reesei	26.61 bcd	1.96 efghij	3.04 hij	0.49 ± 30.75
T. harzianum	44.95 a	62.09 a	77.58 a	61.54 ± 14.98
T. harzianum	11.01 defghi	9.80 j	4.53 j	11.11 ± 25.28
T. harzianum	24.77 bcde	20.92 bcdefghi	61.43 ab	35.71 ± 36.54
T. harzianum	26.61 bcd	14.38 cdefghij	42.60 abcd	27.86 ± 30.42
T. reesei	17.43 bcdefgh	28.76 bcdefg	56.95 ab	34.38 ± 19.20
T. harzianum	17.43 bcdefgh	2.61 efghij	2.69 efgh	7.58 ± 11.99
T. viride	18.35 bcdefg	1.96 efghij	9.28 ghi	0.34 ± 18.68
T. piluliferum	0.92 hij	1.31 ghij	5.70 ghi	5.36 ± 13.33
T. viride	19.27 bcdef	47.71 ab	62.33 ab	43.10 ± 19.02
T. viride	17.43 bcdefgh	21.57 bcdefghi	40.36 bcd	26.45 ± 21.65
T. virens	15.60 bcdefghi	30.07 bcde	19.28 cdef	21.65 ± 33.10
CD at 5%	16.75	30.20	36.26	

Means followed by the same letter are not significantly ($p < 0.05$) different

Sclerotium rolfsii (Non volatile)

In this case, four isolates of *T. harzianum* (T_{21}, T_{22}, T_{23} and T_{25}) were found to provide 100% inhibition of the pathogen, whereas other isolates of *T. harzianum* were less effective. In case of *T. viride*, only one isolate (T26) controlled 100% growth of the pathogen. *T. hamatum* and *T. reesei* had less or no effect on the growth of the pathogen. *T. virens* (T_3) was found 100% effective against the pathogen (Table 22).

Table 22. Effect of different *Trichoderma* spp. isolates on radial growth of *Sclerotium rolfsii*.

Isolate	Per cent inhibition			
	Days after inoculation (DAI)			
	2	6	12	Overall
	Mean	Mean	Mean	Mean ± SD
T. harzianum	-13.04 ijklm	28.13 efgh	27.92 c	14.33 ± 20.61
T. harzianum	-4.71 fghi	23.96 jk	18.13 def	12.46 ± 13.17
T. viride	-7.61 ghijk	26.04 hij	21.25 d	13.23 ± 15.81
T. viride	-15.58 lm	25.21 ijk	21.88 d	10.50 ± 19.92
T. viride	-10.14 ijklm	22.92 k	19.79 de	10.85 ± 15.91
T. viride	-2.90 efgh	24.38 jk	21.88 d	14.45 ± 13.22
T. hamatum	-12.32 ijklm	24.38 jk	20.00 d	10.69 ± 17.40
T. viride	-1.45 efg	27.29 fghi	21.88 d	15.91 ± 13.38
T. viride	-9.13 hijkl	26.88 ghi	21.25 d	13.00 ± 16.88
T. harzianum	12.32 bc	31.88 abc	31.67 bc	25.29 ± 9.83
T. viride	-4.35 fghi	16.88 l	15.83 efg	9.45 ± 11.82
T. hamatum	2.54 de	23.33 k	0.00 h	8.62 ± 11.32
T. viride	-9.06 hijkl	28.96 defg	28.54 c	16.15 ± 19.05
T. reesei	-5.07 fghi	0.00 q	0.00 h	-1.69 ± 3.27
T. viride	-14.13 klm	0.00 q	0.00 h	-4.71 ± 7.33
T. hamatum	-8.70 hijk	12.71 no	12.08 g	5.37 ± 10.75
T. harzianum	0.72 def	5.83 p	31.25 bc	12.60 ± 14.57
T. harzianum	-3.99 efghi	32.08 ab	34.17 b	20.75 ± 18.66
T. reesei	14.13 b	16.25 lm	20.83 d	17.07 ± 3.05
T. harzianum	21.01 a	30.83 bcd	35.21 b	29.02 ± 6.66
T. harzianum	17.03 ab	34.17 a	100.00 a	50.40 ± 37.95
T. harzianum	-16.30 m	29.58 cdef	100.00 a	37.76 ± 51.30
T. harzianum	7.25 cd	33.33 a	100.00 a	46.86 ± 41.43
T. reesei	-7.61 ghijk	18.33 l	28.13 c	12.95 ± 16.06
T. harzianum	-8.70 hijk	11.46 o	100.00 a	34.25 ± 50.16
T. viride	0.00 ef	0.00 q	100.00 a	33.33 ± 50.00
T. piluliferum	-7.25 ghij	30.00 bcde	0.00 h	7.58 ± 17.19
T. viride	-7.25 ghij	0.00 q	0.00 h	-2.42 ± 3.83
T. viride	-3.99 efghi	13.96 mn	15.21 fg	8.39 ± 9.34
T. virens	12.68 bc	29.58 cdef	100.00 a	47.42 ± 40.12
CD at 5%	17.06	2.32	4.07	

Means followed by the same letter are not significantly ($p < 0.05$) different

Sclerotium rolfsii (Volatile effect)

Only T_{18} isolate of *T. harzianum* was found to provide 89.02% inhibition of the pathogen (Fig. 20). Isolate T20 of *T. harzianum* showed 35.29% inhibition of the pathogen; rest of the *T. harzianum* had no effect. In case of *T. viride*, the volatiles from isolates T_{11} and T_{26} restricted the growth by 17.65 and 50.59%. Isolate *T. virens* (T_{30}) was found to provide only 11.76% inhibition of the pathogen (Table 23; Fig. 21 & 22).

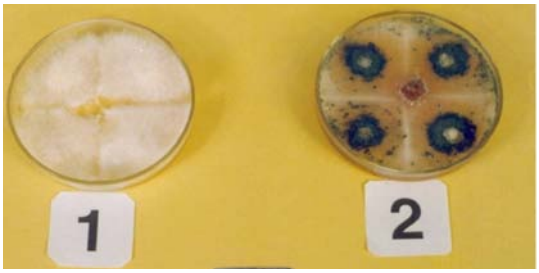
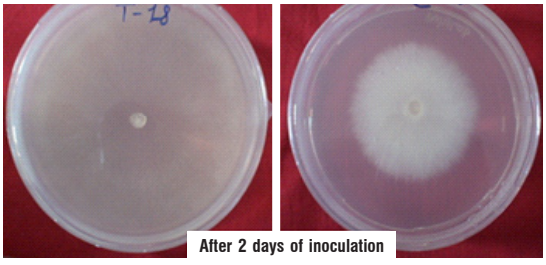


Fig. 20. Antagonist effect of *Trichoderma* spp. against *Fusarium oxysporum* f. sp. *lentis* 1. Control 2. Growth inhibition and complete hyperparasitism with lysis of the mycelium of *F. oxysporum* f. sp. *lentis* by the antagonist (*T. harzianum* isolate T_{18})



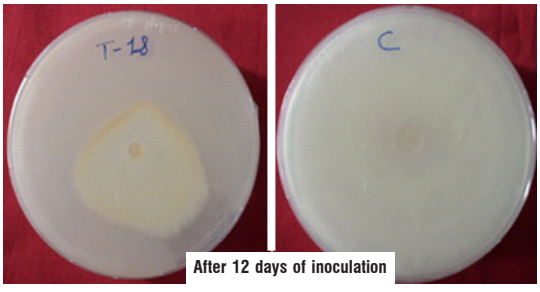


Fig. 21. Effect of volatiles of isolate T_{18} against S. rolfsii after 2 days (zero growth of pathogen) and 12 days of inoculation (mycelium degraded due to volatile effect of antagonist

Table 23. Effect of volatile metabolites of different *Trichoderma* spp. isolates on radial growth of *Sclerotium rolfsii*

Isolate	Per cent inhibition			
	Days after inoculation (DAI)			
	2	6	12	Overall
	Mean	Mean	Mean	Mean ± SD
T. harzianum	40.16 ^{c}	20.78 ^{cde}	0.00 ^{e}	20.31 ± 17.52
T. harzianum	31.10 ^{cde}	18.24 ^{cdef}	0.00 ^{e}	16.45 ± 16.01
T. viride	-4.33 ^{jklm}	0.20 ^{f}	0.00 ^{e}	-1.38 ± 4.07
T. viride	-5.12 ^{klm}	2.75 ^{ef}	0.00 ^{e}	-0.79 ± 6.72
T. viride	17.72 ^{efgh}	8.24 ^{def}	0.00 ^{e}	8.65 ± 10.05
T. viride	-4.72 ^{klm}	1.57 ^{f}	0.00 ^{e}	-1.05 ± 5.84
T. hamatum	13.39 ^{efghij}	31.57 ^{c}	0.00 ^{e}	14.98 ± 19.60
T. viride	-2.76 ^{ijklm}	0.00 ^{f}	0.00 ^{e}	-0.92 ± 2.54
T. viride	7.87 ^{ghijkl}	7.65 ^{def}	0.00 ^{e}	5.17 ± 5.10
T. harzianum	12.60 ^{fghijk}	10.98 ^{def}	0.00 ^{e}	7.86 ± 6.97
T. viride	5.91 ^{ghijkl}	18.04 ^{cdef}	17.65 ^{d}	13.86 ± 24.40
T. hamatum	-4.72 ^{klm}	1.76 ^{ef}	0.00 ^{e}	-0.99 ± 3.28
T. viride	5.51 ^{ghijkl}	8.43 ^{def}	0.00 ^{e}	4.65 ± 6.47
T. reesei	37.01 ^{cd}	16.08 ^{cdef}	0.00 ^{e}	17.70 ± 18.50
T. viride	-4.33 ^{jklm}	0.00 ^{f}	0.00 ^{e}	-1.44 ± 3.22
T. hamatum	-15.35 ^{m}	-0.59 ^{f}	0.00 ^{e}	-5.31 ± 8.12
T. harzianum	6.69 ^{ghijkl}	2.16 ^{ef}	0.00 ^{e}	2.95 ± 6.72
T. harzianum	84.25 ^{a}	100.00 ^{a}	89.02 ^{a}	91.09 ± 7.42
T. reesei	43.31 ^{bc}	26.08 ^{cd}	0.00 ^{e}	23.13 ± 24.95
T. harzianum	60.63 ^{b}	72.75 ^{b}	35.29 ^{c}	56.22 ± 26.71
T. harzianum	19.29 ^{defg}	11.76 ^{def}	0.00 ^{e}	10.35 ± 8.91
T. harzianum	0.39 ^{hijklm}	0.00 ^{f}	0.00 ^{e}	0.13 ± 5.16
T. harzianum	11.81 ^{fghijk}	12.94 ^{cdef}	0.00 ^{e}	8.25 ± 6.57
T. reesei	-6.69 ^{lm}	1.96 ^{ef}	0.00 ^{e}	-1.58 ± 5.18
T. harzianum	18.90 ^{efg}	1.96 ^{ef}	0.00 ^{e}	6.95 ± 9.53
T. viride	44.88 ^{bc}	31.76 ^{c}	50.59 ^{b}	42.41 ± 14.08
T. piluliferum	-3.94 ^{jklm}	3.53 ^{ef}	0.00 ^{e}	-0.14 ± 7.56
T. viride	27.17 ^{cdef}	8.43 ^{def}	0.00 ^{e}	11.87 ± 12.28
T. viride	14.17 ^{efghi}	0.00 ^{f}	0.00 ^{e}	4.72 ± 9.32
T. virens	15.35 ^{efgh}	15.29 ^{cdef}	11.76 ^{d}	14.14 ± 5.49
CD at 5%	17.88	19.08	9.13	

Means followed by the same letter are not significantly ($p < 0.05$) different.

Mass production protocol of bioagents

On the basis of *in-vitro* study, best effective biaoagent (*Trichoderma* spp.) used for large scale production protocol were developed on different

Fig. 22. Degeneration of the formed sclerotia in *T. harzianum* isolate T_{18} and sclerotial parasitization in *T. viride* isolate T_{20}

substrates *viz*., rice husk, sorghum grain, bajra grains, pigeonpea husk, wheat grains, cow dung. Wheat grain based bioagent was found highly sporulation after 12 days incubation (37.50 x 10^9 spores/g) (Fig 23 a & b). Sporulation reached the peak in most of the substrates after 14 days of incubation; rice husk with either pigeon pea husk or sorghum grains was found effective with the sporulation ranging from 150.83 and 177.50 x 10^9 spores/g. Wheat grains formulation were prepared and distributed for FLD in farmers' field.

Fig. 23. (a) Mass production of *Trichoderma* spp. on wheat grain based formulation

(b) Ready formulation for use

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

Rice green horned caterpillar infested with nucleoprotein virus (Fig. 24) (collected in October, 2013) and entomo pathogenic fungus (*Nomuraea rileyi*) on cabbage and chickpea (in January 2014, Fig. 25) were collected for development of biopesticide formulation. It has controlled grain pod border in chickpea upto 89% (Table 24). Biopesticide formulations were also distributed to 15 farmers of Patna district for conducting FLD on chickpea.

Table 24. Collection of naturally dead larvae of *H. armigera* on different crops

Location and Crop	Name of microbial	No. of samples	Month
Nalanda District (Vegetables)	*Nomuraea rileyi*	38	August
ICAR RCER farm Patna (Rice)	*Beauveria bassiana*	5	October
Patna District (Vegetables/chickpea)	*Nomuraea rileyi*	67	January
ICAR RCER farm Patna (Rice)	*NPV on infested with rice green horned caterpillar*	45	October

Fig. 24. Rice green horned catterpillar infested with NPV in rice field

Fig. 25 . Collection of *Nomuraea rileyi* infested larvae of Helicoverpa on different crops and talc based formulation of *Nomuraea rileyi*

The efficacy of various biopesticides is presented in (Table 25). The data revealed that all the treatments were found significantly superior over control. The results showed that formulation of *Nomuraea rileyi* (1.5%) and Bt. (1.0%) followed by NPV(1.0%) were found effective. Among all the treatments, significantly lowest yield (1.89 t/ha) was recorded from untreated control plots (Table 32). Hence, the laboratory prepared formulation of *Nomuraea rileyi* (1.5%) containing (2.7X10^{10} CFU/g), Bt (1.0%) and NPV(1.0%) containing (1.5x10^{12} POBs/ml) was the best tool in managing pod borer in chickpea considering efficacy, profitability and environment friendly in nature.

Table 25. Efficacy of biopesticides against *Helicoverpa armigera* in chickpea

Treatment (percent)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index
Bb- 0.1	2.10	5.39	0.28
Bb-0.25	2.22	4.44	0.33
Bb-0.5	2.22	4.31	0.34
Bb-1.0	2.42	4.67	0.36
Bb-1.5	2.29	4.63	0.33
Ma-0.1	1.96	4.71	0.30
Ma-0.25	1.82	4.76	0.28
Ma-0.5	2.07	4.73	0.30
Ma-1.0	2.17	5.14	0.30
Ma-1.5	1.83	4.78	0.28
Nr- 0.1	2.57	4.04	0.39
Nr-0.25	2.64	5.28	0.33
Nr-0.5	2.49	5.01	0.33
Nr-1.0	2.26	4.68	0.33
Nr-1.5	2.92	5.64	0.34
Bt- 0.1	2.28	4.17	0.35
Bt-0.25	2.05	5.31	0.28
Bt-0.5	2.13	4.54	0.32
Bt-1.0	2.83	4.83	0.37
Bt-1.5	2.26	4.40	0.35
NPV-0.1	1.93	4.18	0.32
NPV-0.25	2.15	4.51	0.32
NPV-0.5	1.81	5.83	0.24
NPV1.0	2.28	5.22	0.30
NPV-1.5	2.22	5.03	0.31
Control	1.89	4.50	0.30

Nuclear polyhedrosis virus (NPV)**, *Beauveria bassiana* **(Bb)**, *Metarrhizium anisopliae* **(Ma)**, *Nomuraea rileyi* **(Nr)**, *Bacillus thuringiensis* **(Bt)

7. Fruits

Mango

Plant genetic resource management

Under the trial on collection, evaluation and characterization of mango genotypes, 118 mango genotypes were evaluated for fruit quality and yield. The average fruit weight ranged between 83.07 g (Illaichi) and to 805.50 g (Sahabale) and a total of 69 numbers of genotypes had fruit weight varying from 200 to 500 g. The average pulp content ranged between 45.23% (Khirospatti) and 85.73% (Fazali) and a total of 37 genotypes had more than 70% pulp content. The TSS varied between 11.56°B (Mahmood-al-Samar) to 24.30°B (Chausa) and a total of 44 number of genotypes had TSS value of more than 18°B. The TSS: acidity ratio ranged between 10.24 (Khirospatti) and 391.93 (Hathijhool) and the genotypes, Jardalu, Gulab Khas, Gaurjeet, Dashehari, Lucknow Safeda, Sarikhas, Indonesia, Mulgoa Hill, Neeluddin, Goa Bandar, Hathi Jhool, Nileshwari and Black Andrew had TSS: acidity value of more than 200. The fruit yield ranged between 2.1 kg/tree (Indonesia) to 87.4 kg/tree (Jardalu) and 18 genotypes of more than 20 years age had yield of more than 45 kg/tree. Hence keeping in view fruit quality (fruit weight > 200g, pulp content > 70%, TSS > 18°B and TSS: acidity > 200) and yield (> 45 kg/tree in case of 20 years or more tree age), the genotypes Jardalu, Lucknow Safeda, Goa Bundar, Neeleswari were found promising.

Under the trial on performance evaluation of mango hybrids, 26 numbers of mango hybrids released from different parts of the country were evaluated for fruit quality and yield. The hybrids, Alfajli, Jawahar, Sundar Langra, Neelphanso, Arka Aruna, Arka Neelkiran, Neeleshan, Manjeera and Neelgoa were found promising for fruit weight (> 250 g). The hybrids, Alfazli, Jawahar, Sundar Langra, Neelphanso, Arka Aruna, Sabri, P.K.M.-1, Ratna, Neeleshan, Neeluddin, Amrapali, Manjeera, Neelgoa, Sindhu were found promising for pulp content (> 70%). With respect to TSS, the hybrids, Alfazli, Nileshwari, Arka Puneet, Sindhu, Mahmood Bahar, Ratna, Neeluddin, Amrapali and Arka Anmol were found promising (> 19°B). The hybrids, Arka Puneet, Neeluddin, Amrapali, Manjeera and Neelgoa were also found promising for high TSS: acidity ratio (> 200). The hybrids, Amrapali, Jawahar, Neeluddin, Ratna, Mulgoa were found high yielder (> 20 kg/plant in 13 year old plants). Hence, keeping in view the fruit quality and yield, the hybrids, Manjeera (Fig. 26), Mulgoa and Neeluddin were found promising.

Fig. 26. Mango hybrid Manjeera found promising for fruit quality and yield

Under the trial on performance evaluation of 20 commercial varieties from different parts of the country, Himsagar was found to be most promising with respect to fruit yield and quality (fruit wt. > 250g, pulp content > 70%, TSS > 19°B and yield > 80 kg/plant of age 33 years). The other high yielding varieties include Zardalu, Totapari, Bombay Green, Vanraj, Mankurad and Mallika.

Standardization of interstock for induction of dwarfing in vigorous mango cultivars growing under eastern plateau and hill conditions

The trial was 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 like Langra, Himsagar and Bombay Green. Plant growth parameters of three years old mango plants with and without

interstock planted in the field were recorded. During third year after planting, significant effect of the interstocks was recorded on plant height, girth of rootstock including scion. The plant height in all the genotypes without interstocks were significantly higher than that recorded in case of plants with interstocks. With respect to percentage increase in plant height over the previous year, mango genotype Latra as interstock resulted in significantly higher values (29.44%) whereas the mango genotype Amrapali as interstock resulted in significantly lower values (5.76%) than that recorded in case of plants without interstock (18.48%). The higher values recorded in case of Latra can be attributed to lower initial plant growth parameters due to delayed establishment of the *in situ* grafted plants with Latra as interstock. Among all the genotypes, the minimum increase in plant height on Amrapali interstock was recorded in case of Himsagar (4.08%). Similarly, significant influence of interstock was recorded on girth of rootstck in all the genotypes and the plants with interstock had significantly lower girth than that without interstock.

With respect to percentage increase in girth over the previous year, the minimum value was recorded in case of Amrapali as interstock (26.76%) as compared to 52.97% recorded in case of plants without interstock. Among all the genotypes, the maximum increase in girth of rootstock was recorded in Langra (58.94%) whereas the other two genotypes were at par. With respect to girth of scion, similar patttern was recorded as in case of girth of rootstock. Panicle emergence recorded after three years of planting in both single grafted as well as double grafted plants (Amrapali as interstock).

Under the trial on "Standardization of rapid plant multiplication technique for production of mango grafts with interstocks", efficacy of two methods *viz*., 1. Simultaneous grafting and 2. Step-wise grafting were evaluated for rapid multiplication of double grafted mango plants. Step-wise grafting resulted in significantly higher success rate (82.95%) than simultaneous grafting (14.85%). In case of stepwise grafting, significant effects of interstock could not be recorded on success rate. However, in case of simultaneous grafting, significantly higher success rate was recorded with Latra as interstock (21.01%) than that of Amrapali (8.69%) and among the mango genotypes, the maximum success rate was recorded in case of Langra (17.41%). (Fig. 27).

Fig. 27. Success rate under different methods of preparation of double grafted plants

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 eco-friendly and economically viable litchi stink bug (LSB) management modules through understanding the seasonal incidence and biology of the bugs. Observation on seasonal incidence indicated that bugs activation from dormancy, feeding potentiality and egg lying capacity was significantly positively correlated with temperature. Bugs were found to congregate at the time of initiation of flowering in panicles. Observations on feeding preference of bugs indicated that the adult and nymphs preferred to feed on flower panicles followed by younger and softer shoots. Maximum population of nymphs was recorded from 12th to 18th Standard Meteorological Week (SMW) on flowering panicles and on stalk of young fruits. The maximum egg laid was found in the month of March to mid April. Fresh laid egg batches were found up to last week of June but very few in numbers. Maximum number of 1.20 ± 0.08 egg batch/twig was recorded in the 15th SMW of year (Fig. 28).

A study was also conducted on parasitization of natural enemies and effect of pesticides on rate of parasitization. All the species of parasitoids (*Anastatus bangalorensis*, *A. acherontiae* and *Ooencyrtus* spp.) were observed in eggs collected from both unsprayed as well as insecticide applied litchi orchard. However, the emergence rate was low in insecticide applied litchi orchard. Eclosion of nymphs and emergence of *A. bengalorensis* started from third week of February in both years. Maximum parasitized eggs were found in the month of

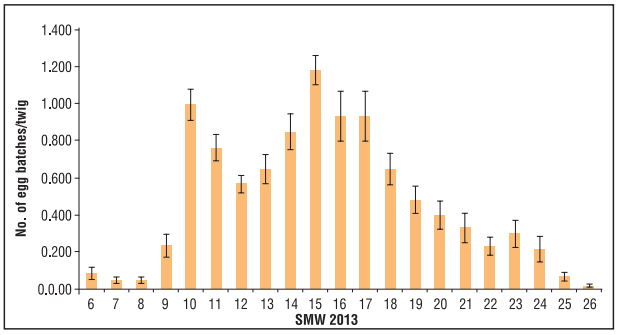


Fig. 28. Seasonality of egg batches of *T. javanica* per twig (± S.D.) on litchi plants

March with 46.12% parasitization in insecticide-free orchard. The maximum rate of egg parasitization was observed in case of *A. bengalorensis*. The emergence time of *Ooencyrtus* spp. was very late than *A. bengalorensis* and *A. acherontiae*. Data on hatching per cent revealed that egg parasitoids have significant influence on reduction of the hatch percentage of LSB eggs in insecticide free orchard (Fig. 29).

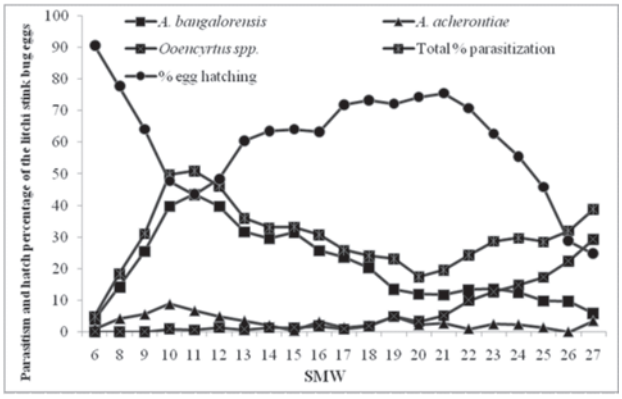


Fig. 29. Egg parasitism and hatch percentage of *T. javanica* eggs in unsprayed litchi orchard

The experimental data showed that *A. banglorensis* and *A. acherontiae* were found to parasitize LSB eggs in early season, however, parasitization by all the parasitoids were found decreased at the time of maximum laid eggs in the season by LSB in the insecticide applied orchard.

Study was conducted to characterize the parasitized eggs for enhancing the parasitization rate. It was found that parasitized eggs could be easily identified based on their colour, shape and size of emergence holes (Fig. 30 (a-c).

Survey and surveillance of pest complex and their natural enemies on litchi

Survey of pest complex in litchi indicated that litchi fruit-borer (or litchi stem end borers), *Conopomorpha sinensis* (Lepidoptera: Gracillariidae) was

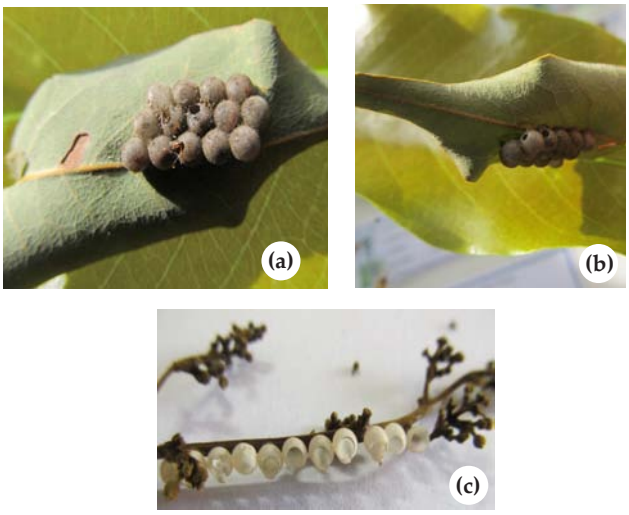


Fig. 30. (a) Parasitization of LSB eggs by *A. bangalorensis* (Size of emergence hole was 0.97±0.06 mm)
(b) Parasitization of LSB eggs by *A. acherontiae* (Size of emergence hole was 0.64±0.07mm)
(c) Unparsitized LSB eggs (size of emergence hole was 1.67±0.11mm)

one of the major insect pests in the eastern plateau and hill region. The larvae bore into developing fruit through the stem and then feed on the seed inside the fruit. The rate of infestation was 26.19 ± 3.67 per cent. Flower Webbers were recorded as another major pest at flowering stage with 1 to 2 webs per flower panicle (Fig. 31).

Fig. 31. Flower web of litchi formed by Dudua aprobola

Developing national repository & creating facilities for DUS testing in litchi (*Litchi chinensis*)

Out of the 34 characters identified for DUS characterization of litchi, characters like young leaf colour, leaflet blade shape, leaf margin curvature, length of paracladia, time of opening of male flower,

flower disc colour of hermaphrodite flowers, fruit shape, time of fruit maturity and seed shape were recorded to be consistent for distinguishing the litchi genotypes. Based on the distinct descriptor states, the example varieties of litchi have also been identified.

Based on the characters identified at both centres, the document on "Guidelines for the conduct of test for distinctiveness, uniformity and stability of litchi (*Litchi Chinensis* Sonn.)" have been finalized (Table 26).

Table 26. Example varieties for distinct states of characteristics for DUS testing of litchi

Characteristics	States	Example variety
Young leaf: Colour	Light green	Sarguja Selection 2
	Reddish green	Rose scented
	Reddish brown	Nafarpal
Leaf shape index (length of leaflet:width of leaflet) (Second middle pair of leaves)	Low (<3.5)	China
	Medium (3.5-3.7)	Green
	High (>3.7)	Late Large
Leaflet margin curvature	Curve upward from midrib	Shahi
	Curve downward from midrib	China
Flower disc colour of hermaphrodite flower	Light cream	Ajhauli
	Pinkish	Green
Inflorescence: Length of paracladia	Short	Swarna Roopa
	Medium	China
	Long	Late Large
Fruit: Fruit maturity group	Early	Shahi
	Mid-maturity	Kasba
	Late maturity	China
Fruit: Fruit shape	Round	Bedana
	Oblong	Shahi
	Conical	China
	Wedge	Shahi
	Obtuse	Bedana
Fruit: Seed shape	Round	Late large
	Oval	Shahi
	Oblong	Purbi
	Elongated	China
	Chicken tongue	Bedana

Fig. 32. Cream coloured flower disc in hermaphrodite flower of Ajhauli

Fig. 33. Pink coloured flower disc in hermaphrodite flower of Green

Bael

Plant genetic resource management

The trial is being conducted to identify suitable genotype of bael for cultivation under eastern plateau and hill conditions. A total of 37 genotypes including 33 seedling selections were evaluated for fruit quality and yield. The average fruit weight ranged between 0.47 (ICAR-RCER BS 6/4) to 2.05 kg (Pant Sujata) and 12 number of genotypes had fruit weight between 1.00 to 1.50 kg (medium sized). The skull content ranged between 14.70 (Godda Collection) to 33.27% (ICAR RCER BS 3/2) and a total of 16 number of genotypes had low skull content (< 20%). The number of seeds per fruit ranged between 49 (ICAR RCER BS 10/4) to 208 (ICAR RCER BS 6/5) while the seed content ranged between 1.51 (Godda Collection) to 7.64% (ICAR RCER BS 2/5). A total of 13 genotypes had low seed content in fruit (< 3.0%). The pulp content in fruit ranged between 63.44 (ICAR RCER BS 3/2) to 83.77% (Godda Collection) and a total of seven genotypes had high pulp content (> 80.0%). The TSS of fruits ranged between 10.4 °B (ICAR RCER BS 6/11) to 24.7°B (ICAR RCER BS 1/1) and a total of nine genotypes had high TSS (> 20°B). The fruit yield per plant ranged between 23.48 kg/tree (ICAR RCER BS 2/7) to 168.4 kg (Pant Aparna) and eight genotypes were recorded as high yielders (> 100.0 kg/tree). Hence, keeping in view the fruit quality and yield, the genotype ICAR RCER BS 4/3 was found promising (average fruit weight–1.12 kg, skull content–15.59%, seed content–3.50%, TSS–20 .6°B and yield–108.4 kg/tree) (Fig. 34).

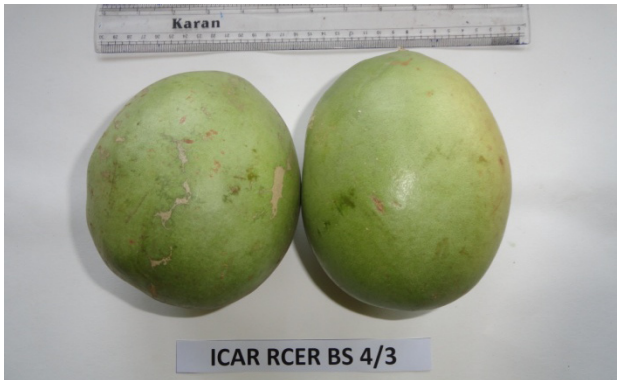


Fig. 34. Bael genotype ICAR RCER BS 4/3

Survey and surveillance of pest complex and their natural enemies on bael

From the survey of insect pest complex in bael, it was found that infestation of the fruit borer, *Cryptophlebia (Argyroploca)* spp. on bael fruits paved way for entry of fruit flies. Nearly 20-30% fruits were infested with fruit borer in surveyed areas (Fig. 35).

Fig. 35. Infested fruit of bael due to fruit borers

Jackfruit

Plant genetic resource management

Under the trial on collection and conservation of germplasm, a field survey was conducted in Tripura to collect superior genotypes of jackfruit. A total of 32 promising genotypes were identified which comprised of nine pink fleshed genotypes, eight Baramasi type genotypes. Cluster bearing was recorded to be a predominant character among the genotypes contributing towards high yield of jackfruit under Tripura conditions (Fig. 36). The genotypes have been collected and conserved in the Field Gene Bank of the institute.

Under the trial on evaluation of germplasm, 32 genotypes conserved in the field gene bank of the institute were evaluated for fruit characters of fully matured fruits. The average fruit weight ranged between 4.12 kg (ICAR RCER JS-1/10) to 13.85 kg (ICAR RCER JS-5/4). The average pulp content in the fruit was 44.61% and the genotypes ICAR RCER JS- 3/9, 3/8, ½, 1/7, 2/10, 1/7 were found promising for high pulp content. Jackfruit seed is a delicacy in the tribal cuisine as a vegetable. Among the genotypes evaluated, the average seed content was 8.70% and the genotypes, ICAR RCER JS-3/9, 3/8, 1/7, 2/10, 1/7, 5/2 and 6/1 had higher seed content than the other genotypes. The average TSS was 18.22°B and the genotypes ICAR RCER JS-2/10, 1/5, 1/7, ¾, 1/6, 2/1 and 5/4 had higher TSS than other genotypes. The rind and core of ripe jackfruit are also used as animal feed. The average rind content was 46.03% and the genotypes ICAR RCER JS-1/9, 1/5, 2/4, 4/6, 6/1 and 5/4 had higher content of rind. The average content of core was 5.66% and the genotypes ICAR RCER JS-3/9, 3/8, 1/2, 1/9, 1/7 and 5/2 had higher content than other genotypes. Hence, based on overall performance, the jackfruit genotype ICAR RCER JS-2/7 was found to be most promising for fruit quality (Medium sized and cylindrical shaped fruit having > 70% pulp content, TSS > 20°B and fibreless flakes with pleasant flavour).

Fig. 36. Cluster bearing jackfruit genotype in Tripura

Survey and surveillance of pest complex and their natural enemies on Jackfruit

Only *Rhizopus* rot disease of Jackfruit caused by *Rhizopus artocarpi* was found as the major biotic stress factor. The incidence of disease intensity was recorded as 34 ± 2.01 per cent on mature fruits.

8. Vegetables

Brinjal

Variety identified for release

The line HABR-21 was identified for release in Zone-IV (Bihar, Jharkhand, Uttar Pradesh, Punjab) in 31st group meeting of AICRP(VC) held at CSKHPKV, Palampur (HP) from 2nd-5th May 2013.

Fig. 37. Brinjal line HABR-21

Table 27. Premium attributes of brinjal line HABR-21

Fruit length	18-20 cm
Fruit breadth	7-8 cm
No. of fruits/plant	10-12 fruits
Fruit weight	300-350 gm
Yield/plant	2.0-3.0 kg
Yield in t/ha	55-60 t/ha

Maintenance of genetic purity of released varieties/parental lines of F_1 hybrids

Maintanance of genetic purity of released varieties (Swarna Shyamli, Swarna Pratibha, Swarna Abhilamb, Swarna Sobha, Swarna Mani, Swarna Shree, HABR-21), parental lines of hybrids (Swarna Ajay, Swarna Shakti, Swarna Mohit, Swarna Neelima) was done through nucleus seed production.

Tomato

F_1 hybrid released

The tomato F_1 hybrid Swarna Anmol, developed by heterosis breeding, was released through Institute Variety Release Committee for protected cultivation in Jharkhand, Bihar and adjoining areas where bacterial wilt is a problem.

Its fruits are round, red, with light green shoulder and borne in clusters of 5-6. Fruit weight 60-70g, TSS 4.5-5.0° brix, acidity 0.30-0.35% and ascorbic acid 40-42 mg/100 g fruit. It is indeterminate in growth habit (5.0-5.5 m), high yielding (160-180 t/ha), resistant to bacterial wilt and can be cultivated round the year. It recorded 110% increase in yield over the check, GS-600 (Fig. 38 and Table 28). An average yield of 159.5 t/ha was recorded in farmers' field under continuous evaluation for three years 2009-2012 (Table 29).

Fig. 38. Swarna Anmol

Table 28. Yield (t/ha) performance of Swarna Anmol (HATH-10) at the experimental farm of the institute

Name of hybrids	2008-09	2009-10	2010-11	2011-12	2012-13	Average
Swarna Anmol (HATH-10)	151.6	187.8	177.2	163.5	182.5	172.5
GS-600 (Check)	95.0	60.8	82.5	92.0	79.5	81.9

Table 29. Performance of Swarna Anmol (HATH-10) at farmers' field during 2009-12

Name & address of Institution/NGOs/farmers	Year	Yield HATH-10 (t/ha)
KGVK, Rukka, Ranchi	2009-12	157.5
A three Agrotech Piska Nagari, Ranchi	2009-12	168.5
Dinesh Mahto, Berwari Angra, Ranchi	2009-12	149.5
Balak Mahto Kuchhu, Ormanjhi ,Ranchi	2010 -12	162.5
Average yield	2009-12	159.5

Maintenance of genetic purity of released varieties (Swarna Lalima, Swarna Naveen), parental lines of hybrids (Swarna Sampada, Swarna Samridhi, Swarna Baibhav, Swarna Vijaya, Swarna Deepti and Swarna Anmol) was done through nucleus seed production.

Genetic enhancement of tomato for nematode and bacterial wilt resistance through molecular markers

Twenty genotypes *viz.*, Swarna Lalima (Highly resistant to BW), HADT-294, HADT-295, HADT-296, HADT-297 (BWR, ABL, Keeping quality low), HAT-300, HAT-302, HAT-305, HAT-306, HAT-308 (BWR), HAT-310, (BWR & NR), HAT-311 (BWS & NR), HAT-312 (BWR & AVRDC collections), HAT-20 (Cherry tomato), Roma (processing), EC-596741 (Resistant to BW, TMV, F_1), EC-596742 (Resistant to BW, TMV, F_1, F_2 & best for processing) EC-596743 (Resistant to BW, TMV, F_1, Sm) EC-596747 (Resistant to TMV, F_1 & AVRDC collections) and Pusa Ruby (most popular, BWS) were collected and screened for bacterial wilt resistance and nematode tolerance in artificial inoculation conditions.

The tomato lines EC-596747, HAT-296, HAT-305 and variety Swarna Lalima were resistant for bacterial wilt. HAT-310 and HAT-311 were found resistant to root knot nematode.

Fig. 39. Screening for nematode resistance

Fig. 40. Nematode resistant tomato line HAT-311

Fig. 41. Nematode susceptible tomato line HADT-296

Chilli

Variety released

The chilli variety, Swarna Praphulya, developed through pureline selection from local germplasm, was released through Institute Variety Release Committee for cultivation in Jharkhand, Bihar and adjoining areas where bacterial wilt is a serious problem.

Plant is vigorous with 90-100 cm plant height and resistant to bacterial wilt under natural field conditions. Fruits are long (6.0-6.5 cm), pungent, dark green and dark red when ripe. It showed its superiority with 34% increase in yield (20-25 t/ha) over the check KA-2 (Table 30).

Table 30. Yield (t/ha) performance of Swarna Praphulya (HC-50) at the experimental farm of the institute

Name of variety	2008-09	2009-10	2010-11	2011-12	2012-13	Average
Swarna Praphulya (HC-50)	23.07	19.52	17.20	23.53	20.20	20.70
KA-2 (Check)	13.50	15.55	17.50	16.25	14.53	15.47

An average yield of 22.59 t/ha was recorded in farmers' field.

Fig. 42 (a). Swarna Praphulya (b) Swarna Praphulya at farmers' field

Evaluation of advance breeding lines (F_8)

Four advance breeding lines were evaluated with Check variety KA-2 (Table 31). Highest yield was recorded in HC-62 X HC-34-2-1-1 (23.48 t/ha, upright fruiting) followed by HC-62 X HC-34-1-4-1(22.50 t/ha, normal fruiting).

Table 31. Evaluation of Chillies advance breeding lines (F_8)

Name of Cross	Yield (t/ha)	Yield / plant (kg)	No. of fruits / Plant	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
HC-51 X HC-62-1-2-6	20.58	1.10	475.25	2.55	5.86	0.80
HC-62 X HC-34-1-4-1	22.50	1.14	460.75	2.55	5.76	2.94
HC-8 X HC-34-2-2-16	17.65	1.80	567.00	1.95	4.94	2.57
HC-62 X HC-34-2 -1-1	23.48	1.16	576.5	2.35	5.16	2.84
KA-2	18.25	1.00	657.00	2.5	4.48	3.12

Maintenance of genetic purity of released/pre-released varieties (Swarna Praphulya, HC-68, HC-25) was done through nucleus seed production

Capsicum

Variety released

The capsicum variety, Swarna Atulya was released through Institute Variety Release Committee for cultivation in Jharkhand, Bihar and adjoining areas.

It was developed through pureline selection from EC-596749 collected from World Vegetable Centre, Taiwan through NBPGR. Plant is vigorous with 45-50 cm plant height, early flowering and fruiting and suitable for kharif and rabi cultivation. It showed its superiority with 63% increase in yield (40-45 t/ha) over local check (California Wonder). It is tolerant to powdery mildew. Fruits (90-100 g) are almost round (4.5-5.0 cm length, 5.5-6.0 cm breadth), green and yellow in colour at maturity (Table 32). An average yield of 43.46 t/ha was recorded.

Fig. 43. Capsicum variety Swarna Atulya

Fig. 44. Swarna Atulya at farmers' field

Table 32. Yield (t/ha) performance of Swarna Atulya (HACAV-271) at the experimental farm of the institute

Name of variety	2008-09	2009-10	2010-11	2011-12	2012-13	Average
Swarna Atulya (HACAV-271)	45.50	42.50	43.50	45.50	43.50	44.10
Local (check)	25.00	27.50	30.00	25.50	27.50	27.10

Maintenance of genetic purity of released/pre-released varieties (Swarna Atulya, HACAV-845), was done through nucleus seed production.

Bottle Gourd

Variety released

The bottle gourd variety, Swarna Sneha was released through Institute Variety Release Committee for cultivation in Jharkhand, Bihar and adjoining areas.

Fig. 45. Bottle gourd variety Swarna Sneha

It was developed through pureline selection from IC 284939, collected from NBPGR, New Delhi. Plant is vigorous with 4-5 m vine length early flowering and fruiting and suitable for rainy season crop. It showed its superiority with 40% increase in yield (50-55 t/ha) over local check (Arka Bahar) (Table 33). It is tolerant to powdery mildew and downy mildew. Fruits are long (30-35 cm length), light green and fruit weight 90-100 g. An average yield of 53.93 t/ha was recorded in farmers' field.

Table 33. Yield (t/ha) performance of Swarna Sneha (HABOG-6) at the experimental farm of the institute

Name of variety	2008-09	2009-10	2010-11	2011-12	2012-13	Average
Swarna Sneha (HABOG-6)	55.00	54.50	55.50	52.50	50.00	53.50
Local (Check)	37.500	40.00	41.50	39.50	32.50	38.20

Maintenance of genetic purity of release/pre-released varieties Swarna Sneha and HABOG-16 was done through nucleus seed production.

Bitter Gourd

Variety released

The bitter gourd variety, Swarna Yamini was released through Institute Variety Release Committee for cultivation in Jharkhand, Bihar and adjoining areas.

It was developed through hybridization followed by pedigree selection. Plant is vigorous with 2.5-3.0 m vine length, early flowering and fruiting and suitable for rainy season crop. It showed its superiority with 49%

Fig. 46. Bitter gourd variety Swarna Yamini

increase in yield (20 t/ha) over local check (Arka Harit). It is tolerant to powdery mildew and downy mildew (Table 34). Fruits (65-70 g) are dark green with deep tubercles. An average yield of 19.39 t/ha was recorded in farmers' field under continuous evaluation for five years 2008-13.

Table 34. Yield (t/ha) performance of Swarna Yamini (HABG-30) at the experimental farm of the institute

Name of variety	2008-09	2009-10	2010-11	2011-12	2012-13	Average
Swarna Yamini (HABG-30)	19.50	19.90	20.50	21.00	20.00	20.18
Local (check)	12.50	13.00	15.00	13.80	13.50	13.56

Maintenance of genetic purity of release/ pre -released varieties Swarna Yamini, HABG-21, HABG-22 and HABG-29 was also carried out through nucleus seed production.

Ridge Gourd

Variety released

The *Satputia* variety Swarna Sawani was released through Institute Variety Release Committee for cultivation in Jharkhand and Bihar and adjoining areas.

It was developed through pureline selection from local collection. Plant is vigorous with 3-4 m vine length early flowering and fruiting and suitable for rainy season crop. It showed superiority with 42% increase in yield (20-25 t/ha) over local check. It is tolerant to powdery mildew and downy mildew (Table 35). Fruits (35-45 g) are borne in clusters with 6-8 fruits per cluster. An average yield of 30.41 t/ha was recorded in farmers' field.

Fig. 47. Satputia variety Swarna Sawani

Table 35. Yield (t/ha) performance of Swarna Sawani (HASS-1) at the experimental farm of the institute

Name of variety	2008-09	2009-10	2010-11	2011-12	2012-13	Average
Swarna Sawani (HASS-1)	23.50	25.55	23.97	24.88	25.99	24.78
Local (check)	15.00	13.98	15.687	21.90	20.90	17.49

Maintenance of genetic purity of released /pre-released varieties Swarna Manjari, Swarna Uphar, Swarna Sawani, HARG-111 was done through nucleus seed production.

Pumpkin

Maintenance of genetic purity of released varieties

Maintenance of genetic purity of released varieties Swarna Amrit was done through nucleus seed production.

AICRP (VC) trial

Under AICRP, in varietal trial AVT-II (6+1) on pumpkin, highest yield was recorded in 2010/PUMVAR-1(14.973 t/ha) followed by 2010/ PUMVAR-3 (13.929 t/ha)

Cucumber

Maintenance of genetic purity of released varieties

Maintenance of genetic purity of Swarna Poorna, Swarna Sheetal, Swarna Ageti was done through nucleus seed production.

Under AICRP, in varietal trial AVT-1 on cucumber, highest yield was recorded in Pusa Sanyog (c) (17.07 t/ha), followed by 2011/CUCUVAR-2 (12.78 t/ha).

Sponge Gourd

Under AICRP, in varietal trial AVT-1 (8+1) on sponge gourd, highest yield was recorded in 2011/ SPGVAR-1(17.7 t/ha), followed by 2011/SPGVAR-3 (13.77 t/ha).

Long Melon

Under AICRP, in varietal trial 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 best check Punjab long melon (13.87 t/ha).

Ash gourd

Under AICRP, in varietal trial IET on ash gourd, highest yield was recorded in 2011/ASGVAR-3 (5.2 t/ha), followed by 2011/ASGVAR-6 (4.3 t/ha). These entries performed better than the best check Pusa Ujwal (13.8 t/ha).

Leafy Vegetables

Leaf Amaranth

Nucleus seeds of the identified stable and high yielding multi-cut type lines HAMTH-15 (red leaved; 1.45 kg) and HAMTH-13 (green leaved; 1.5 kg) along with 3 checks viz. Pusa Lal Chaulai (0.5 kg), Pusa Kiran (0.50 kg) and Pusa Kirti (0.51 kg) were produced for demonstration trials.

Grain Amaranth

Fig. 48. Grain Amaranth

Fourteen germplasm lines of grain amaranth species *viz.*, *Amaranthus cruentus* (5), *A. caudatus* (4) and *A. hypochondriacus* (5), received from NBPGR Regional Station, Phagli, Shimla, Himachal Pradesh, were evaluated during autumn-winter season and maintained through fresh seed multiplication. Among these lines, EC-150201 (*A. cruentus*; 3.39 t/ha), EC-150199 (*A. cruentus*; 3.21 t/ha) and IC-381062 (*A. caudatus*; 2.93 t/ha) were found promising in respect of grain yield.

Other Leafy Vegetables

The germplasm 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. Twenty six germplasm of drumstick are being maintained in the Field Gene Bank.

Underutilized bean

Lablab/dolichos bean

A total of 51 germplasm lines including 11 photo-insensitive lines were maintained through fresh seed multiplication. Out of 47 genotypes analyzed for nutritional qualities, EC-305789 was found very promising in respect of macro and micro nutrients (3.61 g/100 g), P (64 mg/100 g), K (305 mg/100 g), Ca (92 mg/100 g), Mg (90 mg/100 g), Na (127 mg/100 g), Fe (3.12 mg/100 g), Mn (1.12 mg/100 g), Cu (1.68 mg/100 g) and Zn (0.86 mg/100 g), respectively.

Fig. 49. Lablab bean (HADB-5)

Vegetable soybean

A total of 31 germplasm of vegetable soybean including 8 basmatic lines were maintained through fresh seed multiplication. Out of 7 basmatic vegetable soybean lines evaluated, the lines AGS-459 (11.64 t/ha), AGS-460 (11.38 t/ha), AGS-458 (10.67 t/ha) and AGS-456 (10.36 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 71 days after sowing, i.e., 8 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.

Fig. 50. Basmatic Vegetable Soyabean (AGS 459)

Fig. 51. Vegetable Soyabean variety Swarna Vasundhara

Under Multi-locational trial initiated by the Directorate of Soybean Research, Indore, five lines/varieties of vegetable soybean were evaluated at this Centre. Out of these, Swarna Vasundhara recorded the maximum graded green pod yield (17.07 t/ha) with 55.97% recovery of shelled green beans (grains).

Rice bean

Totally, two lines including one dull yellow seeded HARB-1 (30 kg) and another maroon seeded HARB-2 (6 kg) were maintained for use in rice-legume production system.

Yam bean

Out of the two germplasm, Rajendra Mishri Kand-1 (marketable tuber yield 19.4 t/ha) performed better than the line HAYB-1 (marketable tuber yield 13.5 t/ha).

Fig. 52. Yam bean (RMK-1)

Faba bean

The nucleus seeds of HAVFB-41, HAVFB-37 and Pusa Sumeet were produced for demonstration trials at farmers' fields. Pusa Sumeet contained the maximum amount of protein (3.90 g/100 g), P (178.67 mg/100 g), K (282 mg/100 g), Ca (35.41 mg/100 g), Mg (41.76 mg/100 g), S (39.67 mg/100 g) and Cu (1.16 mg/100 g). The high yielding line HAVFB-37 was also found promising for various nutrients (2.99 g/100 g), P (125.67 mg/100 g), K (217.33 mg/100 g), Mg (36.69 mg/100 g),), Mn (0.76 mg/100 g) and Cu (0.74 mg/100 g).

Fig. 53. Faba bean at farmers' field (Hahap, Namkum, Ranchi, Jharkhand)

Fig. 54. Faba bean at farmers' field (Hensla, Jhalda, Purulia, West Bengal)

Lime bean

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

Mung bean

Eight germplasm of mungbean received from AVRDC RCSA, Hyderabad were evaluated along with K-851 (check) in *kharif* season. The lines/varieties *viz.*, CN-9-5 (0.86 t/ha) and VC-3890 A (0.82 t/ha) performed better than the check K-851 (0.47 t/ha) in respect of dry grain yield.

Other beans

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

Vegetable pigeonpea

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

Fig. 55. Vegetable Pigeon Pea (HAVPP-1)

Horse gram

Twenty germplasm of horse gram, received from NBPGR Regional Station, Akola, were evaluated and maintained. The line IC-139518 (0.99 t/ha) performed the best.

Perennial cucurbits

Two germplasm of ivy gourd, one spindle shape fruited and another long fruited, are being maintained in the Field Gene Bank. Four germplasm lines of spine gourd including 2 female and 2 male lines are also being maintained in the Field Gene Bank.

Tuber crops and wild edibles

Collection, characterization and evaluation of potential wild edibles including tuber crops

In order to collect, characterize and evaluate wild edibles including tuber crops, survey were conducted in tribal dominated areas including forests of Jharkhand (10 districts; 15 blocks), Chhattisgarh (1 district; 2 blocks), Odisha (2 districts; 3 blocks) and West Bengal (4 districts; 6 blocks). The districts surveyed include Chatra, Latehar, Garhwa, Palamau, Jamtara, Dumka, Khunti, Lohardaga, West Singhbhum and Ranchi in Jharkhand, Uttar Bastar Kanker in Chhattisgarh, Bhubaneswar and Kalahandi in Odisha and Birbhum, Bankura, Purulia and West Midnapore in West Bengal. A total of 232 germplasm were collected and multiplied in the field for further characterization and evaluation. These include germplasm of *Dioscorea* spp. (62), *Ipomoea batatas* (10), *Maranta arundinacea* (1), *Colocasia* spp. (81), *Amorphophallus* spp. (48), *Alocasia* spp. (18), *Manihot* spp. (7) and *Cucumis melo* var *agrestis* (5).

Fig. 56. Germplasm of different tuber crops in experimental plot

Fig. 57. Wild Musk melon

Cowpea

Varietal evaluation

Under AICRP, two lines of bush type cowpea (HACP-44 and HACP-43) were evaluated. In Cowpea (Bush) AVT-I, the entries 2012/COPBVAR-5 (14.39 t/ha) and 2012/COPBVAR-1 (12.19 t/ha) performed better than the check variety Kashi Kanchan (11.20 t/ha).

In Cowpea (Bush) AVT-II, the entries 2011/COPBVAR-6 (12.94 t/ha) and 2011/COPBVAR-4 (11.89 t/ha) performed better than the check variety Kashi Kanchan (11.20 t/ha).

Garden pea

Development of powdery mildew resistant cultivars

To develop powdery mildew resistant early garden pea lines for testing under AICRP, two powdery mildew resistant and early maturing lines were derived from the cross of VRP-16 x IPS-1 and evaluated. The line (VRP-16 x IPS-1)-4-3 (13.48 t/ha) performed better than the line (VRP-16 x IPS-1)-3-4 (11.68 t/ha). In Peas, early AVT-I, 2012/PEVAR-5 (11.83 t/ha) and 2012/PEVAR-1 (11.10 t/ha) performed better than the check Azad Pea-3 (10.77 t/ha).

Similarly, in early AVT-II, 2011/PEVAR-9 (13.05 t/ha), 2011/PEVAR-7 (12.99 t/ha) and 2011/PEVAR-1 (12.44 t/ha) performed better than the best check Azad Pea-3 (10.77 t/ha).

Midseason AVT-I, 2012/PMVAR-4 (15.33 t/ha) and 2012/PMVAR-1 (13.38 t/ha) also performed better than the best check PC-531 (11.66 t/ha).

9. Mushroom

Mushroom Production

Six strains of paddy straw mushroom (*Volvariella volvacea*) *viz.*, Vv-13/01, Vv-13/02, Vv-13/03, Vv-13/04, Vv-13/05 and Vv-13/06 were evaluated in the month of September, 2013 (Fig. 58). The data revealed that the strain Vv-13/06 (1.17 kg/bed) and Vv-13/03 (1.16 kg/bed) showed maximum biological efficiency followed by Vv-13/05 (0.97 kg/bed) and Vv-13/02 (0.94 kg/bed) (Fig. 59a). Moreover, the maximum average number of fruiting bodies (207.3/bed) were observed in Vv-13/06 followed by Vv-13/02, Vv-13/03 and Vv-13/04 (Fig. 59b). However, highest weight of fruiting bodies were observed in Vv-13/01, followed by Vv-13/03 and Vv-13/06 (Fig. 59c).

Fig. 58. Fruiting bodies of the different strains of *Volvariella volvacea*

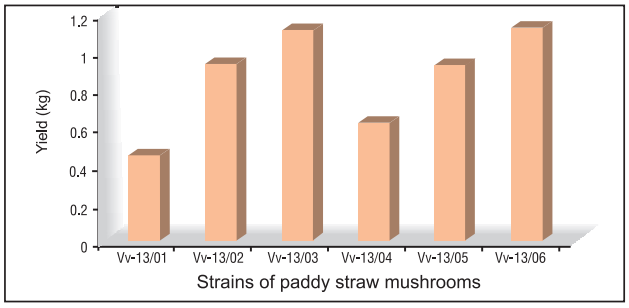


Fig. 59a. Strains of paddy straw mushroom

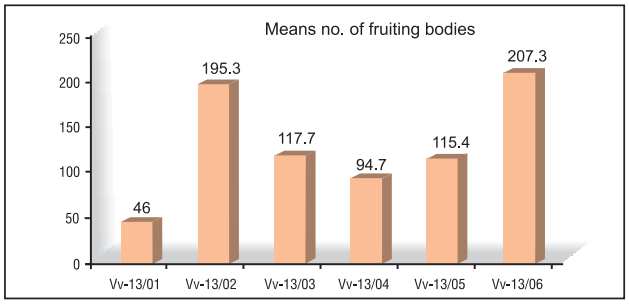


Fig. 59b. Mean number of fruiting bodies

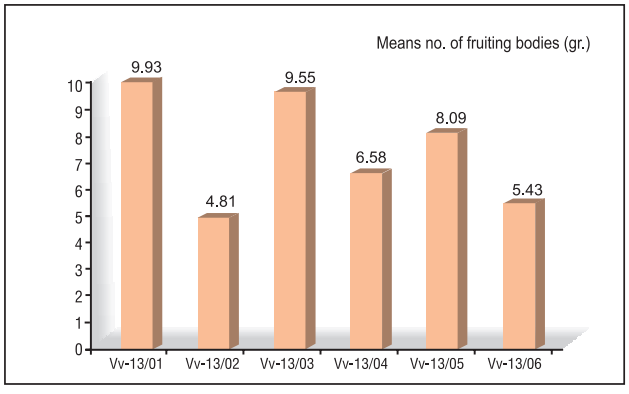


Fig. 59c. Mean weight. of fruiting bodies

Similarly, seven strains of oyster (PL-13/01, PL-13/02, PL-13/03, PL-13/04, PL-13/05, PL-13/06 and PL-13/07) were evaluated for their biological efficiency, number of sporophores and weight of sporophores (Fig. 60). Among various strains of Oyster, PL-13/02 showed highest biological efficiency (74%), followed by PL-13/06 (61.9%), PL-13/04 (64.1%). Moreover, highest number of sporophores per bag were observed in PL-13/02 (63.8), followed by PL-13/06 (59) and PL-13/04 (53.1). The maximum weight of sporophores were observed in PL-13/03 followed by PL-13/04, PL-13/05 and PL-13/07.

Spawn Production

Mushroom unit at Research Centre, Ranchi is a premier spawn production centre of the Jharkhand. Producing of mushroom spawn throughout the year. Maximum spawn production of oyster mushroom was in the month of July to January and wards after, milky and paddy straw mushroom spawns were produced. Maximum spawn sale was observed in the month of October (524.4 kg) followed by December, 2013 (513.6 kg) and January, 2014 (508 kg).

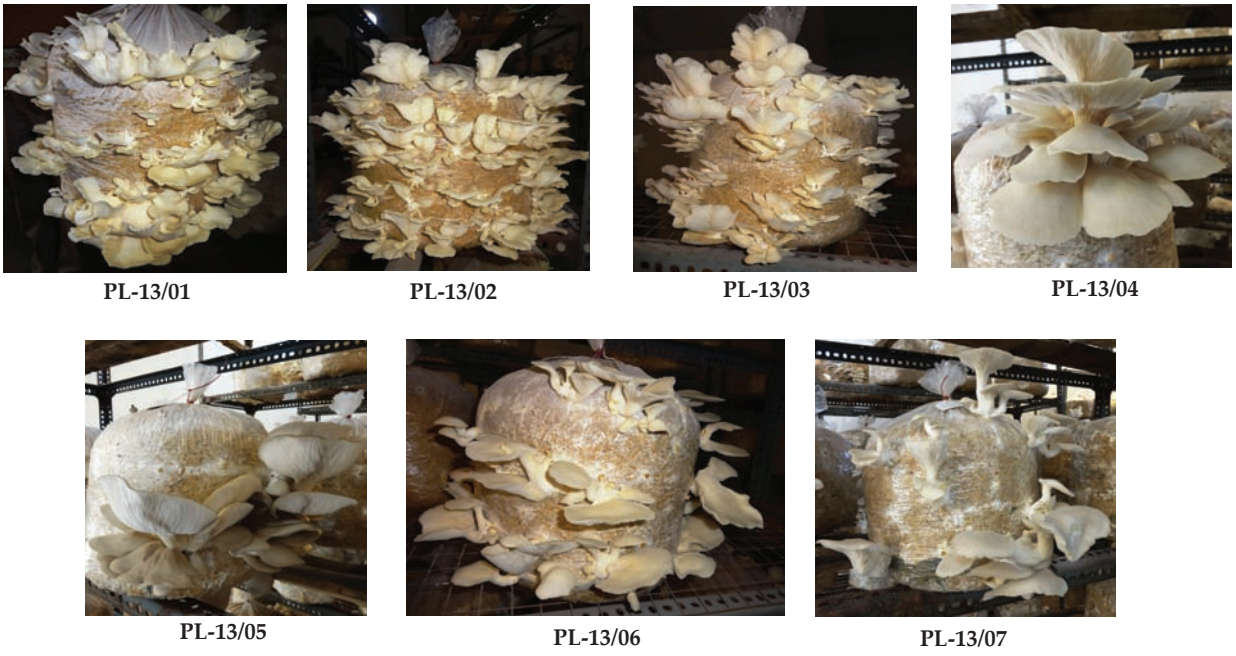


Fig. 60. Different strains of Oyster and their fruiting bodies

10. Makhana

Studies on Genetic Variation in Some Pure Lines of Makhana for Morphological and Yield Contributing Traits

An experiment was conducted on selecting 24 pure lines during the crop season of 2013. The material was transplanted in April 2013 in a well prepared shallow field at a spacing of 1.20 m x 1.25 m in the randomized block design with three replications.

Data on various traits were recorded (Table 36). The observations revealed that, out of 24 pure lines, five lines Sel-5, Sel-6, Sel-13, Sel-14 and Sel-24 were significantly different from others in some particular traits. Among these, the pure line Sel-5 was observed to have white flowers, which is contrary to the normal flowers of makhana. In makhana, purple is the characteristic colour of flowers.

The genotype Sel-6 was observed to have the highest yield potential (983.8 g/plant). The seeds of genotype Sel-13 were observed to be significantly bold (14.0 mm diameter) over the others. While, the pure line-14 was peculiar due to its irregular seed shape (round seeds are the characteristic feature of makhana). The uniqueness of Sel-24 was observed in its earliness for maturity.

Table 36. Genetic variation in some pure lines of Makhana for morphological and yield contributing traits

Name of genotype	Flower color	Seed shape	Days to Seed-ling emergence	Days to Flower-ing initiation	Days to 50% flowering	Days to 100% flowering	Days to initiation of fruit bursting	Leaf dia. (cm)	Fruit dia. (cm)	Fruits/ plant	Seeds/fruit	Seeds/plant	Seed yield/ fruit (g)	Seed yield/ plant (g)	100 Seed weight (g)	Seed dia. (mm)
Sel-1	purple	round	30	121	124	126	149	120.8	6.5	11	53	549	49.3	476.2	92.0	9.2
Sel-2	purple	round	30	119	121	124	145	143.0	6.2	11	56	594	50.3	462.9	86.4	8.7
Sel-3	purple	round	31	123	125	128	153	146.3	5.8	9	42	401	45.6	424.4	105.0	10.5
Sel-4	purple	round	32	127	130	132	156	146.4	6.3	11	45	461	46.9	478.3	109.7	11.0
Sel-5	white	round	30	121	123	125	147	120.3	5.2	16	62	1007	36.6	593.3	63.5	6.4
Sel-6	purple	round	31	122	125	127	151	129.4	7.7	14	78	1068	81.3	983.8	97.3	9.7
Sel-7	purple	round	31	112	114	116	148	131.9	5.7	12	37	453	36.3	432.0	101.2	10.1
Sel-8	purple	round	30	117	120	122	153	118.5	6.5	9	52	466	40.8	398.0	84.3	8.5
Sel-9	purple	round	36	128	130	132	157	132.6	5.4	12	35	387	32.2	373.8	92.4	9.2
Sel-10	purple	round	30	122	124	126	153	123.6	6.0	10	53	519	53.4	526.9	103.5	10.4
Sel-11	purple	round	29	114	116	119	147	119.6	6.3	10	46	457	44.7	423.2	93.8	9.4
Sel-12	purple	round	30	122	125	127	156	128.5	5.8	11	59	639	45.9	493.5	81.1	8.3
Sel-13	purple	round	39	133	136	138	164	153.3	7.2	10	43	426	58.2	583.7	140.1	14.0
Sel-14	purple	irregular	50	160	163	165	190	148.4	8.1	12	139	1653	75.8	928.3	56.6	5.7
Sel-15	purple	round	30	120	124	126	155	149.2	6.6	10	48	478	44.2	423.6	89.4	9.0
Sel-16	purple	round	30	120	123	126	156	153.1	7.2	12	54	637	54.7	624.3	102.5	10.2
Sel-17	purple	round	32	122	125	128	153	136.4	6.7	9	49	448	44.4	401.7	90.3	9.0
Sel-18	purple	round	33	121	124	127	154	119.1	6.2	10	60	587	41.6	412.8	72.8	7.4
Sel-19	purple	round	31	120	123	126	150	117.5	5.9	12	45	533	47.3	472.8	98.0	9.9
Sel-20	purple	round	32	121	123	127	153	121.2	7.7	9	62	556	45.2	407.6	73.3	7.5
Sel-21	purple	round	33	118	121	123	158	152.9	6.1	10	48	467	50.9	506.4	110.9	10.9
Sel-22	purple	round	31	120	123	126	153	108.3	5.6	12	32	388	35.3	415.1	110.4	11.5
Sel-23	purple	round	32	123	126	129	158	123.9	7.2	10	47	463	43.8	424.3	93.8	9.4
Sel-24	purple	round	25	108	110	113	140	119.3	6.4	14	56	762	47.3	662.3	82.3	8.4

Development of Swarna Vaidehi variety of makhana

The Sel-6 strain of makhana has been released as a first ever variety of makhana under the name of "Swarna Vaidehi" by Institute Variety Release Committee. The seeds of Swarna Vaidehi are bold with average productivity of 2.8-3.0 t/ha. This variety sowed 60% higher seed yield compared to local check. The cumulative data of seed yield of Sel-6 strain (*Swarna Vaidehi*) and local checks are presented in Table 37.

The nutritional profile of Swarna Vaidehi has been depicted in Table 38. Makhana was found rich in micro nutrients and essential amino acids (Table 39).

Fig. 61. Seeds of irregular shape (Sel-14) and normal shape (sel-6) in Makhana

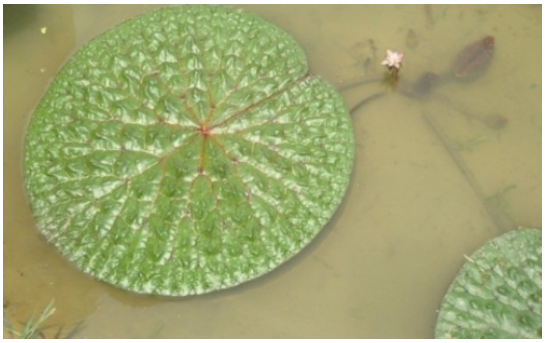


Fig. 62. White flower in Sel-5 pure line of makhana

Fig. 63. Purple flower (Normal color) in Sel-6 pure line of makhana

Table 37. Seed yield of Sel-6 strain (Swarna Vaidehi) and local checks at different sites.

Name of the Institute/Agency	Seed yield of Sel-6 (t/ha)	Seed yield of local check (t/ha)	% increase over check variety
Darbhanga, Bihar	2.98	1.77	6.82
BPS Ag. College, Purnea, Bihar	3.22	2.09	5.38
AAU Jorhat, Assam	2.04	1.2	7.0
Progressive farmers of Darbhanga, Madhubani, Purnea, Katihar and Saharsa.	3.02	2.06	4.67

Table 38. Nutritional profile of Swarna Vaidehi

Parameters	Popped seeds of Swarna Vaidehi	Popped seeds of local check	Raw seeds of Swarna Vaidehi
Moisture (% by wt.)	10.4	11.1	34.7
Total ash (% by wt.)	0.4	0.4	0.3
Fat (% by wt.)	0.5	0.2	0.3
Protein (% by wt.) (N x 6.25)	8.7	8.6	7.2
Crude fiber (% by wt.)	0.2	0.3	0.5
Carbohydrate ((% by wt.)	79.8	79.4	57.0
Calorific value (K. cals /100g)	358	354	259
Amylose %	18.2	18.5	19.0
Phosphorus (mg/100g)	53.2	79.1	66.1
Potassium (mg/100g)	42.0	56.0	35.6
Iron (mg/100g)	1.4	1.9	0.8
Calcium (mg/100g)	18.5	13.0	9.5
Magnesium (mg/100g)	13.9	11.9	11.3
Sodium (mg/100g)	71.0	65.2	48.2
Copper (mg/100g)	0.5	0.4	0.3
Manganese (mg/100g)	1.3	1.3	0.9
Zinc (mg/100g)	1.1	0.7	0.9

Table 39. Amino acid profile of Swarna Vaidehi

Parameter	Popped seeds of Swarna Vaidehi	Popped seeds of local check	Raw seeds of Swarna Vaidehi
	g/100g Protein		
Aspartic acid	7.71± 0.21	7.76 ± 0.18	7.72 ± 0.08
Glumatic acid	17.9 ± 10.57	18.27 ± 0.05	17.26 ± 0.19
Serine	5.42 ± 0.27	5.10 ± 0.25	5.26 ± 0.36
Glycine	3.43 ± 0.17	3.36 ± 0.04	3.62 ± 0.04
Histidine	2.74 ± 0.28	2.50 ± 0.12	3.05 ± 0.08
Arginine	10.57 ± 0.30	10.99 ± 0.19	10.71 ± 0.24
Threonone	3.71 ± 0.21	3.54 ± 0.06	3.65 ± 0.20
Alanine	5.15 ± 0.57	5.42 ± 0.27	5.59 ± 0.06
Proline	3.59 ± 0.25	3.57 ± 0.05	3.26 ± 0.12
Tyrosine	0.45 ± 0.12	0.28 ± 0.06	0.44 ± 0.10
Valine	9.19 ± 0.26	9.84 ± 0.09	9.31 ± 0.06
Methionine	5.64 ± 0.40	5.84 ± 0.17	5.36 ± 0.15
Cysteine	1.84 ± 0.19	1.76 ± 0.22	1.81 ± 0.16
Isoleucine	5.14 ± 0.10	5.48 ± 0.17	5.27 ± 0.25
Leucine	9.77 ± 0.25	10.17 ± 0.07	9.84 ± 0.04
Phenylalanine	4.49 ± 0.91	2.45 ±0.1.02	4.75 ± 0.58
Lysine	3.36 ± 0.48	3.76 ± 0.46	3.09 ± 0.40

11. Farming System Research

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

To increase the livelihood of small and marginal farmers, two integrated farming system models were developed not only for food and nutritional security of the farm family but also for round the year employment opportunities. The area under different components has been allocated as per need of farm family and in view of nutrient recycling within the system.

In one acre model, goat, poultry, mushroom, and vermicomposting have been integrated with the crop components. Under crop components, rice–wheat, rice–maize, rice–lentil and rice–mustard (cereal based cropping system) and cowpea–okra–tomato, okra–pea-cabbage and cucurbits–cauliflower–onion (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 ₹ 1,39,338 in comparison with other cropping systems in a farming system mode which was about five times more than rice-wheat cropping system (₹ 28,256) in isolation (Table 40). In addition, 1.9 t of vermicompost, 1.0 t of goat manure and 2.12 t of poultry manure were also produced by the system which was equivalent to 200.0 kg of Urea, 401.5 kg of SSP and 86.7 kg of MOP (chemical fertilizers) which were recycled within the system (Table 41). An additional employment of 86 man-days was also generated through the system over traditional farming.

In two acre IFS model (Fig. 64), livestock (3 cows + 3 calves), fisheries, duckery and vegetables & 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 IFS model gave the maximum annual return. ₹ 2,34,953 (Table 42) with additional employment opportunity of 257 man-days. In addition to above income, 2.9 t of vermicompost and 8.6 t of cow dung were also produced which were recycled within the system and due to recycling of these wastes 149.6 kg of N,

Fig. 64. Integrated farming system mode of food production system

Table 40. Expenditure and income statement of 1 acre IFS model (2012-13)

Components	Estb. Cost (₹)	Recurring expd./ann. (₹)	Net Income (NI) at 3rd year (₹)
Crop (0.2 ha)	-	16087	14128
Horticulture : 0.09 ha	1080	30624	24656
Fodder	-	8925	9775
Goat (20 + 1):0.018 ha	65,000	48516	21914
Mushroom: 0.003 ha	10,000	11000	5800
Poultry: 700 chicks	12,000	56280	36160
Cropwaste/V.C/FYM pits	8000	6900	27105
Total	96,080	176132	1,39,538

114.6 kg of P and 105.4 kg of K were added to the soil which were equivalent to 325 kg of urea, 716 kg of SSP and 176 kg of MOP (Table 43).

Based upon different enterprises, different combinations were made and analyzed statistically for their sustainability index (SI) and the most sustainable farming system enterprises selected were crop + veg. (S.I : 13.2), crop + veg. + fruits (S.I.-15.6) , crop + fish + poultry (S.I. 32.6), crop + fish + poultry + duck (S.I.-46.1), crop + mushroom +goat, crop+hort. + fish/duck + cattle, crop+ hort. + fish/duck + goat (S.I.-58.1). Further, it was also observed that due to waste recycling within the system there is an increase in organic carbon upto 1.6-9.3%, N 12.2-18.4%, P 9.9% and K 10.8-13.4% in the soil over a period of five years.

Table 41. Recycling of farm waste and gain/saving of nutrients in 1 acre IFS model (2012-13)

Farm waste	Qnt. produced (t)	Production/use pattern (t)	Nutrient gain (kg)	Total nutrient gain upon recycling	Saving due to resource recycling (₹)	Fertiliser saving (kg)
Goat manure	1.46	1.0 (GM- 0.8) 0.46 (VC- 0.35)	N- 17.5 P- 9.25 K-12.2	N-92.0 P-64.25 K-52.0	1011 3614 451	200 kg urea 401.5 kg SSP 86.7 kg MOP
Veg. waste	5.25	2.0 (VC- 1.55) 3.25- As fodder	N- 27.9 P- 23.2 K- 18.6			
Poultry manure	2.12	Used in crops	N-46.6 P- 31.8 K- 21.2			
RWMML straw	4.48	0.22-mushroom 0.12- Hut 4.14 t- sold			Total : 5076	

Table 42. Expenditures and income statement of 2 acre IFS model (2012-13)

Components	Estb. cost (₹)	Total expd./ yr. (₹)	Net income (NI) at 3rd year (₹)
Crop (0.4 ha)	-	30200	33566
Veg. (0.15 ha)	--	31350	18450
Orchards/fruits	2500	13820	14764
Fodder (0.01ha)	-	11000	19650
Fishery (0.1 ha)	70000	9400	17000
Duckery (on the pond)	18000	18300	28590
Dairy (3 + 3) 0.016 ha	100000	95202	38048
Crop waste	-----	1850	36485
V.C.	15000	7120	28400
Total	205000	218242	234953

Table 43. Recycling of farm waste and gain/saving of nutrients in 2 acre IFS model (2012-13)

Farm waste	Qnt. produced (t)	Production/ use pattern (t)	Nutrient gain (kg)	Total nutrient gain from recycling	Saving due to resource recycling (₹)	Fert. equivalent (kg)
Cow dung	17.2	11.2(FYM- 8.6) 2.0 (VC: 1.2) 4.0-Pond treat	N-65.0 P- 44.1 K-49.0	N=149.6 P=114.6 K=105.4	1645 6446 915 Total:9006/-	325 kg urea 716 kg SSP 176 kg MOP
Veg. waste	8.5	28.5 (VC-1.6) 5.7 (As fodder to cattle)	N- 84.6 P- 70.5 K- 56.4			

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

The IFS model was executed in an area of 1 acre comprising of vegetable (33% area), cereal (16%), pulse (7%), fruit (6.25%), fodder (5.4%), oil seed (3.12%), cattle shed (1.25%), compost unit (1.25%), other components (1.87%) and fish integration in pond (24%) with border plantation of *Flemengia semialata* for lac cultivation (Fig. 65).

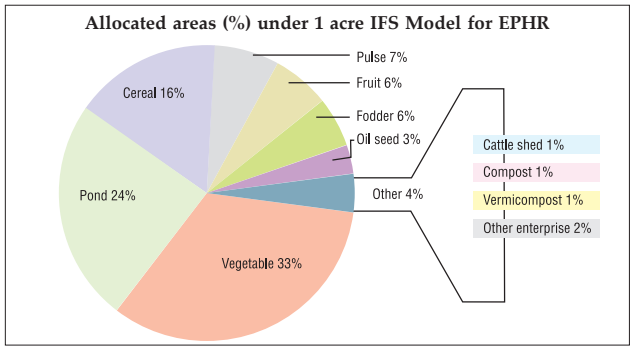


Fig. 65. Layout of different components of IFS

Under vegetable components, vegetable soyabean and pea were grown. A total pod yield of 98 kg (0.74 t/ha) with straw yield of 30 kg (0.19 t/ha) in pea was obtained. The total pod yield of vegetable soybean was 670 kg (5.06 t/ha) with biomass yield of 700 kg (10.0 t/ha). The gross income from vegetable block was ₹ 23,200/- per year.

Sweat corn, paddy and maize were grown as cereal components. Sweat corn produced 224 kg (3.03 t/ha) and 388 kg (6.09 t/ha) grain and straw yield, respectively. Maize produced 238 kg (3.45 t/ha) grain yield with 537 kg (8.43 t/ha) straw yield. Likewise, paddy yielded 51 kg (0.80 t/ha) grain and 200 kg (3.14 t/ha) straw. The gross income fetched from cereal block was ₹ 7,897 per year

310 kg guava (12.4 t/ha) was obtained from fruit block. Inter cropping of French bean in guava (high density) orchard was done to fetch initial income from the newly established orchard. In

French bean, a yield of 27 kg (1.08 t/ha) with straw yield of 35 kg (1.40 t/ha) was received. The gross income from fruit block along with intercrop was ₹ 5,190/- per year.

Among pulses, black gram, mung bean, urd bean; and in oilseed, mustard were cultivated. The gross income from pulse and oilseed was ₹ 3,280/- per year. The fodder sorghum gave the production of 280 kg (12.96 t/ha) and fetched ₹ 1400/- per year.

The fish integration was done as composite culture of Rohu, Catla, Mrigal Common carp in last week of September 2011 and harvested in the last week of December. The fish yield obtained from the pond was 25 kg (0.26 t/ha) with gross income of ₹2,500/- per year. The total milk production was 964 litre with income of ₹ 28,920/- per year. The total vermicompost production of 0.2 t and 200 cft of FYM was recorded which fetched a total income of ₹6,000. About 400 saplings of *Flemengia semialata* was planted at fence for lac production. The total biomass produced from *Flemengia semialata* was 2.5 t/yr (Fig. 66 & 67).

Hence, during second year, net income of ₹ 36,462 per acre per year was recorded from different components under integrated farming system.

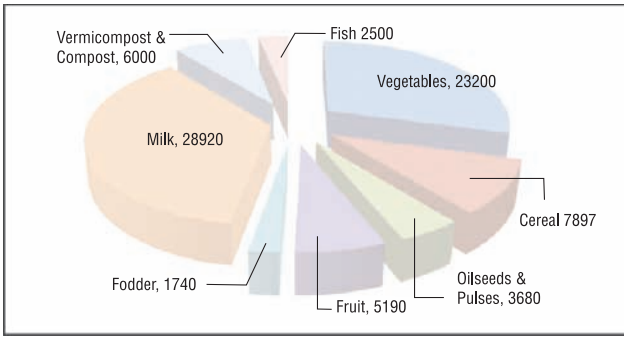


Fig. 66. Yield attributes of different enterprises (₹) from different components under integrated farming system

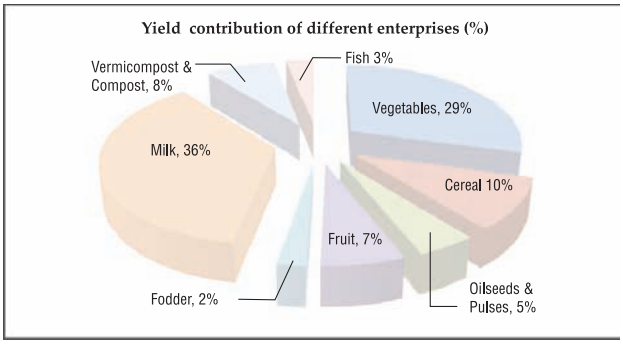


Fig. 67. Yield contribution of different enterprises (%) from different components under integrated farming system

Development of Makhana Based Integrated Farming Systems for Lowlands and Waterlogged Areas of North Bihar

Makhana+ fish–water chestnut, fruit plants, vegetables and poultry (in a 16.72 m^2 area over the pond) were integrated to enhance the net income of traditional makhana ponds. In second model, makhana+fish-water chestnut, makhana-rice-barseem, vegetables, fruit plants, and cattle were tried to augment the net income of makhana based agricultural fields. During the second year (2012-13) net return from all the components in pond model was obtained ₹ 37,890 with a gross income of ₹ 71,970. While, in field based model net return and gross income from all components were ₹ 47,524 and 80,762, respectively (Table 44 & 45). The comparative analysis of two models indicate that the net return in field based integrated model is approximately 25% higher than the pond based model.

Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar

To improve the livelihood of makhana growers the above mentioned project was initiated in April, 2009 in 50 ha pond area of makhana growers of Sadar block in Darbhanga district. During the year 2013-2014, the coverage area of this project was extended from one district to three districts

Table 44. Economic analysis of Pond based model

Name of components	Area (m^2)	Production details		Market rate of produce (₹/q)	Gross return (₹)	Net return (₹)
		Items	Wt. (q)			
Makhana + fish-Water chestnut	1600	Makhana	2.56	7000	17920	8960
		Fish	0.38	15000	5700	3800
		Water chestnut	12.60	1000	12600	8400
Poultry	16.72	120 broiler	2.12	6000	12,720	1200
Fruit plants: Mango- 30 Guava- 35 Banana- 40	1400	Mango	0.75	2000	1500	1200
		Guava	3.20	1500	4800	3600
Vegetables: Okra Bottle guard Sponge guard Bitter guard Cucumber	1000	Okra	6.00	800	4800	3200
		Bottle guard	2.25	500	1350	900
		Sponge guard	1.70	600	1020	675
		Bitter guard	0.95	1000	950	635
		Cucumber	2.85	6 00	1710	1140
		Potato	5.00	500	2500	1250
		Radish	8.80	500	4400	2930
					71,970	37,890

Table 45. Economic analysis of field based model

Name of components	Area (m^2)	Production details		Market Rate of produce (₹/q)	Gross return (₹)	Net return (₹)
		Item	Weight (q)			
Makhana +fish and water chestnut fish	1000	Makhana	2.9	7000	20300	10150
		Fish	0.30	15000	4500	3000
		Water chestnut	12.0	1000	12000	8000
Makhana-rice-barseem	1000	Makhana Rice Barseem	2.8 4.10 56.0	7000 1500 100	19600 6150 5600	9800 4060 4480
Sudan grass-wheat	1000	Sudan grass	50.0	50	2500	2000
		Wheat grain Wheat straw	4.3 4.3	1350 150	5805 645	2900 645
Vegetable crops Bottle guard Sponge guard Bitter guard Cucumber	500	Bottle guard	1.26	500	630	472
		Sponge guard	1.68	600	1008	670
		Cucumber	0. 84	600	504	335
		Bitter guard	1.5	1000	1520	1012
Fruit plants Banana-25 Citrus-25	400	-	-	-	-	-
Cattle	100	-	-	-	-	-
					80762	47524

(Darbhanga, Madhubani and Muzaffarpur) and the mode of makhana cultivation widened from traditional ponds to shallow agricultural fields. Out of 50 ha area, 36.4 ha was allotted under traditional pond system while rest 13.6 ha was covered under field mode of makhana cultivation. In both systems, integrated concepts of farming systems were adopted to augment net income of makhana growers (Table 46 & 47). Results indicate that the net returns in both integrated farming systems was two fold higher than sole makhana production system. The findings of this project suggest that integrated farming may be very helpful to improve the economic status of makhana growers by providing sustainable livelihood to them.

Fig. 68. A view of makhana crop at farmer's field and fish harvesting from makhana field

Table 46. Economic analysis of different combinations in pond system of makhana cultivation

Component combinations	Total area (ha)	Total production (t)			Net return (₹) /ha
		Makhana seed	Fish	Water chestnut	
Makhana + fish	22.60	33.67	14.01	--	1,02,635
Makhana – water chestnut	6.40	10.37	---	88.32	1,07,660
Makhana + fish – water chestnut	4.65	6.73	1.71	64.17	1,26,505
Makhana	2.75	4.55	----	----	57,960

Table 47. Economic analysis of different combinations in field mode of makhana cultivation

Component combinations	Total area (ha)	Total production (t)				Net return (₹)/ha
		Makhana	Fish	Water chestnut	Rice	
Makhana + fish	8.40	24.02	3.78	-	-	1,21,520
Makhana – rice	3.00	9.07	-	-	12.36	1,16,322
Makhana–water chestnut	1.20	3.55	-	25.2	-	1,56,436
Makhana	1.00	3.16	-	-	-	88,368

12. 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* 2012, 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 gourd), 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 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 (Fig. 69). 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 mean value of pH 6.74, electrical conductivity 0.12 ds/m in 1 : 2 soils: water solution, organic carbon 6.90 g/kg, available nitrogen 282.90 kg/ha, phosphorus 26.88 kg/ha and potash 141.85 kg/ha.

Five crop cycles for all diversified cropping systems were completed and the yield of different crops was converted in terms of rice equivalent yeild. Results revealed that variation among most of the growth and development characters in rice were non-significant except plant height, grain/panicle and grain yield in all the cropping systems, levels of irrigation and nutrients during 2012-13. It indicates that there is built up of available nutrient particularly nitrogen and phosphorus after fourth crop cycle, which in turn resulted in significant variation in grain yield of rice crop (Table 48). Results of paddy yield equivalence revealed that during fifth year of experimentation, there

Table 48. Effect of levels of irrigation and nutrient on different growth and developmental characters of rice in different cropping systems (2012)

Treatment	Plant height (cm)	Chaffy grain panicle	No. of grain /panicle	1000 grain wt (gm)	Straw yield (t/ ha)	Grain yield (t/ ha)
Cropping System						
Rice-Tomato-Bottle gourd (C_1)	72.27	26.93	129.57	16.49	6.41	4.83
Rice-Potato-Onion (C_2)	74.46	28.46	141.02	16.52	6.45	4.67
Rice-Mustard-Sponge gourd(C_3)	72.78	26.56	128.05	16.55	6.70	4.73
Rice-Coriander-L. Finger (C_4)	73.02	26.93	131.22	16.39	6.90	7.71
Rice-Cabbage-Cowpea (C_5)	76.38	25.98	131.48	16.61	6.56	4.75
SE m (±)	1.53	1.18	3.97	0.22	0.21	0.11
CD at 5%	NS	NS	12.95	NS	NS	NS
Level of Irrigation (I)						
I_1	72.64	26.28	136.72	16.50	6.48	4.95
I_2	74.93	27.67	127.73	16.52	6.73	4.52
SE m (±)	0.89	0.59	2.82	0.17	0.13	0.07
CD at 5%	NS	NS	8.88	NS	NS	0.22
Level of Nutrient (N)						
F_1	74.90	27.25	136.07	16.68	6.61	4.87
F_2	72.66	26.70	128.39	16.35	6.60	4.60
SE m (±)	0.71	0.58	2.19	0.12	0.13	0.05
CD at 5%	2.09	NS	6.46	NS	NS	0.15

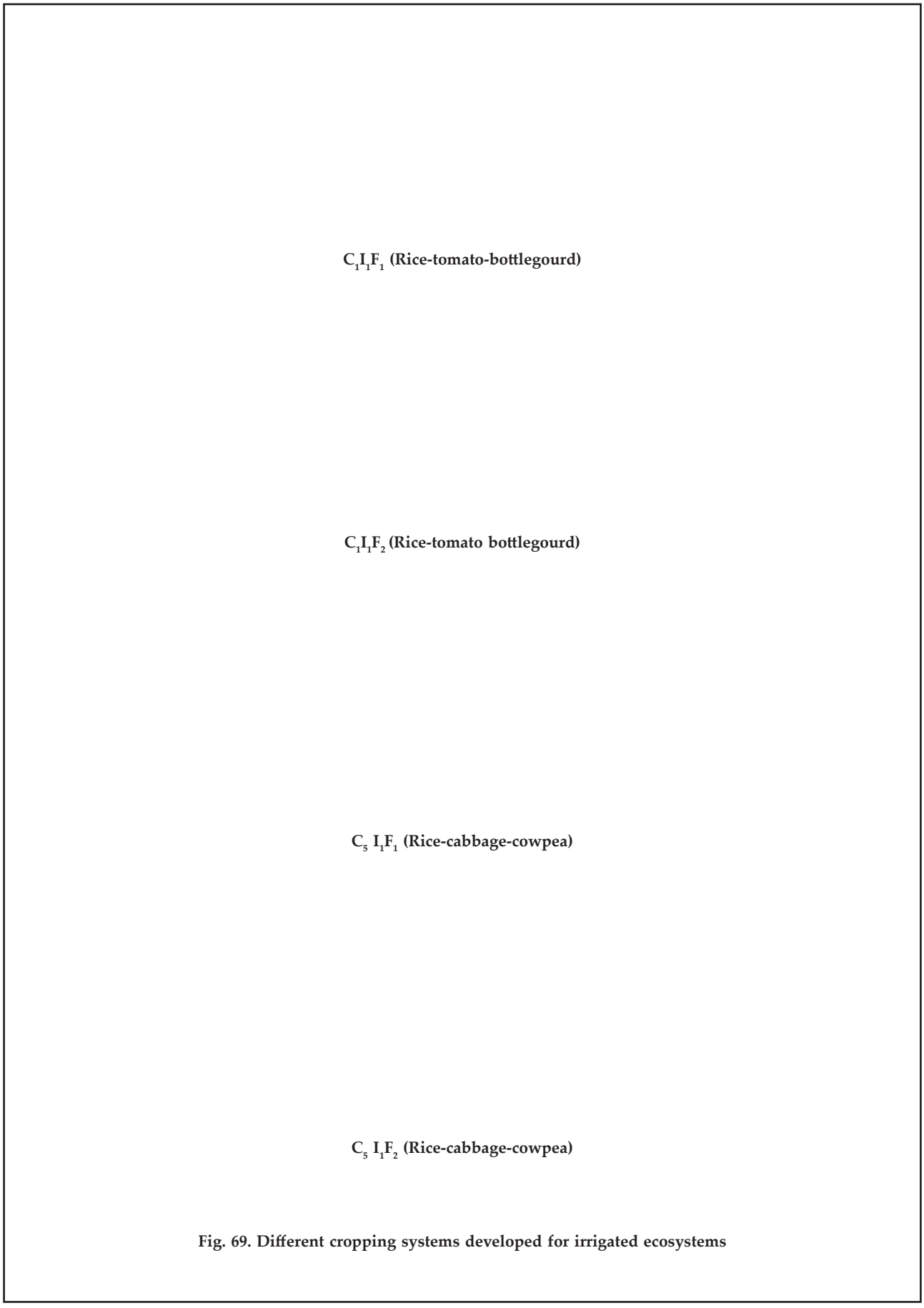


Fig. 69. Different cropping systems developed for irrigated ecosystems

were significant variations among cropping systems, levels of irrigation and nutrients and its interactions. Among the cropping systems (Table 49), maximum yield equivalence was recorded in rice–tomato–bottle gourd (33.46 t/ha) followed by rice–cabbage–cowpea (23.98 t/ha). Among levels of irrigation, maximum yield equivalence was recorded at optimum level (21.73 t/ha) followed by sub-optimum level (20.67 t/ha) and the increase was to the tune of 5.13 per cent. Among levels of nutrient, maximum yield equivalence was recorded at recommended level (21.95 t/ha) followed by 50% of recommended level of fertilizer and the increase was to the tune of 7.33 per cent. Maximum net profit (Table 50) was recorded in rice-tomato-bottle gourd (₹ 1,77,910/ha) followed by rice–cabbage–cowpea (₹ 1,23,220/ha) and rice–coriander–ladies finger (₹ 70,220/ha). Similar trend was observed in benefit cost ratio.Among levels of irrigation, maximum net profit was recorded at optimum level of irrigation (₹ 90,975/ha) as compared to sub-optimum level (₹ 86, 905/ha). Among levels of nutrient, maximum net profit was recorded at recommended level (₹ 92,450/ha) followed by 50% of recommended level (₹ 85,875/ha).

Table 49. Effect of levels of irrigation and nutrient on yield (t/ha) equivalence in terms of paddy (2012–13).

Cropping systems	Irrigation		Mean	fertilizer		Mean
	I_1	I_2		F_1	F_2	
Rice–Tomato–Bottle gourd (C_1)	34.14	32.77	33.46	34.50	32.42	33.46
Rice–Potato–Onion (C_2)	17.45	17.17	17.31	17.97	16.65	17.31
Rice–Mustard–Sponge gourd (C_3)	14.09	13.09	13.59	14.19	12.99	13.59
Rice–Coriander–L. Finger (C_4)	18.33	17.00	17.66	18.31	17.02	17.66
Rice–Cabbage–Cowpea(C_5)	24.62	23.34	23.98	24.78	23.18	23.98
Mean	21.73	20.67	–	21.95	20.45	–
Factors						
	C	I	F	C x I	C x F	I x F	C x I x F
SE(m) ±	0.35	0.08	0.12	0.19	0.27	0.17	0.38
C.D. at 5 %	1.14	0.26	0.36	0.59	0.80	0.51	1.13

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

Soil studies indicated that after completion of fifth crop cycle in all the systems there was increase in pH, EC, nitrogen and phosphorus, but reduction in organic carbon and potassium from initial status of the nutrient. The reduction may be attributed to exhaustive cropping system/vegetable dominated crops in the system followed year after year from same piece of land, whose organic matter and potash requirement is quite higher (Table 51).

Table 50. Yield equivalence in terms of rice, net-return, cost of production and benefit cost ratio in different cropping systems (2012-13).

Cropping systems	Yield equivalence of different crops t/ha			Paddy yield equivalence (t/ha)	Gross return (₹ /ha)	Cost of cultivation (₹/ha)	Net return (₹/ ha)	Benefit cost ratio
	Kharif 2012	*Rabi* 2012-13	Summer, 2013					
Rice–Tomato–Bottle gourd (C_1)	4.83	23.53	5.02	33.46	2,84,410	1,06,500	1,77,910	1.67
Rice–Potato–Onion (C_2)	4.67	8.69	3.97	17.31	1,47,135	1,13,910	33,225	0.29
Rice–Mustard –Sponge gourd(C_3)	4.73	6.02	2.66	13.59	1,15,515	75,680	39,835	0.53
Rice–Coriander–L. Finger (C_4)	7.71	8.12	4.84	17.66	1,50,110	79,890	70,220	0.88
Rice–Cabbage–Cowpea (C_5)	4.75	14.98	4.24	23.98	2,03,830	80,610	1,23,220	1.53
SE m (±)	0.11	0.30	0.14	0.35	—	—	—	—
CD at 5%	N.S.	0.98	0.45	1.14	—	—	—	—
Level of Irrigation (I)								
I_1	4.95	12.59	4.21	21.73	1,84,705	93,730	90,975	0.97
I_2	4.52	11.95	4.08	20.67	1,75,695	88,990	86,905	0.97
SE m (±)	0.07	0.111	0.84	0.08	—	—	—	—
CD at 5%	0.22	0.35	N.S.	0.26	—	—	—	—
Level of Nutrient (N)								
F_1	4.87	12.72	4.34	21.95	1,86,575	94,125	92,450	0.98
F_2	4.60	11.81	3.95	20.45	1,73,825	88,040	85,785	0.97
SE m (±)	0.05	0.119	0.06	0.121	—	—	—	—
CD at 5%	0.15	0.35	0.17	0.36	—	—	—	—

Table 51. Effect of levels of irrigation and nutrient on chemical status of soil in diversified cropping systems (2008-09 to 2012-13)

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
Average nutrient status after fifth crop cycle (2012-13)	6.74	0.12	6.90	282.90	26.88	141.85

Intercropping of Rice and Legumes in Hill and Plateau region

In rice-legume cropping system under rainfed upland situation in kharif season, the upland rice (variety Anjali) and legumes like soybean (variety Swarna Vasundhara), groundnut (variety Birsa Bold), black gram (variety Uttara), green gram (variety CN 9-5), cowpea (line EC 452), rice bean (line HARB-1) and horse gram (variety GKP-7C) were grown both as sole crops (each of 12 rows) and in combination (6 row rice + 6 row of each legume). The sowing of rice, groundnut, black gram, soybean, rice bean and cowpea was done on 03.07.2013 whereas green gram and horse gram were sown on 01.08.2013. The sole crop of groundnut recorded the maximum rice equivalent yield (10.74 t/ha) followed by soybean (9.03 t/ha). Among the combinations, the treatment of 6 row rice + 6 row groundnuts (7.13 t/ha) was the best followed by that of 6 row rice + 6 row soybean (6.38 t/ha) (Table 52 & Fig. 70).

Table 52. Rice equivalent yield (t/ha) in rice–legume cropping system

Treatments	Rice Equivalent Yield (REY)
T_1 (12 Row Rice)	3.44
T_2 (12 Row Black gram)	4.74
T_3 (12 Row Green gram)	2.86
T_4 (12 Row Soybean)	9.03
T_5 (12 Row Cowpea)	2.81
T_6 (12 Row Rice bean)	5.46
T_7 (12 Row Horse gram)	3.49
T_8 (12 Row Groundnut)	10.74
T_9 (6 Row Rice + 6 Row Black gram)	3.89
T_{10} (6 Row Rice + 6 Row Green gram)	2.98
T_{11} (6 Row Rice + 6 Row Soybean)	6.38
T_{12} (6 Row Rice + 6 Row Cowpea)	2.87
T_{13} (6 Row Rice + 6 Row Rice bean)	4.62
T_{14} (6 Row Rice + 6 Row Horse gram)	2.86
T_{15} (6 Row Rice + 6 Row Groundnut)	7.13
CD at 5%	0.83

Fig. 70. Rice-legume cropping system under rainfed situation

Eco-biology and management of rodent fauna of rice-wheat cropping system

The rodent trapping was carried out round the year from different cropping system of Bihar. Three rodents species, i.e., lesser bandicoot rat (*Bandicota bengalensis*), field mouse (*Mus booduga*) and soft furred field rat (*Millardia meltada pallidior*) were collected. Out of three species, former species was found predominantly in the rice-wheat cropping system of the region. Round the year trapping of predominant species revealed that the incidence of both the male and female bandicoot rats were more in October to January and March and April with peak in December. The declined trend was observed in the month of February, May, and June to September (Fig. 71). Body weight of collected bandicoot rat ranged from 123.0 to 221.08 g (Fig. 72). Data indicates that the bandicoots collected from July to October were adult and in other months were sub adult. Due to scarce food availability in the months of July to October, rat stopped their breeding however; the food availability in November to February was abundant due to maturity of paddy and sowing of wheat crops, induced breeding potential of bandicoots hence rats having less body weight (sub adults) were collected. It was also confirmed by percent prevalence of pregnancy during these months (Fig. 73)

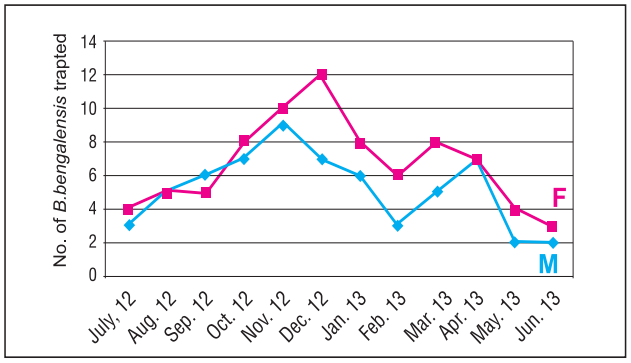


Fig. 71. Monthly variation in male (M) and female (F) trapped Bandicoots

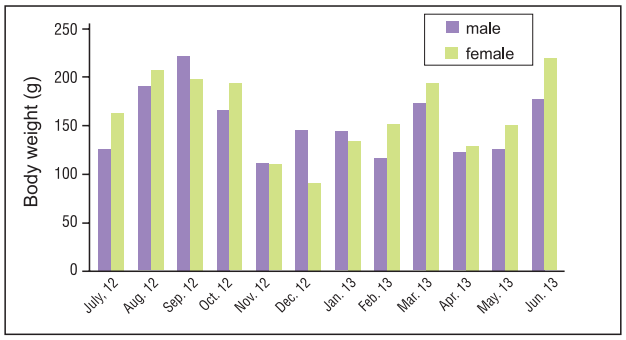


Fig. 72. Monthly variation in body weight of collected Bandicoot rat

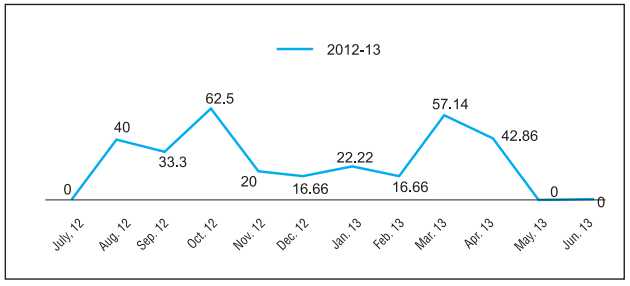


Fig. 73. Percent of pregnancy of *B. bengalensis*

Evaluation of Different Production Systems for Carbon Sequestration Potential

Different agricultural production systems are being assessed for their carbon sequestration potential at Patna and Ranchi.

At Patna, the field experiment is in progress having three crop sequences with different tillage practices in factorial RBD. The crop sequences were rice–wheat, rice–lentil and rice–maize and the tillage practices included conventional tillage, reduced tillage and reduced tillage with 30% residue.

During the first year of experimentation, there was non-significant differences in rice grain yield among different tillage treatments. However, straw yield was significantly higher in conventional tillage (Table 53). Yield performance of rice lentil sequence was significantly superior over rice-wheat and rice-maize sequences (Table 54). Potential carbon addition was maximum in rice -maize sequence (6.93 t/ha) followed by rice-wheat and rice-lentil sequence as shown in Table 55. Oxidisable organic carbon content in the soil was significantly higher in reduced tillage with 30% residue upto 30 cm levels during *rabi* season. However, there was non-significant difference in the soil organic carbon content in pre-*rabi* season (Table 56). In surface soil (0-15 cm) available nitrogen content did not vary with respect to season and tillage but in sub-surface soil (15-30 cm) available nitrogent content was significantly higher in reduced tillage with 30% residue (Table 57).

Table 53. Growth and yield parameters in rice

Treatments	Plant height (cm)	No. of tillers (m^2)	Effective tillers (m^2)	Filled grains	Per cent filled grains	Straw yield (t/ha)	HI
C_1 (R-W)	126.11	448	418	225	96	9.42	0.40
C_2 (R-M)	123.77	437	415	222	96	8.56	0.41
C_3 (R-L)	128.00	441	411	231	96	9.23	0.40
CD	NS	NS	NS	NS	NS	NS	NS
T_1 (CT)	126.33	451	418	228	96	10.10	0.39
T_2 (RT)	124.66	431	409	227	95	8.65	0.40
T_3 (RT30)	126.88	444	417	222	96	8.47	0.41
CD	NS	NS	NS	NS	NS	1.42**	0.014**

Table 54. Rice yield and equivalent yield of *rabi* sequence

Treatments	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index	Equivalent yield of *rabi* (t/ha)	Equivalent yield of sequence (t/ha)
C_1 (R-W)	5.91	6.34	0.32	314	9.05
C_2 (R-M)	5.99	8.79	0.31	2.38	8.37
C_3 (R-L)	5.84	4.13	0.29	4.12	9.96
CD	NS	1.03**	NS	0.57**	0.72**
T_1 (CT)	6.01	6.28	0.31	3.22	9.23
T_2 (RT)	5.97	6.12	0.31	3.22	9.20
T_3 (RT30)	5.77	6.86	0.29	3.19	8.96
CD	NS	NS	NS	NS	NS

Table 55. Potential carbon addition (t/ha) from straw material

Treatments	*Kharif* crops	*Rabi* crops
C_1 (R-W)	3.64	2.57
C_2 (R-M)	3.32	3.61
C_3 (R-L)	3.60	1.67
CD	NS	0.42**
T_1 (CT)	3.81	2.56
T2(RT)	3.41	2.49
T3(RT30)	3.34	2.80
CD	NS	NS

Table 56. Organic carbon content in soil

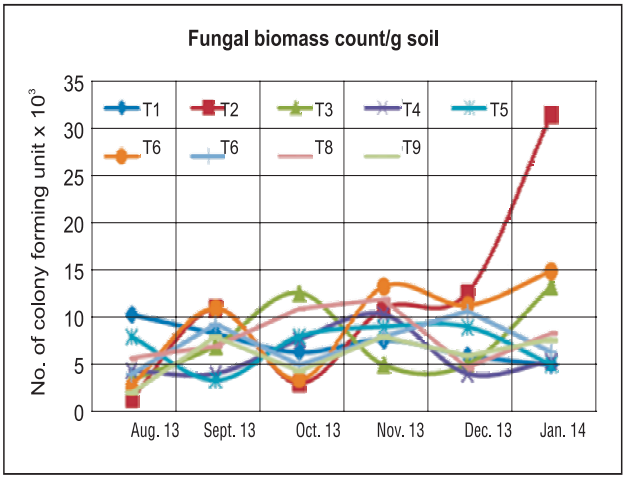
Treatments	0-15 cm (PR)	0-15 cm (DR)	15-30 cm (PR)	15-30 cm (DR)	30-45 cm (PR)
C1	0.6400	0.6789	0.5638	0.5089	0.4911
C2	0.5967	0.8167	0.5578	0.5656	0.5444
C3	0.5456	0.7500	0.4444	0.5256	0.5100
CD	NS	NS	NS	NS	NS
T1	0.6011	0.6544	0.4756	0.5200	0.4622
T2	0.6022	0.7267	0.3933	0.4544	0.5133
T3	0.5789	0.8644	0.4522	0.6256	0.5700
CD	NS	0.1774**	NS	0.1374*	NS

Table 57. Available nitrogen in soil

Treatments	0-15 cm (PR)	0-15 cm (DR)	15-30 cm (PR)	15-30 cm (DR)	30-45 cm (PR)
C_1	235.61	238.33	209.17	212.59	199.38
C_2	216.79	223.76	203.49	225.79	203.64
C_3	226.48	230.76	207.04	211.85	184.78
CD	NS	NS	NS	NS	NS
T_1	219.65	218.75	204.23	193.07	190.39
T_2	227.18	243.21	191.64	227.18	188.30
T_3	223.06	230.79	223.83	229.97	209.11
CD	NS	NS	25.14*	NS	NS

Second year of experimentation is in progress with different crop sequences and tillage practices. Decomposition of organic matters by fungal and bacterial biomass in rice based crop sequences under different tillage practices

Results indicated that the microbial biomass varied month to month. Fungal biomass was observed from August 2013 to January 2014. Maximum fungal biomass, i.e., colony forming unit (cfu X 10-3) was observed in the month of January, 2014 when the waterlogged soil became dry (Fig. 74a). The treatment T_2 showed maximum colony forming unit (32 cfu) followed by T_6 and T_3 soil samples in January 2014. In fungal microflora, Aspergillus and Penicillium were observed in almost all the soil samples, some were also having Fusarium sp. The culturable bacteria / actinomycetes population count, i.e., colony forming unit/g soil (cfu X 10-6) indicated that the highest bacterial/actinomycetes cfu were observed in the month of November, 2013 followed by August, September, October and December, 2013 (Fig. 74b). In the month of November, 2013, treatment T_9 showed highest culturable bacterial/actinomycetes biomass (180 cfu) followed by T_2, T_3 and T_1, respectively. However, in the months of December, minimum bacterial counts were observed in almost all the soil samples and thereafter bacterial count gradually increased. The results indicated that the wet period was associated with higher population of bacterial/actinomycetes biomass and dry period was associated with highest fungal biomass.



T_1 : Rice–wheat under conventional tillage without residue (C_1)

T_2 : Rice–maize under conventional tillage without residue (C_2)

T_3 : Rice–lentil under conventional tillage without residue (C_3)

T_4 : Rice–wheat under reduced tillage without residue (unpuddled tr. Rice–ZT wheat)

T_5 : Rice–wheat under reduced tillage with residue 30% (unpuddled tr. Rice–ZT wheat)

T_6 : Rice–maize under reduced tillage without residue (unpuddled tr. Rice–ZT maize)

T_7 : Rice–maize under reduced tillage with residue 30% (unpuddled tr. Rice–ZT maize)

T_8 : Rice–lentil under reduced tillage without residue (unpuddled tr. Rice–ZT lentil)

T_9 : Rice–maize under reduced tillage with residue 30% (unpuddled tr. Rice–ZT lentil)

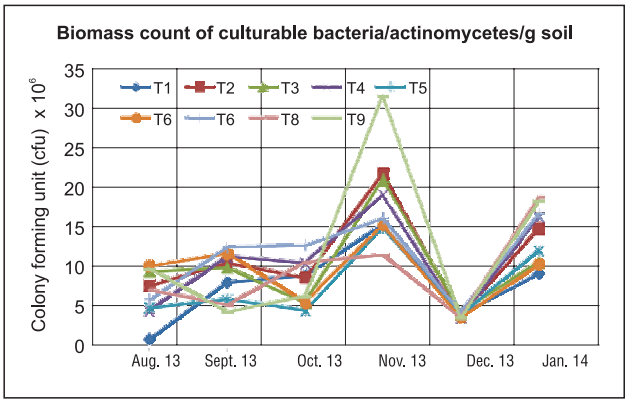


Fig. 74(a) and (b). Showing changes in fungal and bacterial count with time

13. Soil Science

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

Nutrient contribution by makhana crop to the soil and removal of nutrients by seed parts

Roots of makhana plants absorb nutrients from the sediments and accumulate high concentrations of micronutrients like Fe, Mn and Zn (Table 58). Shoots and leaves also contain considerable amount of nutrients.

Biomass of makhana on decomposition added approximately 31, 47, 40 and 22 kg/ha of nitrogen, phosphorus, potassium and iron, respectively, to the soil (Table 59). The removal of N, P, K and Fe by the seed material from the soil was recorded at 40, 9.5, 1.5 and 2.3 kg/ha, respectively. The uptake and removal of other nutrients from the soil was, however, very less (Table 60).

Soil fertility status under different makhana and makhana based cropping system

Field experiments were conducted to study the impact of makhana based cropping systems on fertility status of soil. It was observed that makhana–chestnut–barseem cropping system appreciably increased the nutrient status of soil over other makhana–based cropping systems. Soil organic carbon in makhana–chestnut–barseem increased due to addition of comparatively higher amount of organic matter to the soil. The highest amount of available nitrogen (280 kg/ha), phosphorus (22 kg/ha) and potassium (230 kg/ha) was also recorded with makhana–chestnut–barseem cropping system followed by makhana–barseem cropping system. The lowest quantity of available nitrogen (188 kg/ha), phosphorus (12 kg/ha) and potassium (206 kg/ha) was recorded with makhana–rice–wheat, makhana–rice and makhana–rice–barseem cropping system, respectively. However, all the cropping systems could not registered any appreciable changes in pH and EC of soil (Table 61).

Table 58. Nutrient status of makhana plants

Plant Parts	N (%)	P (%)	K (%)	S (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
Leaf	0.36	0.48	0.30	0.04	2060	942	6	106
Petiole	0.25	0.45	0.41	0.01	2155	885	6	82
Root	0.26	0.38	0.50	0.01	2310	945	7	92
Fruit sheath	0.21	0.51	0.25	0.02	1750	915	9	91
Seed (starch)	1.61	0.38	0.06	0.02	913	25	9	109

Table 59. Nutrient contribution through makhana plants to the soil

Plant parts	N (kg/ha)	P (kg/ha)	K (kg/ha)	Fe (kg/ha)
Leaf	14.59	19.45	12.16	8.10
Petiole	3.60	6.48	5.90	3.16
Root	2.82	6.86	3.36	2.28
Fruit sheath	9.72	14.20	18.69	8.59
Total	30.73	46.99	40.11	22.13

Table 60. Nutrient uptake by crops

Crop	N (kg/ha)	P (kg/ha)	K (kg/ha)
Makhana	74	55	41
Rice	60	13	89
Wheat	103	20	76
Barseem	334	24	174
Chestnut	63	8	79

Table 61. The physico-chemical properties of soil under different makhana based cropping system

Cropping systems	pH	EC (dS^{m-1})	Org. C.(%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)
Makhana–makhana	7.38	0.06	0.51	245	16	215
Makhana–wheat	7.72	0.10	0.60	257	19	213
Makhana–rice	6.53	0.18	0.62	200	12	217
Makhana–barseem	6.78	0.20	0.75	265	20	210
Makhana–chestnut	7.05	0.16	0.55	248	17	225
Makhana–rice–wheat	7.45	0.21	0.65	190	16	208
Rice–wheat	7.40	0.21	0.46	234	18	212
Makhana–rice–barseem	7.12	0.17	0.68	220	14	206
Makhana–chestnut–barseem	7.33	0.22	0.77	280	22	230
Makhana+fish–rice+fish	6.87	0.24	0.58	205	13	209

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 mango orchards Soil profiles were collected from four 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, respectively.

Different forms of acidity in mango orchard soils

In the acidic soils, the concentrations of exchangeable aluminium and hydrogen ions contribute to exchangeable acidity. The exchangeable acidity of control (no orchard), 1-3, 4-5 and 6-7 year old orchard varied from 0.46-0.58, 0.48-0.75, 0.65-0.93 and 0.61-0.82 cmol (p^+)/kg, respectively. The exchangeable acidity gradually decreased with increasing depth of soil profile. The exchangeable aluminium content in the soil of different mango orchards varied from 0.42-0.63, 0.31-0.56, 0.40-1.08 and 0.50-0.58 cmol (p^+)/kg in control, 1-3, 4-5 and 6-7 year old orchard, respectively. The status of exchangeable Al content was low to medium throughout the soil profiles of different orchard. The total acidity in different mango orchard soils varied from 1.13-1.93, 1.18-2.02, 1.28-2.34 and 0.88-1.51 cmol (p^+)/kg in control, 1-3, 4-5 and 6-7 year old orchard, respectively (Table 62).

Table 62. Different forms of acidity in mango orchard soils

Types of orchard	Soil depth (cm)	Forms of acidity [cmol (p^+)/kg]		
		Exchangeable acidity	Exchangeable Al	Total acidity
No orchard	0-30	0.58 ± 0.042	0.42 ± 0.042	1.93 ± 0.20
	30-60	0.50 ± 0.072	0.46 ± 0.042	1.33 ± 0.15
	60-90	0.46 ± 0.042	0.63 ± 0.14	1.33 ± 0.14
	90-120	0.50 ± 0.072	0.58 ± 0.042	1.13 ± 0.03
1-3 year old orchard	0-30	0.75 ± 0.14	0.56 ± 0.09	2.02 ± 0.21
	30-60	0.48 ± 0.09	0.38 ± 0.08	1.47 ± 0.16
	60-90	0.58 ± 0.10	0.40 ± 0.06	1.25 ± 0.13
	90-120	0.54 ± 0.15	0.31 ± 0.04	1.18 ± 0.12
4-5 year old orchard	0-30	0.93 ± 0.24	1.08 ± 0.20	2.34 ± 0.22
	30-60	0.81 ± 0.14	0.78 ± 0.15	1.61 ± 0.20
	60-90	0.65 ± 0.06	0.40 ± 0.06	1.42 ± 0.21
	90-120	0.68 ± 0.11	0.54 ± 0.12	1.28 ± 0.18
6-7 year old orchard	0-30	0.82 ± 0.10	0.58 ± 0.11	1.51 ± 0.08
	30-60	0.67 ± 0.08	0.53 ± 0.013	1.13 ± 0.07
	60-90	0.63 ± 0.04	0.55 ± 0.12	1.00 ± 0.05
	90-120	0.61± 0.07	0.50 ± 0.11	0.88 ± 0.03

± Standard error

Lime potential of different mango orchard soils

Lime potential measures the total acidity of a soil, unlike pH measurement, which is highly variable on account of moisture condition, salt content, etc. Estimation of lime potential is suggestive of the buffering capacity of a soil. The lime potential of soils of mango orchard in control, 1-3, 4-5 and 6-7 year old orchard varied from 3.4-4.07, 3.69-4.20, 3.56-4.36 and 3.69-4.19, respectively (Fig. 75). Smaller the value of the lime potential of a soil, the greater will be the buffering capacity of the soil.

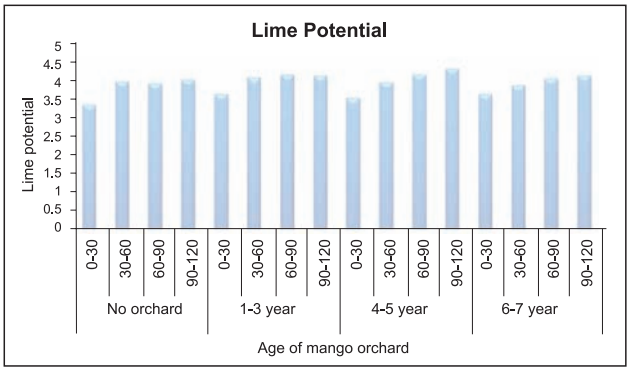


Fig. 75. Lime potential of mango orchard soils

Physical properties of different mango orchard soils

Different physical properties of soils like bulk density, particle density and total porosity of orchard soils of different mango orchards were analysed. The bulk density of control plot (no orchard) varied from 1.17-1.22 Mg/m^3. Similarly the bulk density of 1-3 year, 4-5 year and 6-7 year old orchard varied from 1.04-1.08, 1.16-1.23 and 1.11-1.25 Mg/m^3, respectively. The bulk density was lower in the surface soil compared to sub surface soil. The particle density depends on the chemical and mineralogical compositions of soil. The particle density of control plot, 1-3 year, 4-5 year and 6-7 year old orchard varied from 1.93-2.02, 1.81-1.86, 1.84-2.00 and 1.74-1.82 Mg/m^3, respectively. The total porosity of control plot, 1-3 year, 4-5 year and 6-7 year old orchard varied from 39.2-41.14, 40.42-43.34, 36.02-39.55 and 36.24-40.45%, respectively. The total porosity was higher in surface soil as compared to subsurface soil.

Leaf nutrient status of mango plants of different orchards

Secondary and micronutrient content in mango leaf

The secondary nutrients like calcium, magnesium and sulphur content of mango leaf (var. Amrapali) were analyzed for different orchard varying in age. The calcium content varied from 1.4 to 2.31%, magnesium from 0.26-0.35% and sulphur from 0.11-0.14% among the different mango orchard. The calcium and sulphur content was found in normal range while magnesium content was in deficient range (Fig. 76). The total iron content was 142, 94 and 171 mg/kg in 1-3, 4-5 and 6-7 year old orchard, respectively. The total manganese content was 560, 554 and 721 mg/kg in 1-3, 4-5 and 6-7 year old orchard, respectively. The total iron content was found in normal range while total manganese content was in high range (Fig. 77). The total copper content of different mango orchard varied from 18.91-25.46 mg/kg and was found in high range. The total zinc content in the leaves of different mango orchard varied from 21.6-38 mg/kg and was in normal range (Fig. 78).

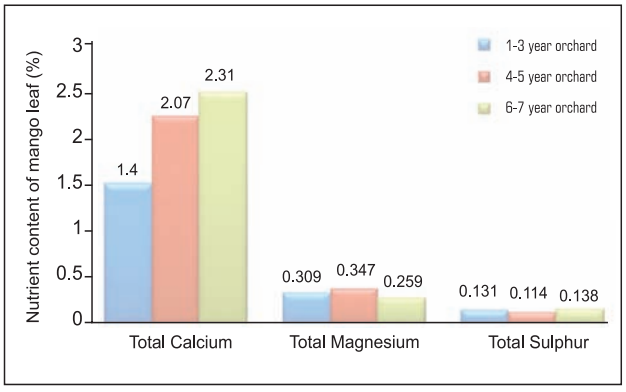


Fig. 76. Total calcium, magnesium and sulphur content of different mango orchard (var. Amrapalli) (± SE)

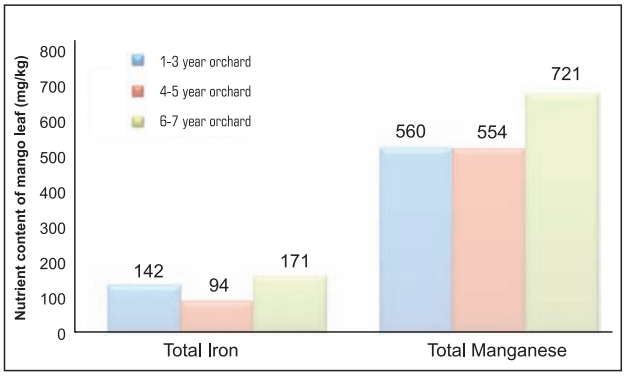


Fig. 77. Total iron and manganese content of different mango orchard (Var. Amrapalli) (± SE)

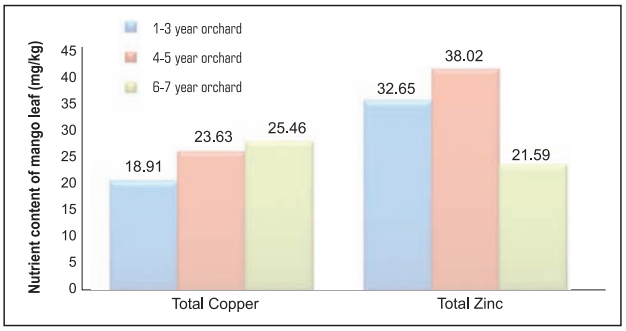


Fig. 78. Total copper and zinc content of different mango orchard (var. Amrapalli) (± SE)

Carbon Sequestration Assessment of Different Tree Systems for Carbon Sequestration Potential (Destructive Study)

The different age of two and six year old orchard of litchi, mango and guava were uprooted. Soil samples were collected at depths of 0-15, 15-30, 30-45, 45-60 cm during harvest of tree. All the soil samples were dried, powdered and passed through 2 mm sieve and stored for analysis in the laboratory. Further the different size fractions of 2000-200 µ, 200-53 µ and ≤ 53 µ were separated and organic carbon content was determined. The organic carbon content in 2000 to 53 µ soil particle size represents the slow pool of organic carbon while organic carbon content in ≤ 53 µ soil particle size corresponds to passive pool of organic carbon.

Organic and biotic carbon content in two year old orchard

The soil organic carbon content (SOC) in different size fractions of soils of two year old orchard at different depths was analyzed. The organic carbon content under the two year old tree canopy in the surface soils by all the size fractions (2000-200 µ, 200-53 µ and ≤ 53 µ) was recorded highest in guava orchard (0.58%) followed by litchi (0.55%) and mango (0.5%). Among the different size fractions, SOC was highest in the 2000-200 µ size in all the orchards. The SOC gradually decreased with increasing depth of soil. The highest SOC in different size fractions in surface soil was 0.39% (2000-200 µ size), 0.13% (200-53 µ size and 0.06% (≤ 53 µ) in guava orchard (Table 63).

The biotic carbon content in different parts of two year old fruit plant in different orchards was recorded. The highest biotic-C was 158.0 g C/plant in mango, followed by litchi (147.8 g C/plant) and guava (78.3 g C/plant) plant (Fig. 79). Among different parts of plant, stem part recorded the highest carbon in all the orchard.

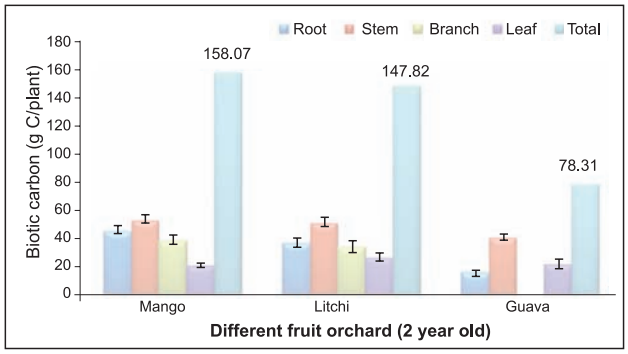


Fig. 79. Biotic carbon content in two year old orchard

Table 63. Soil organic carbon content of particle size fractions in different orchards of two year old.

Soil Depth (cm)	Soil organic carbon (g/100g soil)			
	Particle size fraction			
	S_1 (2000-200 μ)	S_2 (200-53 μ)	S_3 ($\leq$ 53 μ)	Total
Control (No orchard)				
0–15	0.261 ± 0.038	0.112 ± 0.014	0.034 ± 0.009	0.407
15–30	0.201 ± 0.036	0.090 ± 0.016	0.030 ± 0.006	0.321
30–45	0.115 ± 0.029	0.060 ± 0.011	0.028 ± 0.008	0.203
45–60	0.098 ± 0.030	0.046 ± 0.015	0.024 ± 0.003	0.168
Litchi orchard				
0–15	0.385 ± 0.027	0.129 ± 0.015	0.041 ± 0.005	0.555
15–30	0.251 ± 0.031	0.113 ± 0.018	0.047 ± 0.008	0.411
30–45	0.115 ± 0.028	0.071 ± 0.012	0.032 ± 0.007	0.218
45–60	0.105 ± 0.026	0.067 ± 0.011	0.027 ± 0.008	0.199
Guava orchard				
0–15	0.392 ± 0.048	0.132 ± 0.024	0.060 ± 0.004	0.584
15–30	0.214 ± 0.039	0.122 ± 0.008	0.051 ± 0.003	0.387
30–45	0.186 ± 0.025	0.077 ± 0.007	0.045 ± 0.003	0.308
45–60	0.164 ± 0.022	0.070 ± 0.008	0.041 ± 0.002	0.275
Mango orchard				
0–15	0.315 ± 0.043	0.124 ± 0.002	0.061 ± 0.002	0.500
15–30	0.266 ± 0.024	0.096 ± 0.009	0.054 ± 0.007	0.416
30–45	0.119 ± 0.034	0.067 ± 0.003	0.030 ± 0.002	0.216
45–60	0.106 ± 0.029	0.050 ± 0.007	0.025 ± 0.005	0.181

± SE of the mean

Organic and biotic carbon content in six year old orchard

The total soil organic carbon content in all size fractions of soil (2000-200 µ, 200-53 µ and≤ 53 µ) was highest in mango (0.72%), followed by litchi (0.66%) and guava (0.62%). Among the different size fractions, SOC was highest in 2000-200 µ in all orchards. The highest SOC in different size fractions in surface soil was 0.47% (2000-200 µ size), 0.21% (200-53 µ size) and 0.042% (≤ 53 µ) in mango orchard (Table 64).

The biotic carbon content in different parts of six year old fruit plant in different orchards was recorded. The highest biotic-C was 14 kg C/plant in guava, followed by litchi (11.5 kg C/plant) and mango (10.4 kg C/plant) plant. Further, among the different parts of plant, mango recorded highest carbon in stem (9 kg C), litchi (8.52 kg C) and guava, both, in branches (8.22 kg C) (Fig. 80).

Table 64. Soil organic carbon content of particle size fractions in different orchards of six year old.

Soil Depth (cm)	Soil organic carbon (g/100g soil)			
	Particle size fraction			
	S1 (2000-200μ)	S2 (200-53μ)	S3 ($\leq$53μ)	Total
Control (No orchard)				
0-15	0.325 ± 0.045	0.113 ± 0.018	0.026 ± 0.008	0.464
15-30	0.258 ± 0.037	0.087 ± 0.014	0.020 ± 0.004	0.365
30-45	0.201 ± 0.018	0.061 ± 0.008	0.018 ± 0.005	0.280
45-60	0.141 ± 0.009	0.041 ± 0.012	0.016 ± 0.003	0.198
Litchi orchard				
0-15	0.440 ± 0.049	0.192 ± 0.015	0.030 ± 0.003	0.662
15-30	0.336 ± 0.024	0.084 ± 0.012	0.026 ± 0.005	0.446
30-45	0.269 ± 0.019	0.062 ± 0.007	0.018 ± 0.002	0.349
45-60	0.206 ± 0.011	0.041 ± 0.005	0.020 ± 0.004	0.267
Guava orchard				
0-15	0.435 ± 0.034	0.145 ± 0.015	0.040 ± 0.007	0.620
15-30	0.261 ± 0.038	0.117 ± 0.014	0.043 ± 0.005	0.421
30-45	0.216 ± 0.024	0.071 ± 0.011	0.019 ± 0.003	0.306
45-60	0.200 ± 0.017	0.064 ± 0.011	0.018 ± 0.002	0.282
Mango orchard				
0-15	0.469 ± 0.042	0.212 ± 0.010	0.042 ± 0.007	0.723
15-30	0.367 ± 0.044	0.121 ± 0.012	0.032 ± 0.004	0.520
30-45	0.302 ± 0.022	0.086 ± 0.011	0.030 ± 0.007	0.418
45-60	0.150 ± 0.137	0.070 ± 0.019	0.023 ± 0.004	0.243

± SE of the mean

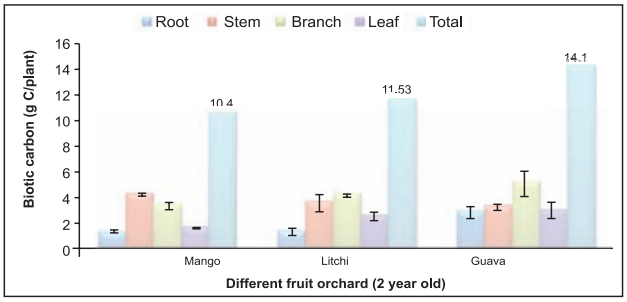


Fig. 80. Biotic carbon content in six year old orchard

Microbial activities and biomass in the soils of different fruit orchard

The rhizospheric soils of different fruit orchards (no orchard, litchi, guava and mango) of four year old were collected at monthly interval for study of microbial diversities. The fresh soils from these orchards were subjected to microbial analysis. Maximum fungal and bacterial colony forming units were observed in the month of November, 2013 followed by January, 2014. Furthermore, maximum fungal activities were observed in guava soils, followed by litchi and mango

(Fig. 81). Similarly, the bacterial/actinomycetes activities were gradually increased from September 2013 and attained its peak in the month of November 2013 and thereafter decreased abruptly in the month of December, 2013. It was observed that the bacterial/actinomycetes activities were highest in litchi orchard soil followed by mango and guava in November 2013. However, a sharp peak activity was observed in the month of January 2014 and recorded the highest in litchi orchard soil followed by mango and guava (Fig. 83).

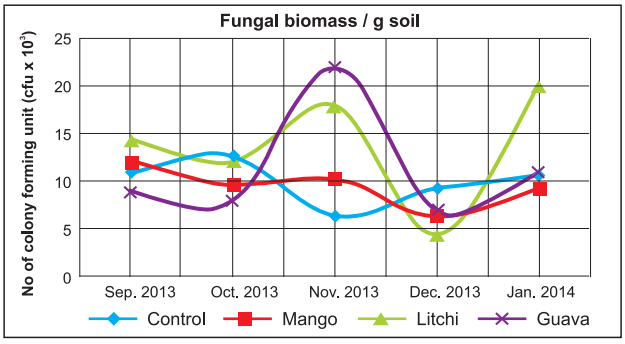


Fig. 81. Fungal biomass in different orchard soils

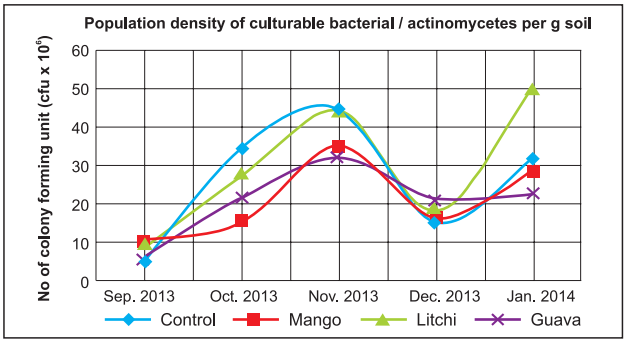


Fig. 82. Bacterial/actinomycetes biomass in different orchard soils

Exploration of biocontrol agents for the management of soil borne phytopathogens in eastern plateau and hill region

Thirty eight isolates of *Trichoderma* were isolated, and characterized for their phosphate solubilization and antagonistic potential against some important soilborne phytopathogens, *viz*., *Fusarium*, *Sclerotium* and *Rhizoctonia*. Two isolates of *Trichoderma* (Th7 and Th14) were identified potential for antagonism, plant growth promotion, phosphate solubilization and cellulase activity. Both the isolates were also characterized for their heavy metal scavenging potential under *in vitro* conditions. The Th7 isolate of *Trichoderma* showed strong scavenging potential of heavy metal {especially Cadmium (Cd) and Lead (Pb)} as compared to Th14. Mass multiplication technique of these potential isolates (Th7 and Th14) of *Trichoderma* was developed on grain and talc based ($CaSO_4$ and $CaCO_3$) formulations. Both the isolates of *Trichoderma* were applied in *Fusarium* wilt sick plot as a seed treatment of pea and furrow application with vermicompost (Fig. 126). The performance in disease controlling efficacy showed 100% protection against *Fusarium* wilt of pea (Fig. 84).

In development of consortia based formulation, three rhizospheric *Pseudomonas* species (A1, A2 and C3) were identified. The *Pseudomonas* species A2 and C3 were found to be compatible with *Trichoderma* isolates Th7 while A1 and C3 with Th14 isolate. They may be mixed together for development of consortia formulation which will have multifaceted mode of action when applied in the field.

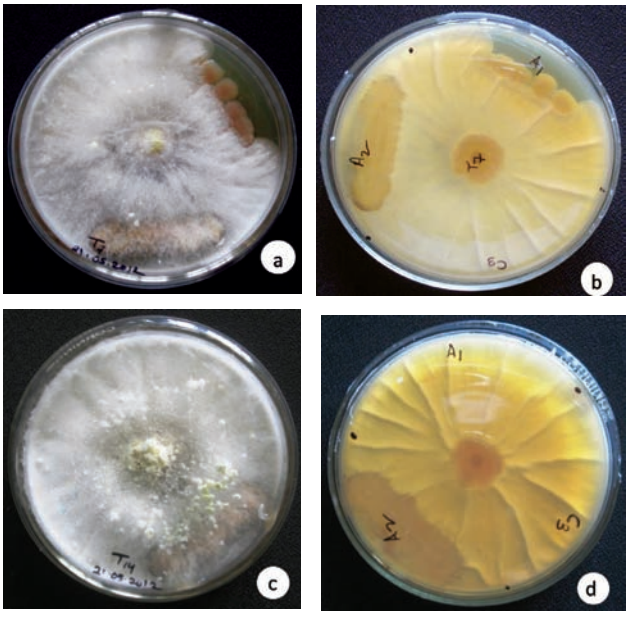


Fig. 83. Test of compatibility of Trichoderma Th 7 with strains of Pseudomonas (A1, A2 and C3, respectively) (a) front view, (b) back view; Th 14 with strains of Pseudomonas (A1, A2 and C3, respectively) (c) front view, d. back view.

Fig. 84. (a) Talc based Trichoderma formulation, (b) Trichoderma based formulation applied in the field of garden pea

14. Water Quality and Productivity

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

An experiment was conducted to evaluate the efficacy of different growth stage based fertigation and crop geometry on yield potential of sweet corn and tomato in acidic soils of eastern hill and plateau region. The experiment comprised of three growth stage based fertigation level of F_1, F_2 and F_3 and four crop geometry S_1, S_2, S_3 and S_4 of twelve treatment combinations. The experiment was laid out in split plot design of summer (sweet corn–cauliflower–tomato) and winter crops (tomato–broccoli–chilli).

Tomato and chillies seedlings were transplanted as per the planting geometry as 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 (PR) 60 cm (Triangulated paired row system), S_3–PP 50 cm; RR 40 cm; PR 60 cm (Triangulated paired row system) and S_4-PP 70 cm; RR 40 cm: PR 70 cm (Triangulated paired row system).

In broccoli, planting geometry as S_1-PP 50 cm; RR 50 cm (square with two rows per lateral system), S_2-PP 30 cm; RR 40 cm; PR 60 cm (triangulated paired rows per lateral system), S_3-PP 45 cm; RR 40 cm; PR 60 cm (triangulated paired row system) and S_4- PP 60 cm; RR 40 cm: PR 70 cm (triangulated paired row system) in an area of 1800 sq. m. was followed.

The three fertigation level as per the crop duration was applied on tomato, chilies and broccoli. The recommended dose of 120:60:60 kg NPK in tomato (Fig. 85 & 86), 50:60:60 kg NPK in chilli and 150:60:60 kg NPK in broccoli was applied.

Effect of different treatments on tomato

At 90 days after transplanting and using fertigation pattern (FP_2) significant differences

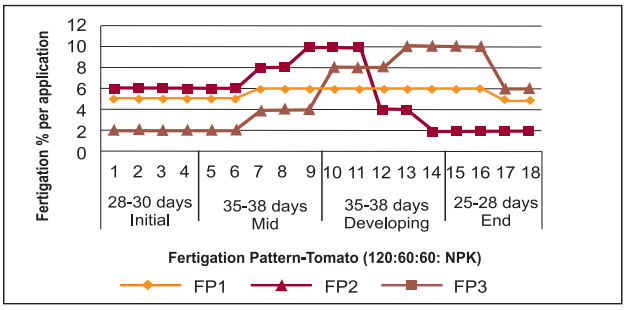


Fig. 85. Fertigation schedule of tomato at different stages

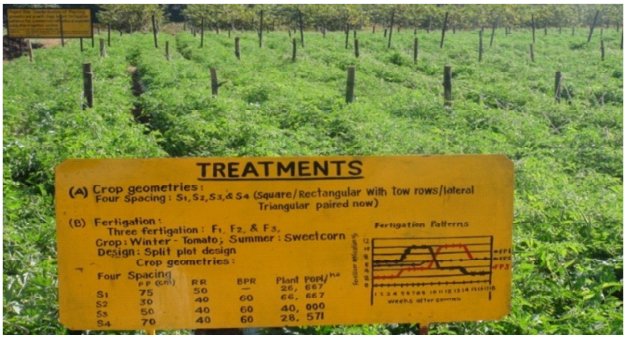


Fig. 86. Tomato cultivation in different geometry and fertigation pattern

were recorded in plant height. Planting geometry, however, did not show any significant differences in plant height. The analysis of data revealed that fruit yield/ plant were significantly affected by the fertigation pattern and crop geometry and fertigation pattern FP_2 resulted in highest fruits yield (874 g/plant) with S_1 planting geometry. The planting geometry S_4 showed highest tomato yield of 98.34 t/ha. (Fig. 87)

Estimation of water use efficiency (WUE) under different treatments in tomato indicated significant difference among the fertigation treatments. The highest WUE (37.6 kg/m^3) was recorded in fertigation pattern FP_3 as depicted in Fig. 88. The S_4 planting geometry showed the highest water use efficiency of 41.3 kg/m^3. The fertigation pattern FP_3 with planting geometry S_4 showed maximum water use efficiency of 41.3 kg/m^3.

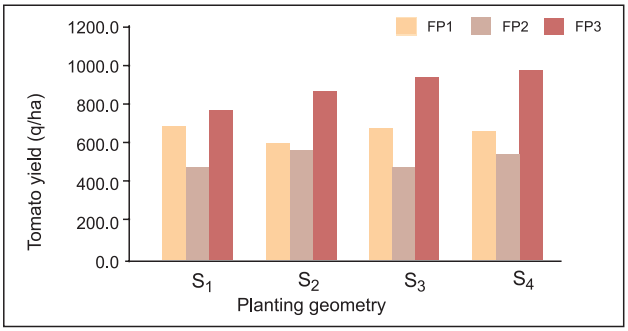


Fig. 87. Tomato yield (q/ha) under different treatments as affected by fertigation pattern and planting geometry

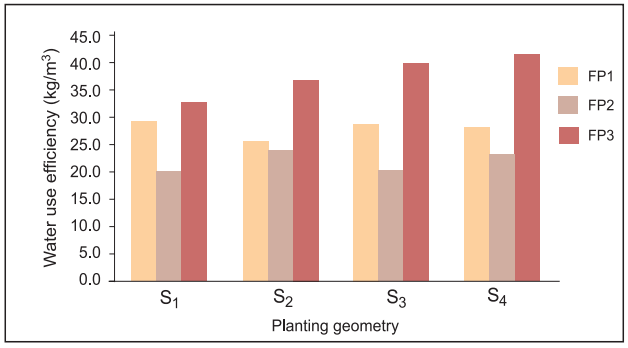


Fig. 88. Water use efficiency (kg/m^3) as affected by fertigation pattern and planting geometry in tomato

Estimation of water productivity indicated significant effect of fertigation pattern and non-significant effect of planting geometry. The highest water productivity of 375.6 ₹/m^3 was recorded in fertigation pattern FP_3. The fertigation pattern FP_3 with planting geometry S_4 showed maximum water productivity of 412.7 ₹/m^3.

Effect of different treatments on chilli

Planting geometry and fertigation pattern did not show any significant differences with respect to yield of chilli. The fertigation pattern FP_1 was best with treatment mean of 10.53 t/ha and found at par with the fertigation pattern FP_3 (Fig. 89).

Estimation of water use efficiency and water productivity indicated that none of the treatment had significant effect on chilli productivity.

Effect of different treatments on broccoli

The plant height of broccoli was recorded at 30, 60 and 90 days after transplanting (DAT) (Fig. 90). At 90 DAT, the fertigation pattern showed significant difference and highest plant height of 63.9 cm was observed in FP_3 with S_4 planting geometry. The plant height of broccoli in FP_3 was at par with

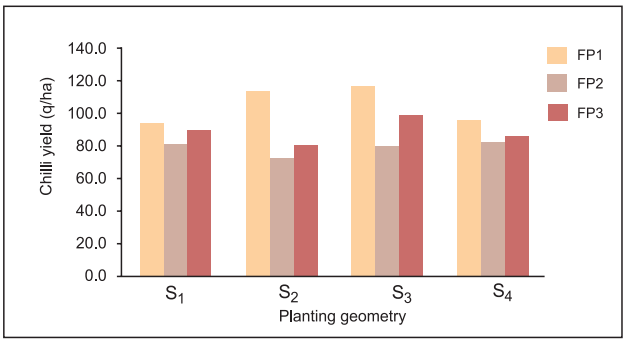


Fig. 89. Chilli yield (t/ha) as affected by fertigation pattern and planting geometry

Fig. 90. Broccoli cultivation under different geometry and fertigation pattern

FP_2 treatment. Planting geometry, however, did not show any significant differences in plant height.

The fertigation pattern FP_2 recorded highest yield of 20.05 t/ha. The broccoli yield obtained under fertigation pattern FP_3 was 16.98 t/ha, which was statistically at par with FP_2. The S_2 planting geometry recorded the highest yield of 18.95 t/ha and was statistically at par with S_3 planting geometry.

The fertigation pattern and planting geometry had significant effect on water use efficiency (Fig. 91). The highest water use efficiency (8.4 kg/m^3) was observed in fertigation pattern FP_2 followed by FP_3 (7.1 kg/m^3) (Fig. 92). Planting geometry S_2 showed the maximum water use efficiency of 7.7 kg/m^3 and was statistically at par with S_3.

The planting geometry had significant effect on water productivity. The highest water productivity was 83.8 ₹/m^3 in FP_2 fertigation pattern. The water productivity of broccoli obtained under crop geometry S_2 was found to be best and was statistically at par with S_1 and S_3. The highest water productivity of 77.3 ₹/m^3 was recorded in fertigation pattern FP_2 with S_2 planting geometry, respectivily.

Effect of different treatments on sweet corn

The fertigation pattern FP_3 with S_4 planting geometry recorded highest yield of 15.95 t/ha and was

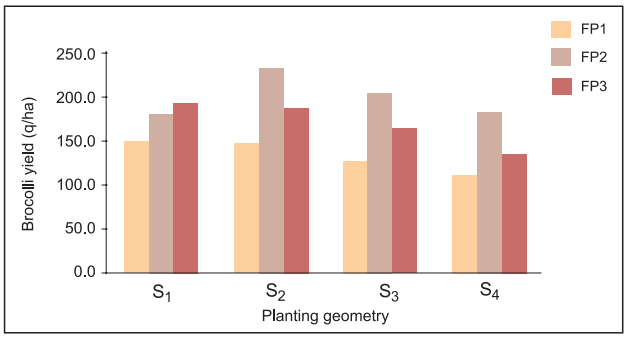


Fig. 91. Broccoli yield (q/ha) as affected by fertigation pattern and planting geometry

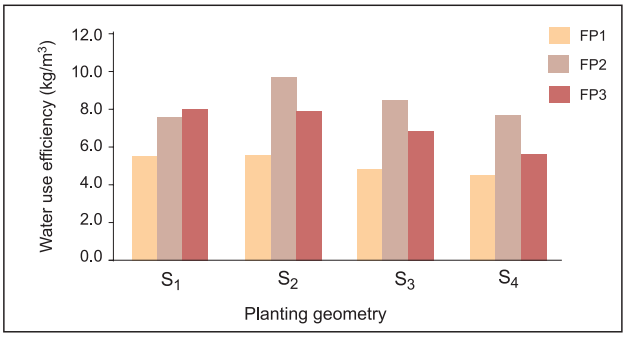


Fig. 92. Water use efficiency of broccoli as affected by fertigation pattern and planting geometry

at par with fertigation pattern FP_3 with S_1 planting geometry (15.87 t/ha). The statistical analysis revealed that fertigation pattern had significant effect on water use efficiency and the highest water use efficiency (11.8 kg/m^3) was observed in fertigation pattern FP_3 with S_4 planting geometry.

Application of micro-irrigation in system of wheat intensification for enhancing water productivity

An experiment was conducted to investigate the performance of three irrigation methods *viz.*, I_1–Low Energy Water Application (LEWA), I_2–Micro-sprinkler and I_3–surface irrigation (check basin) along with three wheat sowing methods *viz.*, E_1–System of wheat intensification (SWI), E_2–Line sowing (LS) and E_3–Broadcast sowing (B) for enhancing water productivity.

Almost all the growth parameters including root area at different stages as well as LAI at flowering stage were found significant. Maximum grain and straw yield was recorded in LEWA, followed by micro sprinkler irrigation system and found significantly superior over check basin. Among method of sowing, maximum grain and straw yield was recorded in SWI and found significantly superior over surface irrigation and remained at par with line sown crop. The gross WP (3.47 kg/m^3) was recorded in micro sprinkler under SWI followed by LEWA and check basin (Table 65).

Table 65. Comparative WP and volume of water used in different irrigation methods in wheat crop

Irrigation method	Grain yield (t/ha)	Straw yield (t/ha)	WP gross inflow (kg/m^3)	WP irrigation (kg/m^3)	Vol. of rain fall (m^3)	Vol of irrigation (m^3)	% less irrigation than check basin
LEWA	6.30	8.12	3.14	4.34	554	1450.23	41.05
Micro Sprinkler	5.47	7.07	3.47	5.35	554	1022.48	58.44
Check Basin	4.69	6.08	1.56	1.91	554	2460.25	–

Refinement of LEWA for its better performance

Refinement in LEWA with engineering plastic material, i.e., High Density Polypropelene was tried (Fig. 93), due to which the brittleness of LEWA device was minimised and provided strength. Less clearance between bush and socket was designed to minimize the leackage. It was also proposed to fit O-ring between bush and socket to minimize spill over of water from LEWA device. Locking system between bush and T of LEWA device was designed in such a way that it will stop LEWA device from coming out of bush and socket arrangement of the system at higher pressure. LEWA System was demonstrated and popularized among farmers, researches and manufacturers. Institute like Cen-

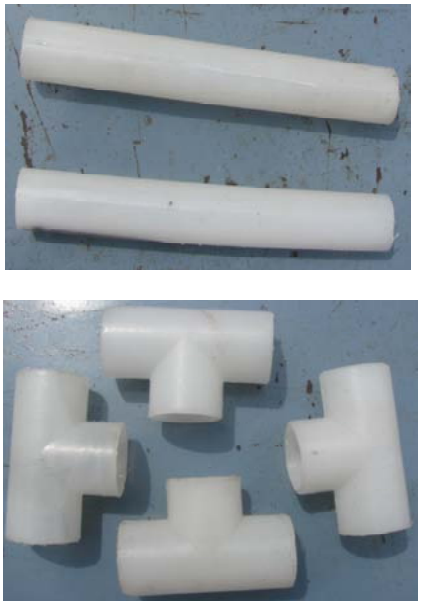


Fig. 93. LEWA manufactured out of pipe of High Density Polypropelene for increasing the life span against breakage

tral Institute of Plastic Engineering & Technology and small scale manufacturer Plastic Abhiyanta, Kolkata were consulted to manufacture it at a large scale.

Land suitability classification for different crops using remote sensing and GIS

Resource survey of Madhubani district related to water resources, soil type, texture, soil properties, present crops and cropping pattern, water-logged area, flooded area, etc were carried out. Soil samples from four blocks of Madhubani district were collected and tested in the institute laboratory for their chemical properties. (Table 66).

Table 66. Soil samples collected and tested for chemical properties of soil from four blocks

Name of blocks/ N, P, K, pH and EC Status	N (kg/ha)	P (kg/ ha)	K (kg/ ha)	pH	EC (ds/m)	OC (%)
Phulparas (East)	150.53	16.526	148.28	6.68	0.34	0.53
Benipatti (West)	194.43	22.937	161.45	6.69	0.22	0.31
Ladania (North)	165.28	18.275	179.85	6.73	0.19	0.55
Pandaul (South)	175.61	11.279	195.35	6.17	0.36	0.51

Ground water resource data collected in Madhubani district of Bihar

Data collected on ground water resources in different blocks of Madhubani districts of Bihar were analyzed (Table 67). The net annual ground water availability in the district was 102856.0 ha.m. Ground water available for irrigation was 25666.8 ha.m. and the stage of ground water development was 30.6% and all the blocks of this district come under safe category because the stage of ground water development is very low (30.6%). The blocks like Pandaul and Basopatti have the highest level of ground water development, i.e., 51% and 44.7%, respectively. The stage of ground water development is lowest in Laukaha block (16.7%). Ground water availability is maximum (9184.1 ha.m.) in Jainagar district and the minimum (3251.7) in Lakhnaur district. So it is observed from above analysis that Jainagar district has the more possibility of taking irrigated crops and may be less dependent on rain.

Table 67. Block wise replenishable ground water resources (m ha) data in Madhubani district

Assessment unit/ blocks	Net annual ground water availability	Existing gross ground water draft for Irrigation	Existing ground water draft for domestic and industrial water supply	Existing gross ground water draft for all uses	Allocation for domestic and industrial requirement supply for upto next 25 years	Net ground water availability for future irrigation development	Stage of ground water development
B	C	D	F	(D+F)	G	(C-D-G)	(D+F)* D/C(%)
Andaratharhi	3498.4	675.7	231.2	906.9	349.4	2473.3	25.9
Babubarhi	5687.9	1140.3	273.7	1414.0	413.6	4134.0	24.9
Basopatti	3499.9	1352.1	212.7	1564.7	321.4	1826.4	44.7
Benipatti	6533.5	1492.0	449.0	1941.0	678.6	4362.9	29.7
Bisfi	5725.6	1495.0	411.3	1906.3	621.6	3609.0	33.3
Ghoghardiha	4349.6	870.7	291.9	1162.5	447.5	3031.4	26.7
Harlakhi	3910.2	712.3	238.2	950.5	360.0	2837.9	24.3
Jainagar	9184.1	2260.8	299.9	2560.7	461.9	6461.5	27.9
Jhanjharpur	4184.1	1087.4	329.3	1416.6	508.3	2588.4	33.9
Khajauli	6522.5	2203.4	327.0	2530.4	494.2	3824.9	38.8
Ladania	5403.8	1481.9	216.2	1698.2	326.8	3595.0	31.4
Lakhnaur	3251.7	862.7	211.1	1073.8	319.0	2069.9	33.0
Laukaha	6009.4	739.3	263.4	1002.7	398.2	4872.0	16.7
Laukahi	7063.6	2071.6	255.5	2327.0	386.1	4605.9	32.9
Madhepura	6886.2	1143.4	342.6	1486.0	517.7	5225.1	21.6
Madhubani	4314.9	1028.0	394.4	1422.4	604.8	2682.1	33.0
Madhawpur	3295.0	750.2	178.4	928.6	269.6	2275.2	28.2
Pandaul	4420.5	1942.0	343.8	2285.8	519.6	1959.0	51.7
Phulparas	4400.6	1146.9	204.8	1351.7	309.5	2944.2	30.7
Rajnagar	4714.4	1211.2	313.9	1525.1	474.5	3028.7	32.4
Total	102856.0	25666.8	5788.1	31454.9	8782.4	68406.8	30.6

15. Conservation Agriculture

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

A field experiment was conducted to evaluate the production technology of resource conservation and methods of planting vegetable cropping system of cauliflower-brinjal-tomato in acid soil of eastern hill and plateau region. (Fig. 94) with a plot size of 22.4 sq. m.

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 and furrow with no plastic mulch) and T_6 (ridge and furrow with plastic mulch) based on drip irrigation. Seventy five per cent manures and fertilizer were applied as recommended basal dose in first crop and 50% each in subsequent 2nd and 3rd crops supplemented by fertigation. The minimum tillage was practiced in mulched treatment by uprooting of crop and planting seedlings of subsequent crop. The results revealed that plastic mulches and different methods of planting have significant effect on weed biomass production and yield attributes of cauliflower (Fig. 95). The mulched treatments showed significantly less weed biomass production in comparison to non mulched treatments. The maximum weed biomass was 27.57 kg/plot in

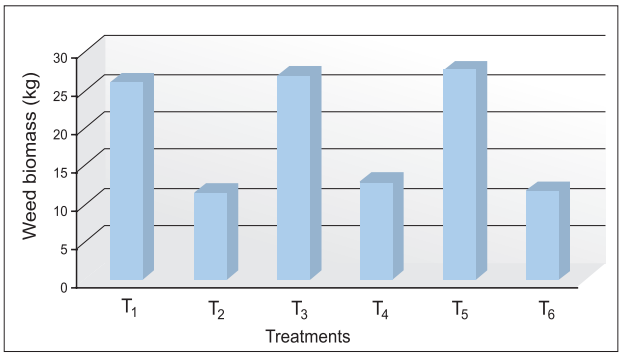


Fig. 95. Weed biomass (kg/ plot) in cauliflower

ridge and furrow followed by broad bed without mulch and least was recorded in flat bed with mulch (11.57 kg/plot) (Fig. 96).

Plastic mulch with ridge and furrow showed maximum cauliflower yield of 35.79 t/ha. The flat bed with no plastic mulch showed lowest cauliflower yield of 14.45 t/ha. The yield recorded in plastic mulching with different systems of planting was higher than non-mulching. The ridge and furrow planting method was found to be superior to other methods of planting irrespective of mulched or non mulched which was followed by broad bed (Fig. 97). There was significant variation in soil moisture content in mulched and non-mulched condition during the crop season, which resulted in yield variation in different treatments. (Fig. 98).

Fig. 94. View of experimental field

Fig. 96. View of cauliflower crop in the field

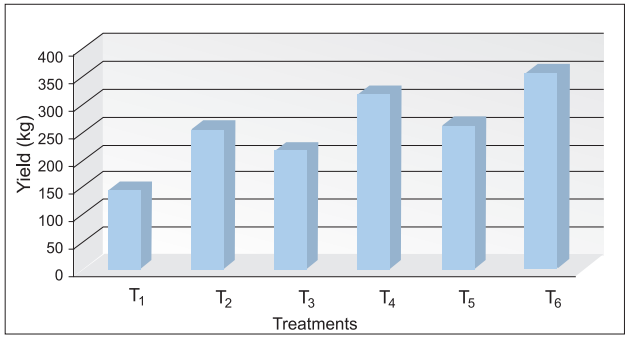


Fig. 97. Yield attributes of cauliflower

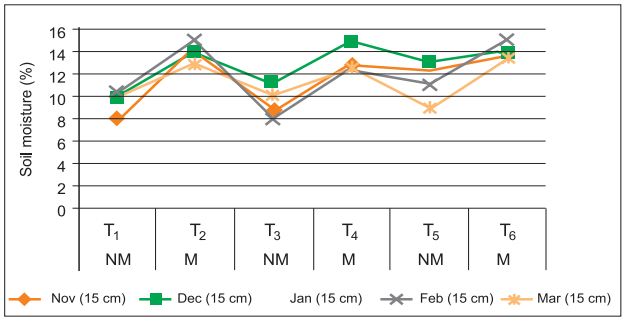


Fig. 98. Soil moisture variation of cauliflower

The data pertaining to water use efficiency (WUE) and water productivity (WP) of vegetable crops revealed that the mulched treatment recorded higher WUE and WP than the non mulched and more economic return (Fig. 99). In cauliflower, highest WUE of 9.54 kg/m^3 and water productivity of ₹ 95.44 /m^3 was found in ridge and furrow method (Table 68).

Table 68. Water use efficiency and water productivity of cauliflower

Treatments	Water use efficiency (kg/m^3)	Water productivity (₹/m^3)
T_1	3.85	38.54
T_2	6.78	67.90
T_3	5.76	57.72
T_4	8.48	85.18
T_5	6.94	69.51
T_6	9.54	95.44
CD (0.05)	2.11	

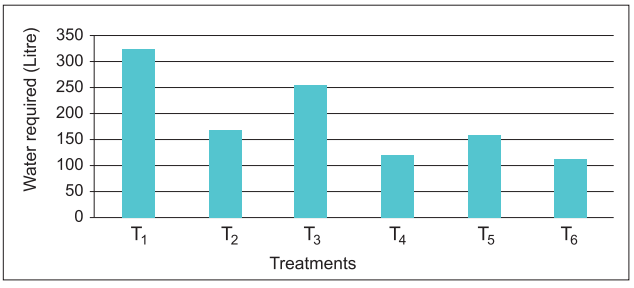


Fig. 99. Water required to produce one kg of cauliflower

Nutrient balance in different resource conservation technology for vegetable cultivation

Nitrogen: In the flat bed system of planting with and without plastic mulch, there was slight increase in actual gain in N content of soil after harvest of cauliflower. However, there was apparent loss of N in mulched and without mulched flat bed system of planting. Further, there was increase of apparent gain and actual gain in N content of soil after harvest of cauliflower in the raised bed system of planting with and without plastic mulch followed by the ridge and furrow system of planting. The highest actual and apparent gain of N was 35 .37 and 29.37 kg/ha, respectively in raised bed system of planting with plastic mulch (Table 69). The higher actual and apparent gain of N in ridge and furrow and raised bed system of planting may be attributed to the higher mineralisation rate of N compared to flat bed system of planting. In the second crop of brinjal, both the actual and apparent gain of N started to decline in all the systems of planting (Table 70). The actual and apparent loss of N after harvest of brinjal may be attributed to the poor physical structure of the rhizospheric soils which resulted in loss of N through surface run-off, leaching and volatilization.

Table 69. Nitrogen balance sheet after 1st crop of cauliflower under RCT

Treatment	Initial status (kg/ ha) A	Nutrient added (kg/ ha) B	Crop uptake (kg/ ha) C	Expected balance (kg/ha) D=A+B-C	Actual balance (kg/ha) E	Apparent gain/loss (kg/ha) F=E-D	Actual gain/loss (kg/ha) G=E-A
T_1	250.5	176	152	274.5	251.82	-22.68	1.32
T_2	250.5	176	160	266.5	255.66	-10.84	5.16
T_3	250.5	176	166	260.5	276.11	15.61	25.61
T_4	250.5	176	170	256.5	285.87	29.37	35.37
T_5	250.5	176	160	266.5	266.56	0.06	16.06
T_6	250.5	176	168	258.5	279.74	21.24	29.24

Table 70. Nitrogen balance sheet after 2nd crop of brinjal under RCT

Treatment	Initial status (kg/ha) A	Nutrient added (kg/ha) B	Crop uptake (kg/ha) C	Expected balance (kg/ha) D=A+B-C	Actual balance (kg/ha) E	Apparent gain/loss (kg/ha) F=E-D	Actual gain/loss (kg/ha) G=E-A
T_1	251.82	105	72	284.82	198.4	-86.42	-53.42
T_2	255.66	105	81	279.66	237	-42.66	-18.66
T_3	276.11	105	72	309.11	252	-57.11	-24.11
T_4	285.87	105	80	310.87	286	-24.87	0.13
T_5	266.56	105	69	302.56	243.68	-58.88	-22.88
T_6	279.74	105	83	301.74	260	-41.74	-19.74

Phosphorus: The actual gain of P after harvest of cauliflower was recorded with use of plastic mulch in all the systems of planting (Table 71). However, there was actual loss of P in non-mulched planting systems after harvest of cauliflower. The actual gain of P in mulched plots may be attributed to the formation of uniform soil moisture zone in the rhizospheric soil which resulted in increased availability of P as compared to non-mulch system of planting. The highest actual gain of P was 10.31 kg/ha in raised bed system of planting with plastic mulch. There was an apparent loss of P in all the systems of planting irrespective of plastic mulch due to fixation of P by sesquioxide in acidic soil. Further, after the harvest of second crop of brinjal, there was actual as well as apparent loss of P in all the systems of planting (Table 72).

Potassium: The actual gain of K after harvest of cauliflower was recorded in the treatments having plastic mulch (Table 73). The highest actual gain was 20.67 kg/ha in raised bed with plastic mulch over the initial K status in soil. There was an apparent loss of K in all the systems of planting, except in raised bed and ridge and furrow with plastic mulch, due to leaching of K in the acidic sandy loam soils. After the harvest of cauliflower, there was actual as well as apparent loss of K in all the systems of planting in brinjal due to compaction of the soils resulting from no tillage (Table 74).

Table 71. Phosphorus balance sheet after 1st crop of cauliflower under RCT

Treatment	Initial status (kg/ha) A	Nutrient added (kg/ha) B	Crop uptake (kg/ha) C	Expected balance (kg/ha) D=A+B-C	Actual balance (kg/ha) E	Apparent gain/loss (kg/ha) F=E-D	Actual gain/loss (kg/ha) G=E-A
T_1	55.5	76	16	115.5	49.53	-65.97	-5.97
T_2	55.5	76	20	111.5	62.61	-48.89	7.11
T_3	55.5	76	14	117.5	53.31	-64.19	-2.19
T_4	55.5	76	15	116.5	65.81	-50.69	10.31
T_5	55.5	76	15	116.5	51.21	-65.29	-4.29
T_6	55.5	76	14	117.5	59.14	-58.36	3.64

Table 72. Phosphorus balance sheet after 2nd crop of brinjal under RCT

Treatment	Initial status (kg/ha) A	Nutrient added (kg/ha) B	Crop uptake (kg/ha) C	Expected balance (kg/ha) D=A+B-C	Actual balance (kg/ha) E	Apparent gain/loss (kg/ha) F=E-D	Actual gain/loss (kg/ha) G=E-A
T_1	49.53	60	15	94.53	45.5	-49.03	-4.03
T_2	62.61	60	18	104.61	58.33	-46.28	-4.28
T_3	53.31	60	16	97.31	47.32	-49.99	-5.99
T_4	65.81	60	19	106.81	60.34	-46.47	-5.47
T_5	51.21	60	17	94.21	45.27	-48.94	-5.94
T_6	59.14	60	19	100.14	55.24	-44.9	-3.90

Table 73. Potassium balance sheet after 1st crop of cauliflower under RCT

Treatment	Initial status (kg/ha) A	Nutrient added (kg/ha) B	Crop uptake (kg/ha) C	Expected balance (kg/ha) D=A+B-C	Actual balance (kg/ha) E	Apparent gain/loss (kg/ha) F=E-D	Actual gain/loss (kg/ha) G=E-A
T_1	280	82	70	292	278.72	-13.28	-1.28
T_2	280	82	72	290	285.00	-5.00	5.00
T_3	280	82	73	289	280.03	-8.97	0.03
T_4	280	82	77	285	300.67	15.67	20.67
T_5	280	82	70	292	273.92	-18.08	-6.08
T_6	280	82	74	288	289.01	1.01	9.01

Table 74. Potassium balance sheet after 2nd crop of brinjal under RCT

Treatment	Initial status (kg/ha) A	Nutrient added (kg/ha) B	Crop uptake (kg/ha) C	Expected balance (kg/ha) D=A+B-C	Actual balance (kg/ha) E	Apparent gain/loss (kg/ha) F=E-D	Actual gain/loss (kg/ha) G=E-A
T_1	278.72	84	70	292.72	255	-37.72	-23.72
T_2	285.00	84	79	290.00	268	-22.00	-17.00
T_3	280.00	84	67	297.00	265	-32.00	-15.00
T_4	300.67	84	76	308.67	290	-18.67	-10.67
T_5	273.92	84	69	288.92	255	-33.92	-18.92
T_6	289.01	84	79	294.01	275	-19.01	-14.01

Post harvest studies of vegetable crops in different RCTs

The shrink pack exhibited less physiological loss in weight than unpack sample. The shrink pack resulted in higher appearance ratings and less curd and bud discoloration. However, shrink pack under heat should be avoided as it leads to damage of curd tissue resulting in a favourable environment for decay. Among field treatments, T_2 (flat bed with minimum tillage and plastic mulch) exhibited minimum physiological loss in weight as well as minimum dry matter content (Fig. 100 & 101).

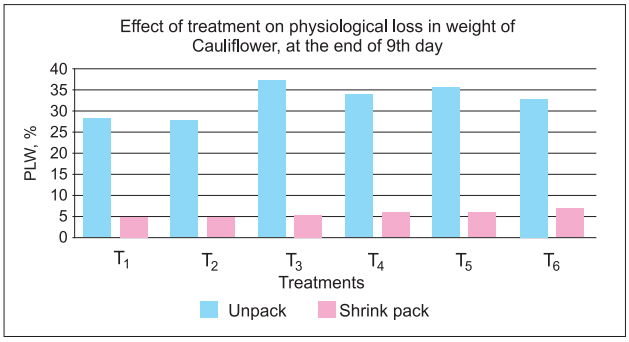


Fig. 100. Physiological loss of weight in cauliflower with influence of packing

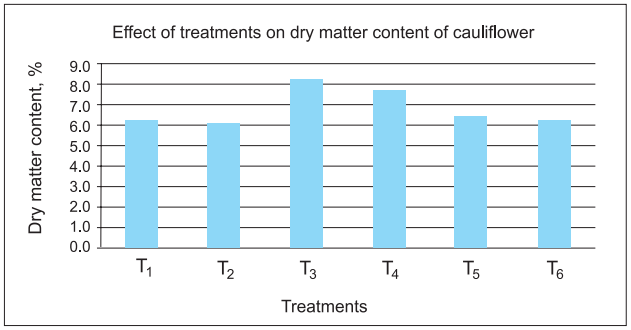


Fig. 101. Physiological loss of weight in cauliflower with influence of packing

In case of brinjal also, shrink pack exhibited less physiological loss in weight than unpack sample. The shrink pack resulted in higher appearance ratings & discoloration. Among field treatments, T_6 (Ridge and furrow with minimum tillage and plastic mulch) exhibited minimum physiological loss in weight while minimum dry matter content was found in flat bed with minimum tillage and plastic mulch (Fig. 102 & 103).

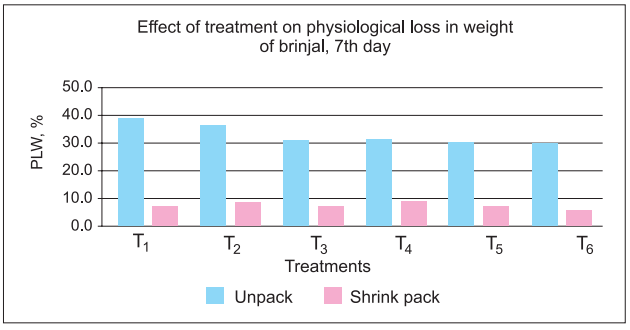


Fig. 102. Physiological loss in weight of brinjal with influence of packing

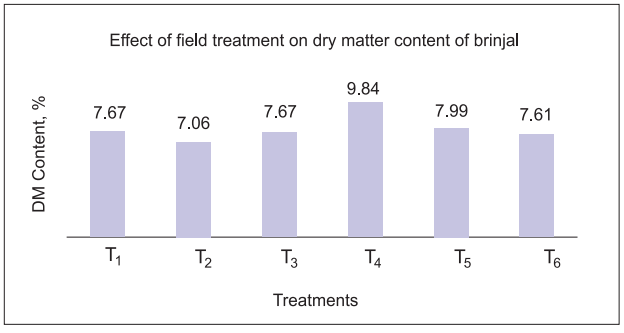


Fig. 103. Drymatter content of brinjal

Effect of tank mixture application of post emergence herbicides on complex weed flora under direct seeded rice (DSR)

DSR is getting popular in rice grown areas to save time, energy, water and labour but severe weeds is observed to be the major problem. Integrated weed management is an important tool for weed management in DSR, where tank mixtures of herbicides play a vital role in controlling complex weed flora. Keeping above facts in view, the experiment has been repeated to evaluate the efficiency of tank mixture of POE herbicides to control the weed population under DSR and to study the shifting and control of weed flora. The major weed population observed under (ZT)DSR were mainly, i.e., mixed population of narrow leaved, broad leaved and sedges. *Echinochloa* sp., *Cynodon* sp., *Leptochloa* sp., under narrow leaves weed, *Physalis* sp., *Ageratum* sp., *Cleome* sp. under broad leaved weed, and *Cyperus* sp. under sedge group were found more dominant.

Application of tank mixture of Bispyribac + Ethoxysulfuron (T_5), controlled the weeds most efficiently over other combinations except weed free treatments (T_9) and was followed by the tank mixture of Bispyribac + Azimsulfuron (T_5). Higher yield of rice (5.1 t/ha and 4.7 t/ha) was recorded under these treatments, respectively which were found at par with weed free yield (5.2 t/ha). Weed index was found minimum (Fig. 104) while, weed control efficiency was found higher to the tune of 82.7% with spray of tank mixture of Bispyribac + Ethoxysulfuron (Fig. 105) than other weedicide combinations applied (Table 75).

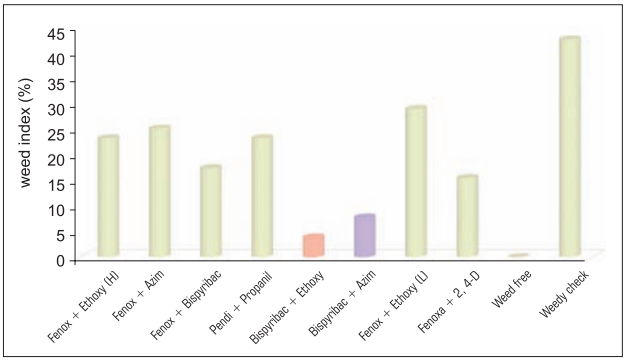


Fig. 104. Weed index at 60 DAS as affected by different tank mixture of herbicides

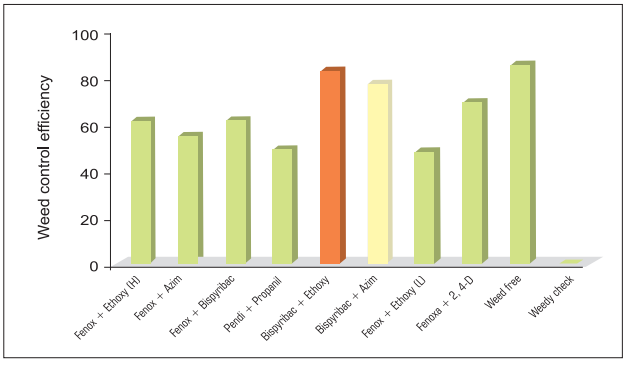


Fig. 105. Weed Control efficiency at maturity as affected by different tank mixture of herbicides

Table 75. Effect of different weed management practices on weed density, weed dry weight, weed index and weed control efficiency in direct seeded rice

Treatment	Weed density/ m^2			Weed dry wt. (g)			Weed index(%)	W.C.E. (%)
	15 DAS	40 DAS	Flowering	15 DAS	40 DAS	Flowering	at maturity	at flowering
T_1	19.1	21.5	26.0	6.02	47.8	77.3	23.1	61.1
T_2	24.2	25.0	30.2	7.15	61.4	89.5	25.0	54.9
T_3	19.3	21.7	25.8	5.34	50.2	73.5	17.3	61.4
T_4	22.3	27.3	34.0	7.00	78.2	100.2	23.1	49.2
T_5	14.9	13.5	11.6	5.83	30.2	49.6	3.8	82.7
T_6	16.3	15.0	15.4	6.02	38.3	57.0	7.7	77.0
T_7	23.0	26.1	34.8	6.77	61.2	80.6	28.8	48.0
T_8	18.5	21.0	20.6	6.40	44.8	66.8	15.4	69.2
T_9	18.2	12.5	10.0	5.63	17.5	34.6	-	85.1
T_{10}	34.2	47.6	66.9	8.12	138.4	233.0	42.3	-
S.E.M.±	4.87	3.82	3.63	2.42	5.7	4.4	1.9	1.8
C.D. (P=0.05)	14.5	11.3	10.8	7.19	16.9	13.1	5.6	5.3

16. Livestock and Fisheries

■ LIVESTOCK

Characterization of Lesser Known Breeds of Farm Animals in Eastern India

Field survey was undertaken in 53 villages belonging to 5 blocks of Sitamarhi district of Bihar to study the morphometric and performance traits of Bachaur cattle in its breeding tract. A total of 752 animals of both sexes belonging to different age groups were studied. The results revealed that the Bachaur cattle was a small sized breed with height at withers, body length and chest girth were found to be 119.23±0.47 cm, 116.99±0.48 cm and 150.88±0.55 cm in adult males and 112.53±0.25 cm, 109.71±0.25 cm and 140.46±0.32 cm in adult females, respectively. The estimated body weights of adult Bachaur cattle were 246.76 ± 2.42 kg and 200.55 ± 1.32 kg for males and females, respectively (Fig. 106).

Among the draught breeds of India, the Bachaur cows are reasonably good milkers with an average lactation yield of 752.10±5.82 kg/yr and peak yield of 4.70±0.07 kg per day. The breed is reported to be regular in reproduction cycle with the age at first calving and calving interval of 31.55 ± 0.35 months and 14.44 ± 0.22 months, respectively. Bachaur cattle fulfilled the livelihood requirement of cattle farmers in the breeding tract by its draught power to a greater extent and by milk and dung to a smaller extent.

Buffalo Improvement

In order to improve the productivity of buffaloes, the institute is maintaining a herd of Murrah buffaloes with adult herd strength of 20 animals. The objective of the project is to assist in selection of elite Murrah bulls for improving milk productivity. The test semen doses of elite buffalo bulls were brought from CIRB, Hisar and used in AI programme in buffaloes being maintained under institute farm and at 6 cooperative centres of Patna and Vaishali districts.

The different production traits such as lactation milk yield, peak yield, lactation length and fat percentage recorded under this project in the institutional herd are depicted in the Table 76.

Table 76. Production performance of Murrah buffaloes in Bihar

Parameter	Mean±S.E.
Lactation milk yield (kg)	2106±70.14
Lactation length (days)	278.35±4.75
Peak yield (kg/day)	12.3±1.25
Fat percentage	7.12±0.17

The growth parameter including monthly growth of Murrah buffalo calves recorded in the institute herd is illustrated in Fig. 107.

The number of effective inseminations carried out and the overall conception rate achieved in institute herd and under field conditions are presented in Table 77.

Fig. 106. (a) Bachaur cow (b) Bachaur bull and (c) Bachaur cattle on farm operations

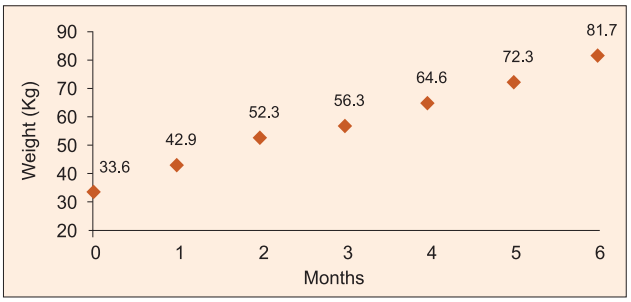


Fig. 107. Body weight of buffalo calves at different months

Table 77. Conception rate of buffalo under field conditions

Name of the location	Number of AI done	Conception rate (%)
Institute farm	23	39.7
Saidpur Ganesh Dugd Utpadak Samiti, Paanpur, Hajipur	80	34.3
Dugd Utpadak Mahila Samiti, Madhurpur, Hajipur	61	37.4
Dugd Utpadak Samiti, Gokhula, Hajipur	60	40.2
Dugd Utpadak Samiti, Beranchak, Patna	70	33.8
Dugd Utpadak Samiti, Sona Naubatpur, Patna	63	36.2
Dugd Utpadak Samiti, Pali Naubatpur, Patna	90	38.7

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

Round the year fodder production

Annual cereal and legume fodder were grown in 3.5 ha land for round the year production. Multi cut sudan as cereal and cow pea (Bundel-2), rice bean (RBS-16) and soybeans (NRC-37) as legumes were grown during rainy season. Cereal fodder was grown under 85% areas whereas, legumes under 15% areas only. The cereal fodder oat under 40% area and legume fodder berseem under 60% areas were grown on the same land during winter season (Fig. 108). The yield of perennial ground nut legume fodder, transplanted two years back, was recorded at 57.00±3.00 t/ha in three cuttings with inter-cutting gap of 55 days having DM and CP contents of 32.24 and 14.36 percent, respectively.

Season-wise total biomass yield with compositions are presented in Table 78. It is estimated that total biomass production of 67.90 t during rainy season and 51.99 t during winter season from 1ha land area is sufficient to meet fodder requirements of 14 crossbred cows round the year (Table 78 & 79). Thus, it can be concluded that this type of fodder production system is beneficial for balance feeding of ruminants.

Fig. 108. Fodder crop production in different seasons

Table 78. Season-wise production of various fodders

Particulars	Total fodder yield (t/ha)	DM (%)	CP (%DM)
Rainy season			
Sudan in 3 cuts at 60, 105 & 145d	74.78±2.92	14.48	8.72
Cow pea at 90d	29.06±4.06	12.77	15.18
Rice bean at 90d	35.67±1.52	17.19	15.30
Soybean at 90d	22.15±0.65	26.53	19.45
Winter season			
Berseem in 4 cuts at 50, 85, 115 & 145 days	67.84±1.22	11.65	15.83
Oat in 2 cuts at 50 & 105d	28.23±0.64	14.18	11.14

Table 79. Carrying capacity of one ha land through fodder cultivation

Particulars	Rainy season	Winter season
Crop composition (%)		
Cereal	85.00	40.00
Legume	15.00	60.00
Total green fodder yield (t/ha)	67.90	51.99
Mix fodder DM (%)	14.76	12.40
Mix fodder CP (%DM)	9.23	14.42
Number of cows can be fed green fodder @ 25 kg/day /head for 150 days	18	14

Effect of feeding total mixed ration on the performance in crossbred cow

Feeding experiment was conducted on crossbred cows to study the effect of total mixed ration (TMR) on milk production and nutrient digestibility. Total four cows of first lactation were selected from dairy herd of the institute and distributed into two cows in each group *viz.*, T_1 (TMR) and T_2 (Individual feeding system). TMR was prepared by

mixing wheat straw (2 kg), multi cut sudan (25 kg), rice bean (2 kg) and concentrate feed (5 kg with 17 per cent CP). The total quantities of feed were divided into two parts and each part after mixing with water given to the cows (T_1) in the morning and in the evening hours (Fig. 109). In the T_2 group, same quantities of above feed ingredients were fed separately to the cows also in the morning and evening hours. Initially wheat straw and concentrate feed was offered after mixing with water and after a gap of 1-2 hours un-chopped green forages was offered. Total 10.68 kg dry matter (DM) per day per animal was provided to both the groups. Daily milk production was recorded before and during experiment period. A digestion trial at end of the experiment was conducted to study the nutrient digestibility.

Fig. 109. Preparation of TMR and feeding to cows

At the end of study, T_1 and T_2 group showed 19.49% and 6.41% increase in milk production, respectively. This increase might be due to feeding of balanced ration either in mixed form or fed separately.

However, feeding of TMR increased 2.48% DMI (Dry matter intake), 12.43% digestibility of DM and 42.26% of CP (Table 80) in T_1 group. This might have resulted in 580 g increase in milk production per day per cow than individual feeding system. Thus, it can be concluded that feeding of TMR is beneficial for nutrient digestibility and milk production in cow.

Table 80. Performance of cow fed on TMR

Particulars	T_1	T_2
Age from date of calving (d)	246±19.50	222±2.50
Av. body wt. (kg)	354±42	360±32
Av. DMI (kg/100 kg body wt.)	4.14±0.49	4.04±0.41
Milk production (kg/d/head)		
Before experiment	5.13±0.06	6.55±0.44
During experiment	6.13±0.24	6.97±0.09
Nutrient digestibility		
DMD (%)	67.54±0.41	60.07±0.02
CPD (%)	44.70±0.91	31.42±2.72
DCP (%)	5.30±0.11	3.73±0.32
DE (Kcal.kg DMI)	2542±2.00	2287±14.50

Production Performance and Management Study of Rabbit in Bihar

Nutritive value of legume fodder for rabbit feeding

Digestion experiment was conducted in New Zealand White (NZW) rabbits to assess the nutritive value of legume fodders. Adult male NZW rabbits (n=18; average body weight of 2067±111g) were divided into three groups and kept in nine cages in pairs. All rabbits were provided concentrate pelleted ration having 18% dietary crude protein in *ad-libitum* during morning hours. Three fresh legume fodders *viz.*, perennial groundnut (T_1), rice bean (T_2) and soybean (T_3) were provided daily to the rabbits during evening hours in *ad-libitum*. After preliminary feeding of 21 days, a digestion trial was conducted for the period of 5 days. Daily feed intake and faeces voided were recorded. Samples were analyzed for dry matter (DM) and crude protein (CP). digestible crude protein (DCP) and digestible energy (DE) values were calculated and presented in the Table 81.

Table 81. Intake and nutritive value of legume fodder in rabbit

Particulars	Treatment		
	T_1	T_2	T_3
DMI (g/d/h)			
Fodder	96.95b±3.84	52.10a±2.18	65.52a±1.93
Concentrate feed	31.10b±1.54	17.91a±1.39	15.46a±2.07
Total	128.05b±5.37	70.01a±2.44	80.98a±1.91
% Fodder intake	75.73±0.22	74.42±1.77	80.95±2.31
Digestibility and nutritive value			
DMD (%)	61.49±0.93	58.57±1.39	59.56±0.86
CPD (%)	62.29b±0.56	56.06a±1.52	62.44b±0.67
DCP (%)	9.49a±0.09	8.80a±0.21	12.89b±0.40
DE (Kcal/kg DMI)	2227±16.01	2224±23.29	2235±30.14

Values with different superscripts in a row differ significantly (P<0.01). Data are expressed in Mean±SE

Significantly maximum DMI (fodder, concentrate feed and total) in rabbits was recorded in group T_1, but fodder intake percentage out of total DMI was not affected. Similarly, there were no significant differences for DM digestibility and DE value of the ration provided to rabbit, However, higher CP digestibility (P<0.01) and DCP values (P<0.01) were recorded in rabbits fed on soybean fodder (T_3). Thus, it is concluded that feeding of legume fodder to adult rabbits can save 75-80% concentrate feed requirement in rabbit.

Field Bailing of Crop Residues

It was observed that 6 t of wheat straw can be harvested from 1 ha of land if collected manually. Use of reaper recovered only 50% of straw by taking 3 hours per ha of land (Fig. 110). Cost of collection of wheat bhusa was ₹ 125 by reaper and ₹ 365 by manual operation resulting a saving of 65% of the cost. Chemical analysis of both the bhusa collected by reaper and manual operation revealed that the bhusa contained 18% more protein and 25% less acid insoluble ash.

Fig. 110. Use of reaper for collection and preparation of wheat bhusa

Soil–plant–animal continum in Bihar

Feeds & fodder, soil, blood and water samples were collected from 8 districts of Bihar from four agro-climatic zones **(**Fig. 111**).** It was observed that 100% soil samples contained excess iron, manganese and copper, however, 72% samples were deficient in Zn to the tune of 70% than the critical level**.** Similarly, rice and wheat straw contained excess of copper, iron and manganese but were deficient in zinc to the tune of 72%. All the samples of green fodder contained excess iron, copper and manganese except the green fodder collected from Darbhanga and Madhubani districts, which contained excess manganese. Green fodder collected from Jamui, Buxar and Madhubani were deficient in zinc. All grains and crop by-products used for animal feeding were deficient in manganese and zinc but contained excess iron and copper. Likewise, serum of cattle and buffalo contained excess iron and copper, however, deficient in manganese and zinc as compared to the critical values.

Fig. 111. Feeding practices of livestock in Bihar

Effect of phytase supplementation on growth performance and nutrient balance in broiler chicken

Feeding experiment was conducted on broiler chicken to study the effect of phytase enzyme supplementation on growth performance and nutrient balance. Broiler chickens (4 days old; 70 Nos.; Vencob strain) were distributed into two groups. The pelleted concentrate ration, containing dietary crude protein 19 and rice polish 12 per cent, was provided to group one (T_1) and same ration was provided to group two (T_2) after fortification with phytase enzyme @ 20 g/100 kg feed. Metabolism trial was conducted at the end of feeding experiment for the period of four days to study the nutrients balances. The results revealed that average daily gain (ADG) was increased by 2.25% with improvement in feed conversion ratio (FCR) value by 5.62% over control group due to phytase supplementation (Table 82). Similarly, DM and CP retention was also increased marginally by 2.04 and 2.17 per cent, respectively. Thus, it is concluded that phytase supplementation may be beneficial for better growth performance and nutrient balance in broiler chicken fed higher rice polish based ration.

Table 82. Growth performance and nutrient balance in broiler chicken

Particulars	T_1	T_2
Growth performance		
Initial wt. (g)	55.2±0.20	56.6±0.40
Final wt. (g)	1189±7.03	1216±10.37
ADG (g/d)	40.48±0.24	41.39±0.40
Av. feed intake (g/d)	76.30	73.59
FCR	1.88	1.78
Nutrient balance (g/100 g DM)		
DM	77.87±1.52	79.46±1.35
CP	74.17±1.27	75.78±1.06

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

A 272 bp fragment (partial intron 2, exon 3 and partial intron 3) of growth hormone gene was amplified (50 samples) by polymerase chain reaction. 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 followed by 30 cycles of denaturation at 95°C for 30 Sec, annealing at 59°C for 45 Sec, extension at 72°C for 45 sec and then final extension of 72°C at 5 min (Fig. 112).

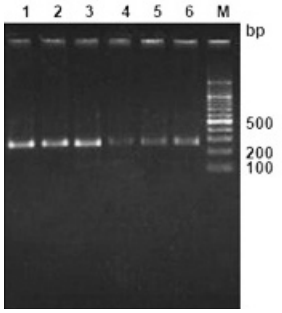


Fig. 112. Amplified 272bp fragment

Effect of various allelic pattern of amplified 245 bp fragment (partial intron 1, exon 2 and partial intron 2) of growth hormone gene on birth weight was studied by least square analysis and found that genotypes had significant effect ($P \leq 0.05$) on birth weight in Black Bengal goat (Table 95). Animals having AC genotype had highest birth weight whereas animals having CC genotype had lowest birth weight. Animals having AC genotype had 47% more weight than the animal having CC genotype. The order of performance for birth weight was AA, CC < AB, AD < AC (Table 83). One interesting finding in this study is that both the homozygote AA and CC are having lowest birth weight. However, heterozygous condition, i.e., AC genotype is having highest birth weight. Therefore, growth hormone can be used as a marker to improve growth performance in Black Bengal goat.

Table 83. Genotype wise least-square means of birth weight (kg)

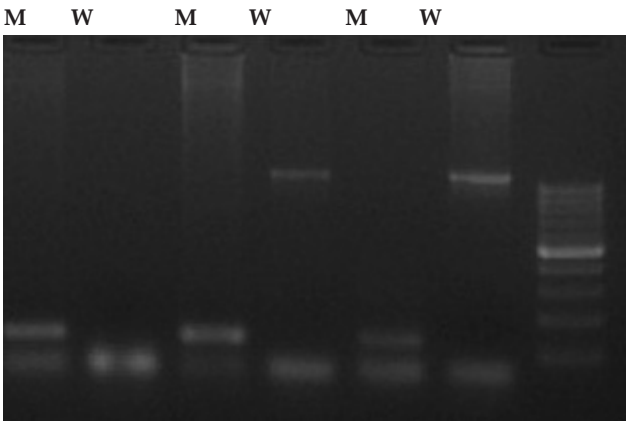
Species	Genotype Frequency				
	AA	AB	AC	AD	CC
Birth weight (kg)	0.98 ± 0.06^{a}	1.15 ± 0.14^{b}	1.40 ± 0.20^{c}	1.12 ± 0.08^{b}	0.95 ± 0.08^{a}

Different superscripts indicate significant difference at 5% level

100 random samples of Black Bengal goat and its crosses were screened for the study of fecundity genes. Three fecundity genes, namely bone morphogenetic protein receptor type 1B (BMPR1B; or activin-like kinase 6, ALK6), known as FecB on chromosome 6; growth differentiation factor 9 (GDF9), known as FecG on chromosome 5 and bone morphogenetic protein 15 (BMP15) known as FecX on chromosome X were amlified. BMP15 and GDF9 genes were found monomorphic in Black Bengal goat where as BMPR1B gene was found polymorphic. BMPR1B locus in Black Bengal goats revealed two genotypes-GG and GA and consequently two allelic variants A (wild) and G (mutant). Frequency of both genotype in studied population is 0.5 indicating the abundance of mutant type (G) nucleotide in Black Bengal goats (Fig 113). Animal having homzygus mutant genotype, i.e., GG gives 2.1 kids per kidding whereas carrier animal, i.e., heterozygous animal (GA) gives 1.6 kids. Twinning percentage in homozygous mutant (67.66%) was much higher than the heterozygous carrier (54.755%) animals. Therefore, BMPR1B gene polymorphism can be used for MAS to improve prolificacy in low prolific breeds (Table 84).

Table 84. Genotype wise variation in litter size

Litter size	Genotype	
	GG	GA
Singles	12.22%	45.235%
Twins	67.66%	54.755%
Triplets	20.00%	–



GG GA GA

GG-Homozygous mutant; GA- Heterozygous mutant
AA-Wild type, non carrier; M=mutant- 136 bp
W= wild- 1100 bp

Fig. 113. Agarose gel electrophoresis of allele specific Fec B PCR product

Elucidating the Mechanisms Involved in Higher Feed Efficiency of Bovine Species by Expression of the Genes Regulating Mitochondrial Proton Leak Kinetics

Twenty four Holstein Friesian × Deshi cross-bred calves of 4 to 5 months of age were procured. After deworming and vaccination the calves were maintained for one month for adaptability. Calves were fed wheat straw, concentrate and green grass *ad libitum*. Body weight and feed conversion efficiency were recorded fortnightly. Growth rate and feed conversion ratio of calves varied from 250-500 g/d and 3.82-5.82, respectively (Fig. 114(a-b) & 115(a-b)).

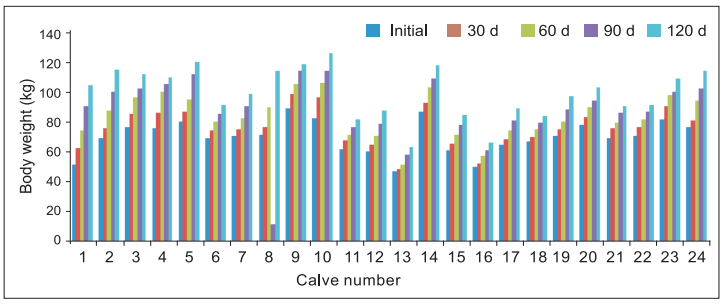


Fig. 114a. Body weight of calves

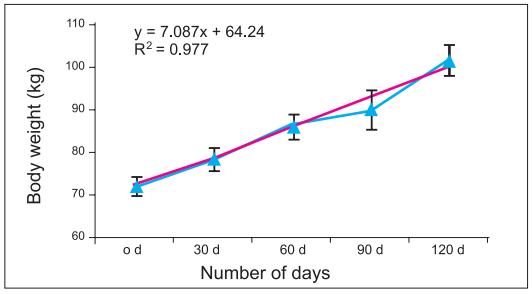


Fig. 114b. Average body weight of calves at different time interval

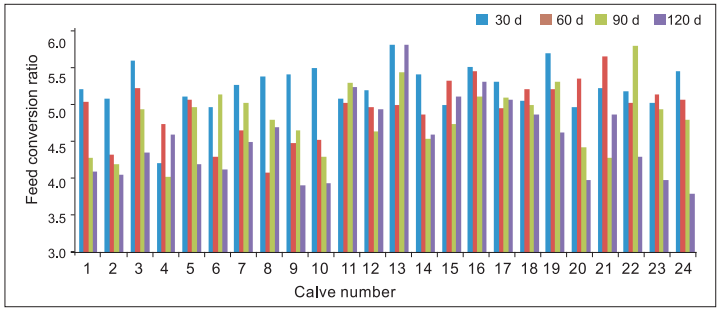


Fig. 115a. Feed conversion ratio of calves

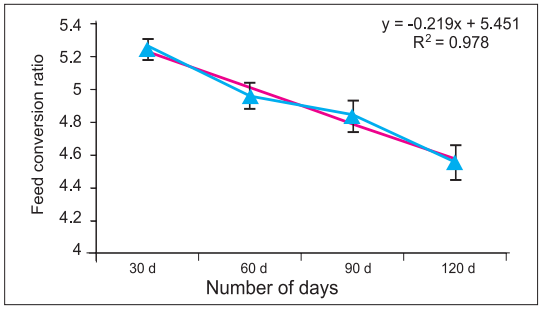


Fig. 115b. Variations in feed conversion rations of calves at different time interval

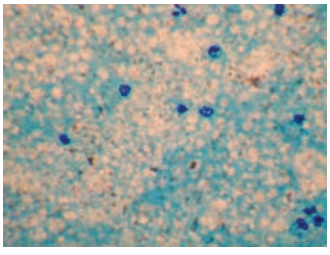
Chronic Exposure Effect of Carbofuran and Chlorpyrifos in Ducks and Role of Vitamin C and E in its Amelioration

Effect of Chlorpyrifos on ducks was investigated by giving individual oral dose of chlorpyrifos at 2.24 mg/kg (1/5th of LD_{50}) for a period of 6 weeks. Ducks were also given pretreatment with vitamin C and E for one week. Results indicated that vitamin C and E at the provided dose (@ 400 mg/kg body weight and 250 mg/kg body weight., respectively had ameliorative effect on reducing the oxidative stress parameters (Catalase, SOD, GPx), lowering the mean erythrocyte osmatic fragility rate, increasing body weight gain and maintaining normal biochemical parameters in chlorpyrifos exposed ducks. Thus, it is concluded that Vitamin C and vitamin E had ameliorative effect on oxidative stress induced by chronic exposure of chlorpyrifos in ducks.

Evaluation of nutraceuticals as supportive therapy for subclinical mastitis in peri-urban cattle

Milk sample collected from institute farm, peri-urban areas of Patna, Motihari, Sitamarhi, Saharsa and Vaishali were screened for subclinical mastitis by CMT. Results were arbitrarily graded from 0 to +3 depending upon the type of clumps and coagulation of milk. Subclinical mastitis was considered when CMT score were <2. pH of milk samples was estimated using pH meter ranged from 6.09-6.96. Somatic cell count of individual milk samples counted. Samples were also cultured for bacterial identification. SCC was estimated after spreading 10 µl milk in 1 cm^2 area. On glass slide and stained with modified Newman's stain and counted under microscope. SCC in milk samples with no CMT result ranged from 1.92-3.64 × 10^5/ml. Milk samples with CMT positive upto + 2 had SCC ranging from 9.50 to 12.56 × 10^5 cells /ml. The positive samples of milk were subjected to bacterial isolation in blood agar (Himedia) followed by selective media. Bacterial isolate identified was Staphylococcus (62.50%), Streptococcus (12.5%) and mixed infection (12.05%). Positive samples of milk were subjected to Mastitest ABST test kit (Himedia) for antibiotic sensitivity (Fig. 116 a-b). Results of ABST indicated gentamicin as most sensitive, followed by enrofloxacin, ciprofloxacin, Ampicillin/cloxacillin, tetracycline. However, chlorphenicol, strepto-penicillin was found to be non-sensitive.

Fig. 116 (a) California Mastitis Test



b) Somatic cell count for detection of sub-clinical mastitis

Serological epidemiology of major viral pathogen of caprine in Bihar

Under this project serum samples (for antibody detection) from goats were collected from institute farm, farmer's goats during health camp, and organized farms from Buxar, Patna, Sitamarhi, Purnea and Begusaria. Nasal and rectal swabs were also collected from clinically affected goats for antigen detection. Serum samples were screened for three viral antibodies (PPR, CAE and BT) and one viral antigen (PPR) using ELISA kits procured from IVRI, Izatnagar and VMRD. Results indicated that there was no prevalence of Lenti virus antibody in goat and all the samples tested were negative for CAE antibody. Prevalence of PPR (Fig. 117) and Blue Tongue in samples investigated were 34.07% and 14.01%, respectively. In outbreak of PPR morbidity rate was 95% (38/40) and mortality rate was 22.5 % and case fatality rate was 23.68%. In ORF outbreak, the morbidity rate was high in Sirohi goats compared to Jamunapari goats.

Fig. 117. Goat showing the symptoms of PPR

Health Monitoring and Disease Surveillance of Farm Animals

In this project, activities were carried out to monitor health and disease surveillance in farm animals (Fig. 118). Timely vaccination provided to all farm animals against major diseases i.e. FMD in cattle, buffalo and goats; Haemorrahgic Septicemia in buffalo and cattle; Black Quarter in buffalo and cattle; PPR in goats; Enterotoxemia in goats. Regular deworming has been done to all farm animals at 3-4 monthly interval with broad spectrum anthelmentic. Ectoparsiticidal spray was applied at regular interval of 6 months with potent insecticides. Mass Prophylactic vitamin supplementation provided at regular interval. Mastitits control program implemented with regular examination and treatment of individual teats and

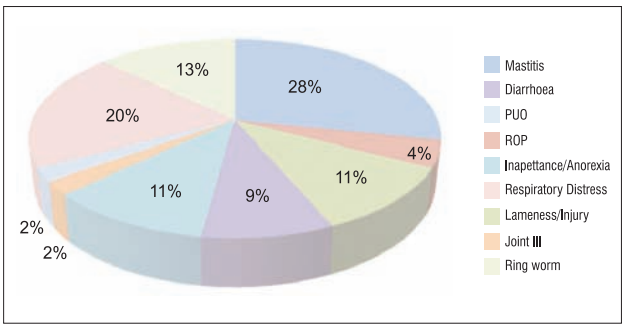


Fig. 118. Disease pattern in cattle farm

animals. Subclinical mastitis was found in positive by CMT in 8 lactating cattle of institute farm. All farm animals were Jonhne's Disease, Tuberculosis and brucellosis free, and tested negative for SID testing. Fecal examination of goat reveled 58.62% positive, which after specific treatment tested negative for helminths.

■ FISHERIES

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

Desi magur (*C. batrachus)* brood were raised in 0.01 ha earthen pond for gonadal development and maturation. Magur was regularly fed at the rate of 2% of their body weight with commercial sinking pelleted feed containing 22% crude protein. During the breeding season, both males and females were collected from the brood stock pond and maintained separately in cement cistern for breeding operation. The standard breeding protocol for breeding of magur was followed (Fig. 119).

Mature magur | Mature eggs | Fertilization processes

Fertilized eggs | Hatching | About to Hatch

Inauguration Magur hatchery

Fig. 119. Induced breeding of magur

On an average, about 6,000-7,000 eggs were obtained from a fully riped female. The fertilization percentage obtained varied from 89 to 96% with an average of 93.16% whereas the hatching percentage varied between 23 and 75% with an average of 55.10%. An average of 21.55% survival was achieved from spawn to fry stage with a maximum of 34%. Detail embryonic developmental stages of magur larvae are illustrated in Fig. 120.

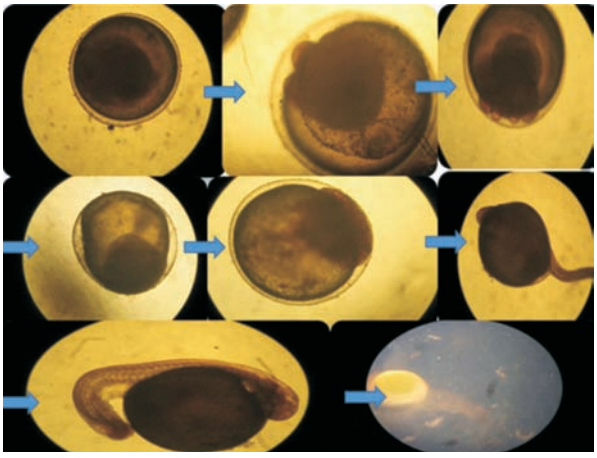


Fig 120. Embryonic development of fertilized eggs of magur

Hatchery water temperature, pH, dissolved oxygen and total alkalinity were in the ranges of 26-32°C, 7.4-8.1, 6.5-7.7 mg/l and 160-190 mg/l, respectively. Hatching time varied between 23 hours and 26 hours at a temperature range of 29°C–34 .5°C and water pH range of 7.6-8.1. The maximum survival percentage from spawn to fry was 34%. Three different dosages of ovaprim was attempted to study the effectiveness of the dose on ovulation. Out of these, a single injection of 0.7 ml/kg body weight was the most effective. The males were given a single dose of 0.1-0.2 ml/kg body weight. Breeding response of the magur was evaluated and found to be good. The translucent eggs containing embryonic eyes were considered fertilized. Unfertilized eggs were removed immediately from the tray to avoid the fouling of water. After hatching to at least 16-20 days they were maintained in the hatchery itself and were transferred to 2 × 0.5 × 0.3 cm^3 size FRP tanks for another 30 days. More than 1000 early fry and fingerlings with average length (75 mm ± 9 mm) and average weight (5.1 ± 0.10 g) were obtained after first sampling. After that fishes (8-10 cm size) were released to the nursery pond for further rearing and fed with eggs yolk suspension along with crumbled powder feed having 20% protein and boiled poultry eggs.

Natural breeding of magur was also successfully attempted after suitably modifying the breeding ground with 70-80 cm depth. About 20 breeding pits were dug on upper portion of the breeding pond. Several earthen pots, aquatics weeds and hideouts were provided for facilitating good breeding response. 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 recovered from natural breeding ground were being reared for further maturity and development (Fig. 121).

Fig 121. Natural breeding of magur

Diversification of Fish Farming System to Maximize the Water Productivity

The objective of the study is to standardize the breeding protocol and rearing practices of IMCs, Grass Carp and *Labeo bata* and to evaluate the performances in different fish farming system.

Breeding of *Labeo bata* and IMCs

Labeo bata, locally called as Bata belongs to the Family Cyprinidae. The most identifying characteristic of the fish is the presence of small black spot on 5th and 6th scales on the lateral line. The hatching of larvae took place between 5-6 hours after ovulation at 27-28°C in all the breeding trials. The highest percentage of hatching was recorded at 84.00% and the lowest at 39.67%. The best dose

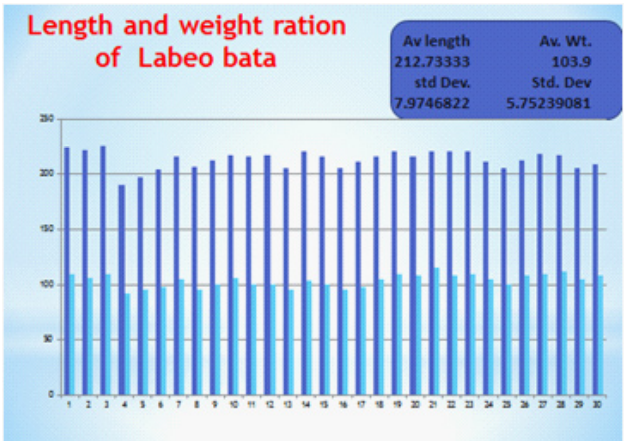


Fig. 122. Length and weight ratio of Labeo bata

of inducing agent ovaprim for female was 0.3 ml and for male 0.1 ml /kg body weight, respectively. Breeding trials of IMCs, Grass carp and *Labeo bata* was taken up and approximately 10 lakhs fish spawn seed has been produced for further rearing them to stunted fingerling. Regular water quality and sampling were done to monitor and assess the growth and maturation of IMC, Grass carp and *L. bata* (Table 85 & 86).

Table 85. Physio-chemical properties of water used in hatchery

Parameters	Onset of monsoon
pH	7.8 ± 0.6
Salinity (ppt)	0.40± 0.30
Temperature (°C)	26-29
Air temperature (°C)	30-34
Hardness (mg/l)	110
Dissolved Oxygen (mg/l)	4.0-7.5
Alkalinity (mg/ l)	140.0-210.0

Table 86. Fertilization and hatching rate of carp eggs with respect to different hormonal treatment

Species	Ovaprim (ml)		Average weight of brooder (kg)	Ovulation period (hrs)	Fertilization percentage	Hatching percentage
	Female	Male				
Rohu	0.4	0.1	1.8± 0.45	6-8	65	46.25
Catla	0.5	0.1	2.2 ± 0.36	6-7	42	38.60
Mrigal	0.4	0.1	1.5 ± 0.25	7-8	51	36.20
Bata	0.3	0.1	0.28 ± 0.08	5-6	70	56.00
Grass carp	0.6	0.2	2.6 ± 0.40	7-8	36	31.50

Refinement of production technology for IMCs

Studies were also undertaken for assessment and refinement of production technology of IMCs through stocking the stunted yearlings. Experiment undertaken in the institute farm suggested that stocking densities and species combinations are important issues to be decided, depending on the level or intensity of operation and the carrying capacity of the system. The production performance of stanted yearling (140 ± 20 g) at a stocking density of 7000 nos/ha with rohu, catla, mrigal and grass carp (4:3:2:1) has been evaluated. From the study, total production of 1450 kg and productivity of 3.625 t/ha/y was obtained. Commercially available sinking pelleted fish feed containing 22% crude protein was bag fed to fishes daily @ 3-5% of standing biomass. Taking only supplementary diet into consideration, the feed conversion ratio (FCR) of diet to fish was 2.2:1. During the summer, when growth rates are high, fish were provided *ad libitum* feed. However, during winter season fish was fed @1% of biomass daily. The specific growth rate (SGR) estimated for Rohu was 1.56% which was higher than SGR of Catla at 1.29% of same zero year class fishes (Fig. 123). The monthly variation in the level of dissolved oxygen in different fish pond has been presented in Fig. 124.

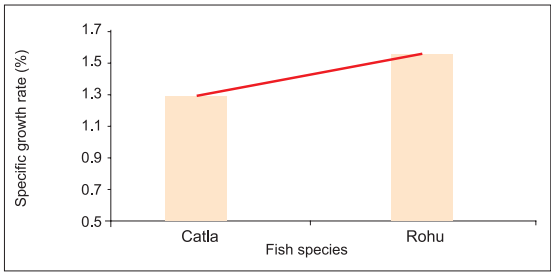


Fig. 123. Specific growth rate of Catla and Rohu species

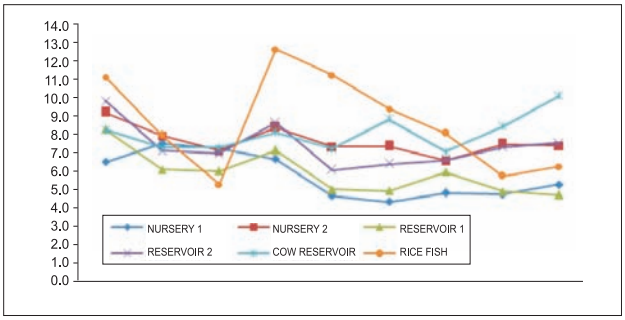


Fig. 124. Monthly variation in dissolved oxygen concentration in different fish ponds

Rice cum fish culture in low lying areas

Rice-fish culture, useful in productive utilization of seasonally waterlogged lands, was undertaken to grow fish in the rice fields with central pond type fish refuge (10% area). Rice seedlings of BPT 5204, i.e., Super Mansuri was transplanted in the 1st week of August. A total of 100 numbers of IMCs stunted carp yearlings (with average weight of 150 ± 16 g) mainly rohu and catla species were stocked @10,000 yearlings/ha of refuge area (100 $m^{2)}$ yielded 1.62 to 1.86 t/ha of fish (Fig. 126).

Fig. 125. Harvestable size of Prawn

Fig. 126. Rice cum fish farming with harvested fishes

Feed Formulation for Production of Quality Fish Feed From Locally Available Feed Ingredients

To assess the impact of commonly available feed ingredient and vitamin C, a preliminary experiment was conducted. Four treatments in duplicate namely control feed (T_1), rice bran+oil cake (T_2), rice bran+ oil cake+vitamin mix (T_3) and rice bran+oil cake+ vitamin mix+vitamin C (T_4) were taken up. Good quality and freshly procured rice bran and oil cake was used in T_2, T_3 and T_4 in equal proportions while in T_1 local feed with a protein level of around 20% was used. All the ingredients used were in powdered form. Experiment was carried out in 500 L FRP tanks and 8 days old spawn (100 in each tanks) were stocked. At the end of 60 days, fishes were harvested. From the study it was found that T_4 (58%) gave the best survival rate followed by T_3 (49%). Similarly the final weight was taken and found that there was higher growth increment in the T_4 followed by T_3 compared to other two treatments. This concludes that higher dose of vitamin C incorporated diet is better for growth and survival of rohu spawns (Fig. 127).

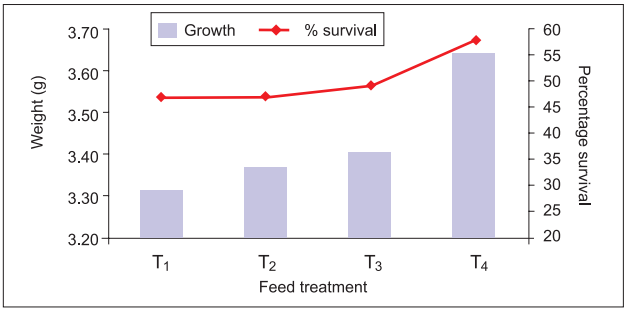


Fig. 127. Growth of Labeo rohita spawn fed with Vitamin C incorporated diet

Improving the Livelihood Security in Salt-affected Watersheds of Muzaffarpur & Sheohar districts of Bihar

Bihar has large area under salt affected soil (0. 37 m ha). Utilization of the salt affected areas for productive purpose is the major challenge for the region. Soil and water samples were collected from Motipur, Muzaffarpur , Bihar during dry season and found that average soil and water pH was 8.29+0.07 and 7.70+0.13 and salinity was 0.48 ± 0.07 and 0.56 ± 0.12 ppt, respectively. Rohu (*Labeo rohita*) is the most widely cultured species of that region and to assess the impact of salinity on rohu fish, acute toxicity was performed for 96 h. From probit analysis the $LC_{50}$for 96 h of salinity was 9.6 ppt and no mortality was recorded on or below 4 ppt for 96 h. To popularize the fish culture in those areas, demonstration trial of duck cum fish integration was undertaken in the Motipur block, Muzaffarpur.

17. Energy

Solar Energy Utilization in Agriculture

Eastern India is blessed with enormous solar energy resources, and therefore it can be a year round reliable source of energy for ground water pumping and operating pressurised irrigation system to enhance water use efficiency as well as crop productivity. For effective harnessing and proper utilization of solar energy, appropriate system design and preliminary data sets are required for system optimization to fulfil the irrigation needs in view of cropping pattern, land holding sizes and solar irradiance conditions round the year. Installation and testing of a solar photovoltaic system (Fig. 128) was undertaken at ICAR Research Complex for Eastern Region, Patna.

Fig. 128. Solar unit for ground water

A 3.0 kWp solar array was used to energize a 3 H.P. A.C. submersible pump with drawdown depth of 20 m. Selection of depth was taken in view of water depth in Eastern India where, in general, the water depth below ground label lie in the range of 2 to 15 m with annual fluctuations of ± 2 to ± 4 m in post and pre monsoon, respectively.

The ground water extracted into a grounded storage tank of dimension 9.75 m × 4.8 m × 2.5 m, i.e., (117 m^3). An additional 2 H.P D.C. centrifugal pump, operated by 1.4 kWp solar array was used to deliver water from storage tank to the adjoining fields to irrigate crop either by flood or pressurized method of irrigation, as this pump create high

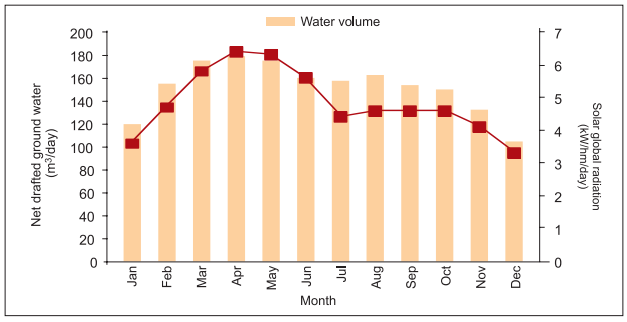


Fig. 129. Mean monthly daily water output of submersible pump along with solar global radiation for different months

delivery pressure. The average daily water output from 3 HP pump in different months is shown in Fig. 129. Interpretation shows that, on a bright sunshine day nearly 179 m^3 of water can be extracted in the month of April whereas 105 m^3 of water in the month of December. On the basis of daily water availability, farmers can develop crop calendar as per the cropping pattern and water requirement. The excess water can be used for adjoining fields, as delivery pump can easily send water up to 250-300 m through pipe system.

Generally 6 cm water is required for irrigating field crops under flood irrigation method. Therefore, on an average a cropped area of 2000-3000 m^2 can be irrigated on a bright day.

The *static* delivery head *vs.* discharge and static delivery head *vs.* solar irradiance of centrifugal pump on a cloud free day is shown in Fig. 132 and Fig. 131, respectively. The centrifugal static delivery head of this pump ranges from 0.9-1.5 m and solar irradiance is ranges between 550-850 W/m^2. This range of irradiance value prevails in almost all the months between 9.30 am to 2.30 pm, except November and December (Fig. 132). Therefore, delivery pump can successfully handle any pressurized irrigation system requiring operating pressures of 1.0 -1.5 bar on every cloud free day round the year between 9.30 am to 2.30 pm.

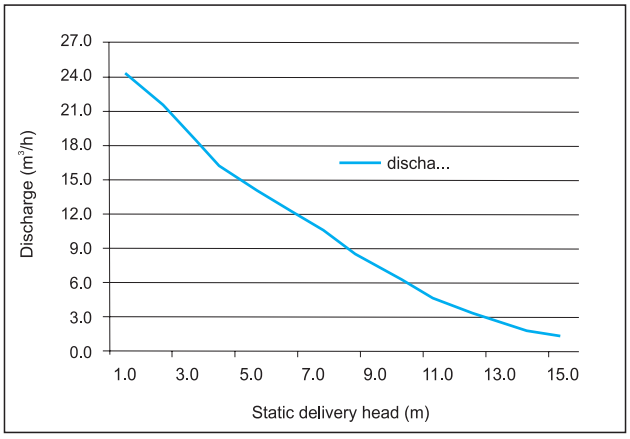


Fig. 130. Static delivery head vs. discharge curve of centrifugal pump

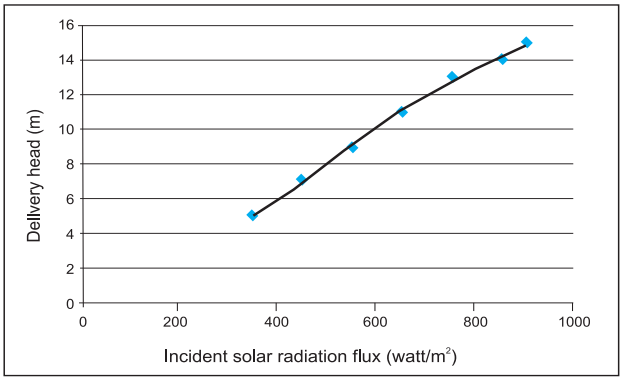


Fig. 131. Delivery head vs. solar irradiance curve of centrifugal pump

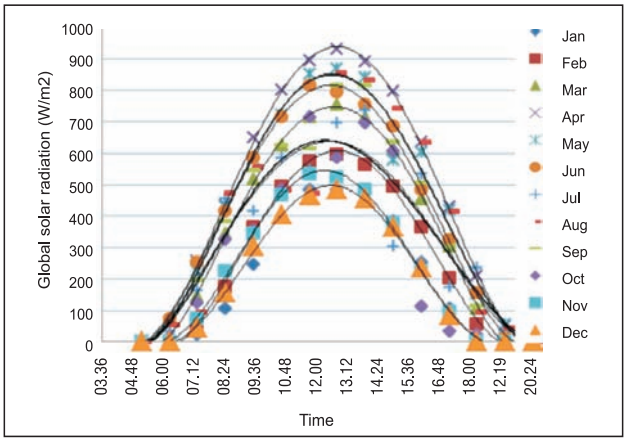


Fig. 132. Diagram, showing the mean monthly diurnal variation of solar irradiance, received on cloud free day at Patna (25.65°N).

18. Post Harvest Technology

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

Drying of 'Cherry' tomato under different physical treatment for producing powder

Studies were conducted to evaluate the drying of 'Cherry' tomato for producing powder with different physical treatments. The treatment consisted of longitudinally cut into 16 pieces, longitudinally cut into 8 pieces, cross-sectional cut slice and longitudinal cut segments. The effectiveness of these physical treatments on drying characteristics and quality of the prepared powder were examined. Drying of tomato sections was carried out at 55 °C in an air circulatory electric tray dryer with loading capacity of 6.2 kg/m^2. Initial moisture content (Table 87) of tomato was 93.97% (w. b.) with an average total soluble solid of 4.6% which was dried to a moisture content of around 5.0% (w. b.). The longitudinally cut in 16 pieces and cross section slice segments took less time to dry as compared to other two treatments. The drying yield (6.5%) was also found maximum in these two treatments. Empirical mathematical models (Newton, Henderson and Pebis, Page's and Midlli Kucuk), generally describing thin-layer drying of various biological materials have been investigated to illustrate the drying characteristics of the physically treated tomato. A non-linear regression analysis using a standard statistical program was employed to evaluate the coefficients of mathematical models to appropriately depict the drying behavior of 'Cherry' tomato in different segments. The results indicated that the 16 pieces and cross sectional segments are effective to achieve faster drying and further milling to obtain free flowing powder with maximum yield. The powder was used to prepare soup mix and served to human subjects for sensory evaluation. The overall sensory perception revealed that all four samples reconstituted well and achieved nearly equal scores on different attributes.

'Cherry' tomato can be conveniently dried by applying convective hot air drying at air temperature of 55°C (Table 88). Blanching of tomato pieces in microwave gave an excellent result during the period of storage without addition of any kind of additives or preservatives. Out of the four physical treatments, all treatment proved to be convenient in preparation and drying, however for faster drying slice could be used either in horizontal or vertical section with thickness not more than 6 mm. According to the results of non-linear regression analysis of drying data, among the 4 model equations, the Midilli and Kucuk model was found most suitable for describing the convective

Fig. 133. Dried powder of 'Plum' tomato

Table 87. Physico-chemical characteristics of Plum tomato

Parameter	Value (mean±SD)
Peel thickness, mm (n=10)	0.17±0.035
No. of seeds (n=10)	94±4
Seed thickness, mm (n=10)	0.232±0.032
Pulp:peel:seed, % (n=10)	95.1±4.2 : 4.01±0.74 : 0.99±0.12
Single fruit weight, g (n=10)	77.27±20.37
Length (L), cm (n=10)	8.06±0.57
Width (W), cm (n=10)	4.38±0.36
Thickness (T), cm (n=10)	4.35±0.35
Geometrical mean dia. (Dp), cm	5.35±0.37
Sphericity, ø = [(L.W.T)1/3]/L	0.66±0.03
Surface area, cm2	60.21±9.49
Bulk density, kg/m3	540
True density, kg/m3	998
Moisture content, % wb	93.97±1.28
Water activity of fresh tomato	0.946
Total soluble solid (TSS), oB	4.62±0.05
Acidity, g of citric acid/100g	0.28±0.022
Ascorbic acid, mg/100g	23.54±2.32

Table 88. Overall drying rate of 'Plum' tomato at 55°C

Treatment	Mi (% d.b.)	Mf (% d.b.)	Drying time (h)	dM/dt (%/h)	Dried wt (g powder/kg)	DR	DY (%)
T_1	1884	4.6	14	134.2	56	15.6	6.4
T_2	1893	4.8	10	188.8	58	15.4	6.5
T_3	1888	4.5	10	188.4	55	15.5	6.5
T_4	1882	4.7	11	170.4	56	15.7	6.4

M_i and M_f– Initial and final moisture content, DR– Drying ratio, DY– Drying yield

T_1: longitudinally cut into 16 pieces, T_2: longitudinally cut into 8 pieces, T_3: cross-sectional cut slices of thickness, T_4: longitudinal cut segments of thickness

air drying of 'Cherry' tomato (Table 89). Milling of dried slices yielded a free flowing and non sticky powder which can be stored up to 6 months under air tight polypropylene pouches without any appreciable change in quality. Tomato powder reconstituted well and accepted organoleptically. Powder prepared from dried pieces of 'Plum' tomato may be useful in various soups and sausages formulations.

Table 89. Parameters specific to each model equation for drying of 'Plum tomato' at 55°C

Model	Treatment	k	n	a	b	r^2	s^2
Newton	T_1	0.291	-	-	-	0.976	0.00262
	T_2	0.386	-	-	-	0.976	0.00293
	T_3	0.336	-	-	-	0.967	0.00417
	T_4	0.367	-	-	-	0.970	0.00363
Henderson and Pebis	T_1	0.309	-	1.069	-	0.981	0.00227
	T_2	0.404	-	1.057	-	0.980	0.00277
	T_3	0.356	-	1.068	-	0.973	0.00391
	T_4	0.388	-	1.068	-	0.975	0.00337
Page	T_1	0.160	1.420	-	-	0.998	0.00019
	T_2	0.236	1.421	-	-	0.998	0.00023
	T_3	0.179	1.489	-	-	0.997	0.00038
	T_4	0.199	1.508	-	-	0.998	0.00028
Midilli-Kucuk	T_1	0.150	1.457	0.986	0.00015	0.999	0.00020
	T_2	0.233	1.409	0.992	-0.00121	0.999	0.00023
	T_3	0.172	1.486	0.987	-0.00160	0.998	0.00037
	T_4	0.190	1.532	0.987	-0.00028	0.998	0.00033

a, b and n are model coefficient, k is the drying rate constant (h^{-1})

Drying characteristics of Drumstick Pod (*Moringa oleifera*)

Drying characteristics of drumstick pods at two maturity stages were investigated under convective hot air drying. The fresh pods at tender (D_1) and matured green stage (D_2) were obtained from the local market. The sample was thoroughly cleaned and cut into pieces of approximately 5.0 cm length. Another sample was taken as a whole fruit. All the samples were blanched or heated with microwave for 2 min (D_1) and 5 min (D_2) in order to inactivate

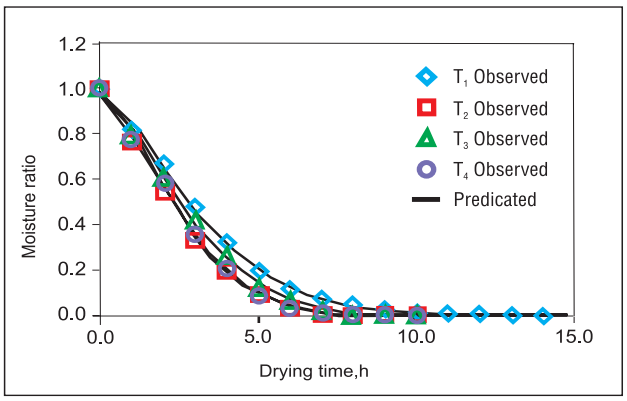


Fig. 134. Effect of physical treatment on moisture ratio of 'Plum' tomato as described by Midilli-Kucuk model equation

the enzymes. Another set of samples were blanched in boiling water for the same period. Blanched samples were subjected to drying in single layer under convective hot air at a temperature of 55±2 °C. Moisture loss data were recorded hourly during the process of drying and drying continued till the product becomes dried to moisture content approximately 6-7% (w.b.). Unblanched samples were also dried for comparison of drying data and quality of the dried products. The dried pieces and whole pods were packed in PP bags and stored at room temperature for shelf life studies. The tender and dried pods were processed into powder. The seeds of matured drumsticks were separated from the pods and powder of the seeds was also prepared. Rehydration tests of dried pods were carried out and rehydration ratio was found in between 2.8 to 3.1 for 10 min rehydration in boiling water. The dried pods and powders were used for culinary purposes.

Experimentation on drying of drumstick concluded that drumstick should be dried at an air temperature of 55-60°C in the form of matured whole pod. The pod should be blanched in hot water for 4-5 min before drying for extended culinary use during off season.

Table 90. Drying characteristics of drumstick, convective hot air drying of blanched sample

Stage	IMC, % (wb)	Drying time, h	FMC, % (wb)	Average DR, % moisture/h	DR	DY, %	Shrinkage, %
D_1	81.8	5	5.2	15.3	5.4	18.5	68.0
D_2	76.3	8	8.4	8.5	3.9	25.6	61.8

Table 91. Ascorbic acid (Vit C) in dried drumstick

Sample type	Vit C (mg/100g)
Shade dried without blanching	42.5
Convective hot air dried without blanching	60.0
Convective hot air dried with blanching	49.0

Evaluation of different weeding technologies for Direct Seeded Rice-Maize cropping system

Different weeding technologies and their combinations were evaluated for maize crop and it was found that hand weeding was most efficient followed by herbicide/weedicide application and cono weeder.

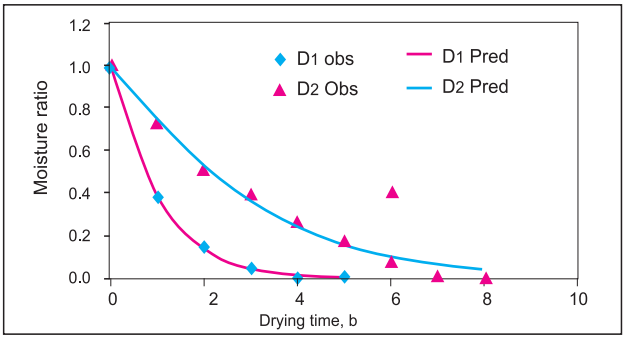


Fig. 135. Effect of drumstick type on moisture ratios as described by Page's model MR = exp(-ktn) [For D_2, k = 0.284, n = 1.161, r_2 = 0.998

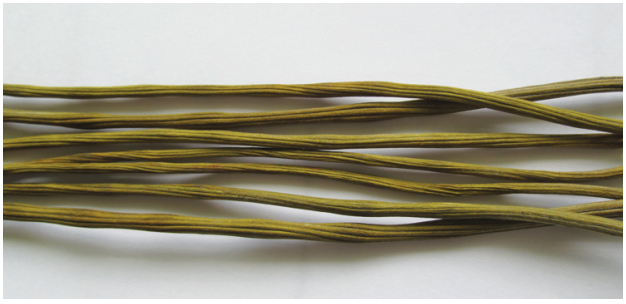


Fig. 136. Drumstick powder and dried drumstik pods

The project was taken with two objectives, to evaluate the existing weeding technologies and to modify the weeders as per local needs. It was felt that there is a need of little modification in the size of shovel/tyne and method of weeding in existing weeder. Traditional weeders work between the rows of the crops. A new weeder is developed which can work between rows of crop as well as over the crop (Fig. 137).

When weeder works over the crop the field efficiency of the weeder is almost double as compared to traditional weeder. However, during the evaluation it was felt that during the second weeding of crop, crop height is around 20-25 cm. Hence suitable attachment has been provided to overcome this problem. The weeder can work over the crops up to a crop height of 30 cm. The cutting width of the weeder is 27.5 cm which works very well between the row crops (Fig. 138). The average weeding efficiency was 78%. By interchanging the position of shank in the groves the method of weeding can be changed. The weeder has been evaluated in direct seeded rice field (Fig. 139).

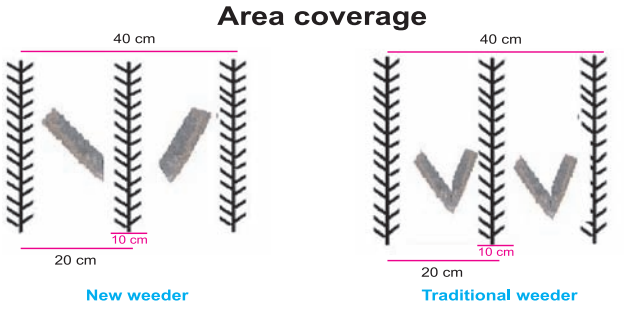


Fig. 137. Method of weeding of new weeder and type of tyne used

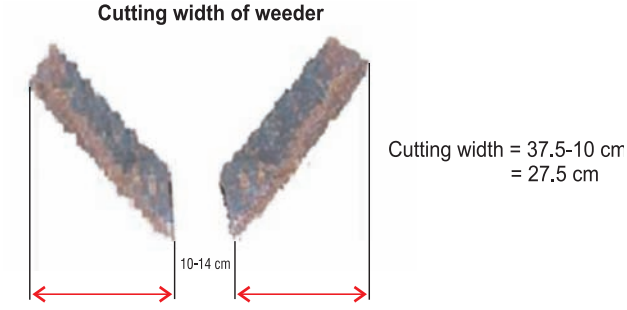


Fig. 138. Cutting width of the weeder

Fig. 139. Performance evaluation of weeder in direct seeded rice field

19. Transfer of Technology

Evaluation of Promising Rice Genotypes for Drought Tolerance in Rice-Sugarcane Cropping System at Harinagar, West Champaran (Bihar)

Ten rice genotypes having drought tolerance traits have been evaluated in 10 hectare areas during *kharif* 2013 in rice-sugarcane cropping system at Harinagar, West Champaran (Bihar). More than hundred farmers have visited rice field and helped in identification of promising genotypes for this region. Some rice genotypes *viz*., IR83373-B-B-25-3 (5.32 t/ha), IR83373-B-B-24-3 (4.54 t/ha), IR83387-B-B-110-1 (4.31 t/ha), IR84895-B-127-CRA-5-1-1(4.67 t/ha), IR83376-B-B-24-2 (3.89 t/ha), Sahbhagi (4.60 t/ha) and Susk Samrat (4.23 t/ha) have performed better than existing recommended rice varieties of this region. Seed of these promising genotypes have been distributed to fifty farmers of eight villages for cultivation in *kharif* season 2014. These genotypes have also been found suitable for Rice-Sugarcane cropping systems.

Technology Outscaling for Sustainable Food Production and Livelihood Improvement

Objective of the project was to demonstrate and refine technologies for sustainable food production and livelihood improvement. The project is operational in Beerpur, Khajury and Sangrampur clusters of Patna district, Jandaha cluster of Vaishali district and Sarairanjan cluster of Samastipur district of Bihar. Interventions on multi-tier cropping system, introduction of improved crop cultivars, Integrated Faming System Model with integration of poultry, fish and agri-horti crops, trenches-cum-raised bed system for fishery and horticulture, waste recycling through vermicomposting, livelihood support system through goatry and poultry have been initiated in different clusters of Patna district; and composite fish culture, integrated fish farming with duck, goat and horticulture, quality fish seed production through participatory mode, development of quality brood stock have been initiated at Jandaha and Sarairanjan for improving productivity of chaurs.

Futher, turmeric and seasonal vegetables were under taken in mango based multi-tier cropping in three farmers' fields at Beerpur that gave additional profit of ₹ 80,110/ ha, besides saving of water.

Rice varieties of Rajendra Sweta, Rajendra Suhashini and Pusa-1176 were introduced in 17 farmers' field of Patna district and average yield of 5.05 t/ha was obtained.

Cryo-preservation technique was applied to produce quality fish seed for production of brood stock. About 45,000 fish fries were produced from this technique at Jandaha. Similarly, average fish production of 1.04 t/ha was obtained in 10 nos of

Fig. 140. Waste recycling through vermicomposting at Beerpur and Sarairanjan

Fig. 141. Livelihood support through Divyan red breed of poultry and Black Bengal breed of Goat at Beerpur cluster

farmers' field at different clusters of Patna district without any supplemental feeding during 8 months' culture.

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

Study revealed that in Bihar, per capita income increased by about two-fold during last two decades, but the increase was higher during last five years mainly due to increase in crop and livestock productivity and more employment opportunities in even rural areas. Per capita income differed significantly from one village to another village, mainly due to per capita land availability and educational level. Non-farm employment was the main source of income and income through migration was much higher in all the villages. There was no trend in diversity of income, but it was more on large households than on labour households. The inequality of income was higher on large households than that on labour households, mainly due to higher level of education and income diversification on these households.

In Jharkhand, the rate of decline in poverty was more in agricultural labour class households (27%) than that of farming households (1.9%). A high incidence of rural poverty ranging from 20 to 76% was observed in different villages. Incidence of poverty among different groups of households showeda mixed pattern. Labour households and large households were comparatively less poor, than small and medium households in most of the villages. Under the project, two Farmers Field Days were organized in Jharkhand during 2013 and a total of 950 farmers participated in the programme.

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

Low polytunnel cultivation of cucurbits in winter for early summer harvest and better remuneration

Low polytunnel cultivation of cucurbits in winter for early summer harvest and better remuneration was demonstrated in 88 farmers' fields in Jamtara and Dumka districts of Jharkhand. Farmers have earned the maximum net income of ₹ 1571/- (estimated ₹ 392750/ha) from bottle gourd cultivation in 1.0 decimal (40 m^2) area. The crop was sown on 13.12.2012 and the first harvest started on 10.3.13 and continued up to 14.5.2013. Total harvest was 191 kg (estimated 47.75 t/ha) which was sold @ ₹ 10–8 per kg.

Demonstration of vegetable cultivation

The improved method of vegetable cultivation was demonstrated in the 713 farmers' field in Jamtara and Dumka districts of Jharkhand. The maximum annual net income of ₹ 2544/- was obtained by a marginal farmer through cultivation of summer and *kharif* vegetables in 1.0 decimal (40m^2) area of backyard garden. Pointed gourd, a perennial cucurbit was introduced as a new crop in NAIP area in three farmers' fields and its cultivation was found to be remunerative. After undergoing training on vegetable seed production at ICAR RCER Research Centre, Ranchi, Sh. Churamani Prasad Yadav started production of pure seeds of improved varieties of vegetable crops in his own field. He could able to sell pure seeds of brinjal (560 g), bottle gourd (1300 g) and cucumber (1020 g) in local village markets (*haats*) and to 6 farmers of 3 villages of Jama block of Dumka district.

Fig. 142. Marketing of bottle gourd produced under low poly tunnel

Demonstration of fruit based multitier cropping system

Twenty mango and guava based multitier orchards were established and out of which, 14 are being maintained. The maximum income of ₹ 24950/- from filler crop (guava) and intercrops (vegetables like potato, tomato, brinjal, radish, okra and chilli) was obtained by the farmer in the 5th year (2013) of establishment of fruit based multitier cropping system.

Women empowerment and drudgery reduction

Farm women play an important role in agriculture. To reduce their drudgery and induce empowerment, some improved farm implements have been introduced and women were trained in mushroom production and value addition in fruits and vegetables. Out of 247 trained women, 128 tribal women farmers are now engaged in oyster mushroom cultivation in NAIP villages with adoption rate of 51.81%. This includes 46 women under 4 SHGs in 3 villages of Jama block and 82 women under 5 SHGs in 2 villages of Dumka block of Dumka district. The harvest is 1-2 kg per bag and the produce is sold @ ₹ 80-120 per kg. The farm women also contributed in the group fund. It has been found that mushroom production is more on wheat straw than that on paddy straw. Twelve women of Gulab Baha SHG of Karela village of Jama block of Dumka district produced the maximum of 678.85 kg oyster mushroom from 446 inoculated bags which was sold @ ₹ 120-130/kg valuing the produce at ₹ 83146/-. Regular production and consumption of oyster mushroom and green vegetables have positive impact on health and nutrition of the members of farm families. The progressive farmer, Smt. Lilmuni Soren has trained 228 farmers (39 male & 189 females) in 12 non-NAIP villages under 3 blocks (Jama, Dumka and Ramgarh) of Dumka district. These 228 farmers have started cultivation of oyster mushroom. Smt. Soren is also earning money through training from sponsors like Department of Soil Conservation, Govt. of Jharkhand, local Grameen Banks, etc. Even after withdrawal of NAIP support, Miss Parvati Baski of Guhiajori village of Dumka block of Dumka district is coming regularly to purchase mushroom spawn from ICAR-RCER, Research Centre at Ranchi and continuing the mushroom production. The farm women were also trained in preparation of mushroom pickle, tomato sauce and jack fruit pickle and papad making.

Fig. 143. Oyster mushroom cultivation by tribal women

Cluster based Farmer's Participatory Research under Rainfed Farming System of Saraitoli village (TSP funded)

The TSP funded project on cluster based farmers participatory research in integrated farming systems perspective has been started at village Saraitoli, panchayat Rampur, block Khirji, Distt. Ranchi. The village is located between the parallel of latitude 23°15.0′ N & longitude 85°28.2′ E at an altitude of 598 m above mean sea level (MSL). The annual average rainfall is 1200 mm.

The soils of Saritoli, Namkum block, Ranchi of Jharkhand state belongs to the order Alfisols. The soils are sandy loam to loamy texture in nature. Erratic rainfall, lack of irrigation facilities, poor water retentive capacity and permeability of the soils are the major problems limiting successful double-cropping. The pH and organic carbon of the soil varied from 5.5-6.0 and 0.35-0.45% in the upland to lowland situations, respectively. The available N and K are low to medium status throughout the entire soils of Saraitoli. The availability of P is very low due to chemical fixation by sequioxide.

The rice-fallow cropping system is followed predominantly in the Saraitoli village. Enhancing productivity from the available piece of land/natural resources by cluster based integrated farming system approach in participatory mode is the key for enhancing the livelihood of the stakeholders.

Keeping this fact in view, the Saraitoli village was selected for interventions covering 54 households (76 male, 78 female and 94 children) with total population of 248. The village population is predominated by ST, SC and OBC.

The livelihood approach adopted by ICAR focused on capacity building of stakeholders and working with them in participatory mode, people's existing strength and utilization of available resources.

The holistic approach for land improvement by soil reclamation, water conservation techniques, renovation of well, check dam preparation, construction of dobha, multi-tier orchard establish-

ment, vegetable seed production, hybrid seed production, commercial production of vegetable seedling in poly house, cultivation of off season vegetables in low poly tunnel, cultivation of vegetable by drip irrigation, vermi compost production, lac cultivation, composite fish farming, goatery, duck and backyard poultry farming by introduction of improved breed were carried out.

Before initiation of the project, the average annual income per household was accounted for ₹ 29,765 per year. Initially the farmers were trained on scientific cultivation of lac, vegetables and fruits, agro-forestry, organic and integrated farming, drip irrigation and livestock farming, etc.

Livelihood sustainability through lac cultivation

Training was imparted to 54 households for scientific method of lac cultivation and 400 kg of brood lac was provided to the beneficiaries. After one year, total lac production of 2,906 kg was obtained in the month of July 2013. Out of this 2,741 kg was re-inoculated by the farmers in 226 of Kusum and 140 nos of Ber trees. Till date, a total of ₹ 8,28,385 of lac is being sold by the farmers which has significantly increased the average annual income from ₹ 4,653 to ₹ 14,040 per household/yr through lac cultivation alone.

Fig. 144. Collection of scrap lac

Livelihood sustainability through goatery

A total of 15 households were supported with rearing of 150 nos of Black Bengal goat (135 female and 15 male bucks). The initial average weight of goats ranged from 8-10 kg. At present, a total of 83 (75 female and 8 male) goats are being reared by the households. The average body weight gain in goats was 13.44 kg in a period of 5 months. The total 20 kids were produced.

Livelihood sustainability through poultry

A total of 14 households were assisted in poultry farming. Divyayan Red (152 nos) were distributed equally to all the households. At present, a total of 101 (30 female and 71 male) poultry are being reared by the households. An average body weight gain of female bird was 2.54 kg and male bird was 3.6 kg. The total gross income of ₹ 34,642/- was obtained from sale of egg and meat by these households.

Fig. 145. Backyard poultry rearing

Livelihood sustainability through duck farming

A total of 11 households interested in duck were given the 100 number of birds of Khaki Campbel breed. The average body weight gain of female and male duck was 1.60 and 2.24 kg, respectively. A total of 1184 nos of eggs were obtained. The total income from sale of egg and duck meat was recorded to be ₹ 12,303/-.

After one year of intervention by the institute in Saraitoli village, average annual income of the household increased to ₹ 54,271/-.

Fig. 146. Integrated fish farming

Training-cum-awareness Programmes for Management of Mango Fruit Flies using Para-Pheromone traps

A series of training-cum-awareness programmes for the management of mango fruit flies have been conducted under the NICRA project on Mango pest. A total of 25,000 nos of methyl eugenol based para-pheromone traps have been distributed among the farmers of Jharkhand, Chhattisgarh and West Bengal for creating awareness about the traps. Training of mango farmers of Lohardaga, Khunti and Gumla was also conducted. In the training programme, farmers were made aware of the use of fruit flies traps alongwith other approaches of integrated fruit flies management.

Technology dissemination in Bali Island, Sundarban, South 24 Parganas of West Bengal

The Bali island covering an area of 20 km^2 with an population of 35000. Two farmers-scientist interactions were organized by ICAR-RCER. Various vegetable seeds like Swarna Lalima (Tomato), Swarna Shymali (Brinjal), Swarna Praphulya (Chilli), cucurbitaceous seeds (Cucumber, Ridge gourd, Sponge gourd, Pumkin, Bitter gourd and Bottle gourd) of ICAR-RCER, RC, Ranchi and Azad (Mung bean) were distributed to 100 farm families and package of practices of these varieties were briefed to them.

Fig. 147. Farmers' meeting and distribution of vegetable seeds at Bali Island, West Bengal

Training on dendrobium orchid cultivation in Jharkhand

One day training programme on Dendrobium orchid cultivation was organized at ICAR Research Complex for Eastern Region, Ranchi Centre on 26th September 2013. The details of production technology of Dendrobium cultivation was described with demonstration to the farmers' of Jharkhand.

Fig. 148. Training on Dendrobium orchid cultivation

■ EXTENSION PROGRAMMES

On-farm trial for the management of brown plant hopper in rice

Rice-wheat cropping system is the dominating cropping system in Buxar where 80% area is covered under rice cultivation during kharif season. The Brown plant hopper *(Nilaparvata lugens)* is the most destructive insect pest found in high yielding rice crop in Buxar. Continuous two year trial for the management of brown plant hopper in rice with 4 treatments and 6 replications revealed that, application of 875 ml/ha Buprofezine (25 SC) increased rice yield by 16.90% (5.05 t/ha) and was better over the conventional practice of brown plant hopper management. Application of Ethiprole + Imidacloprid (40% WG) 100 g/ha increased yield to 14.58% (5.05 t/ha). The net return (₹ 55680/ha) and B:C ratio (3.28) was also higher by application of Buprofezine (25 SC).

Demonstration of fine rice variety (Rajendra Shweta)

KVK Buxar has demonstrated production processes of fine rice variety, Rajendra shweta in

Fig. 149. Demonstration of rice var. Rajendra Shweta

3.75 ha at 13 farmers' field. The average yield was recorded to be 4.65 t/ha, indicating 13.41% higher over traditional fine varieties and it matured 15-20 days earlier than conventional varieties. To ensure timely sowing of *rabi* crop and in situ moisture conservation, Rajendra Shweta could be grown.

Frontline demonstration on kuroilers

Five hundred day old chicks were given to farmers for rearing. Vaccination against Newcastle Disease and Infectious Bursal Disease was provided. Farmers' could earn net monetary return of ₹ 150.00 after 4 months of rearing.

Fig. 150. Demonstration of kuroilers

Water harvesting structure-cum-secondary reservoir

A demonstration trial was carried out at farmers' field under NICRA project in the year 2013-14 to provide life saving irrigation to the crops and livestock under drought condition by conserving runoff water and recharging ground water. Two water harvesting structures encompassing a total area of 0.154 ha and of 1.5 m depth were created. The runoff (2310 m^3 water) conserved was enough to provide irrigation to 22 ha land with 1 cm^3 depth of water in rice/ vegetable and pre-sowing irrigation for wheat.

Seed production at KVK farm

To supply the quality seed and gear up seed replacement ratio by ICAR in district Buxar, KVK Buxar has started production of foundation and certified seed at its farm. KVK Buxar produces 15.8 t of paddy (var. Pusa sugandh-5 BPT 5204 and MTU 7029) in *kharif* season.

■ DISEASE DIAGNOSIS

Foot and mouth disease among cattle in Buxar district

Cases of FMD among cattle were seen in the various villages of Buxar district. Clear lesions in mouth and foot were observed. Application of Boroglycerine in mouth lesions and alum in foot lesions alongwith mineral and vitamin supplementation and biosecurity measures were advised. Vaccination against this viral disease was found the best preventive measure.

Fig. 151. FMD in cattle

ORF among sheep and goat

Cases of ORF among sheep and goat population were noticed in Buxar district. Papules, vasicles, pustules and scabs on the skin of face, and teats were observed. This viral disease is immunosuppressive, causing economic losses from morbidity rather the mortality which is usually low.

Fig. 152. Orf disease in goat

Degnala in cattle

Cases of Degnala disease have been observed in the Bijhaura, Bhelpur and adjoining villages in Buxar district. *Fusarium* sp. was responsible for causing the disease. The treatment (administration of sulpha drugs mixed with cod liver oil and acriflavine on the affected extremities such as tail along with supplementation of mineral mixture and vitamins) was recommended. Farmers' were also advised to maintain hygiene and feed wheat straw instead of paddy straw.

Fig. 153. Degnala in buffalo

Animal health camps organized

Six animal health camps were organised as depicted below:

Table 92. Animal health camps organized at different villages by KVK, Buxar

Particulars of Animal Health Camp	Date organized
Farmers Field, Animal Health camp and awareness programme at Sarai-Ranjan, Samastipur, Bihar	27th Sep., 2013
Animal Health camp and awareness programme at Baghakol, Ara, Bihar	1st Oct., 2013
Animal Health camp at Kushwar, Sheohar, Bihar	30th Jan., 2014
Animal health camp at Motipur under NAIP (Component III)	25th Oct., 2013
Animal health camp at Sheohar under NAIP (Component III)	30th Jan. 2014
Animal health camp at Belsand, Muzaffarpur, under NAIP (Component III)	30th Jan. 2014

Exposure visit of farmers under NICRA project to Pusa Krishi Vigyan Mela at IARI, New Delhi

A visit of group of twenty farmers of adopted village Kukurha of NICRA Project was made in Pusa Krishi Vigyan Mela at IARI, New Delhi to create awareness and exposure towards various modern innovative technologies, research highlights, and frontline demonstration on new variety of field and vegetable crops, hi-tech vegetable cultivation, water management techniques, latest farm machinery and quality seed production and farmer-scientist interaction.

Training Programmes Conducted

The details of training programmes conducted are depicted below:

Table 93. Training programme conducted by Institute HQs, Patna

Title of the training programme	Sponsored by	No. of Participants
Soil Conservation and Integrated Watershed Management	BAMETI	43
Soil and Water Conservation	Department of Environment and Forest, Govt. of Bihar	26
Watershed Management through Soil and Water Conservation	Department of Environment and Forest, Govt. of Bihar	25
DPR Preparation under IWMP	Directorate of Soil Conservation (BWDS), Govt. of Bihar	30
Training Programme on DPR Preparation under IWMP	Directorate of Soil Conservation (BWDS), Govt. of Bihar	30
Characterization of Rice (*Oryza sativa* L.) Genotypes for abiotic stress tolerance for the students of VMKVEC, Salem, T.N.	VMKVEC, Salem, T.N.	03
Makhana cultivation	Govt. of Bihar	28
Gender perspective in IFS (National level)	DAC, Govt. of India	25
Integrated goat farming	NABARD	45
Integrated fish farming	NABARD	25
Field survey and electronic compilation of data for project staff of Bihar, Jharkhand and Odisha at ICAR-RCER, Patna	ICRISAT, Hyderabad	25

Table 94. Training programme conducted by Regional Research Centre, Ranchi

Topic	Sponsored by	No. of Participants
Improved production technique in vegetable cultivation	ATMA, Lohardaga	24
Udyan Mitra Training (total 10 numbers)	Directorate of Horticulture, Govt. of Jharkhand	184
Establishment of Bari	ATMA, Purnea(Bihar)	20
Plant Propagation	ATMA, Purnea(Bihar)	24
Fruit based multitier cropping system	ATMA, Purnea(Bihar	25
Fruit based multitier cropping system	ATMA, Lohardaga	25
Cultivation of pointed gourd	Atma,Pakur	21
Improved production technique in fruits &vegetable cultivation	Central Coalfield limited, Ranchi	27
Phase 2 of Udyan Mitra Training (total 10 numbers)	Directorate of Horticulture, Govt. of Jharkhand	176
Phase 3 of Udyan Mitra Training (total 10 numbers)	Directorate of Horticulture, Govt. of Jharkhand	206

Topic	Sponsored by	No. of Participants
Off-season cultivation of vegetables	ATMA, Bokaro	19
Micro irrigation in vegetable crops	ATMA, Bokaro	28
Nursery management in horticultural crops	ATMA, Bokaro	29
Mushroom cultivation	ATMA, Bokaro	33
Improved practices of vegetable cultivation	ATMA, Giridih	16
Seed production in vegetable crops	ATMA, Deoghar	27
Off-season cultivation of vegetables	ATMA, Jamtara	22
Improved practices of vegetable cultivation	ATMA, Purnea	23
Production, processing, storage and statury requirement in marketing of vegetable seeds	ATMA, Lohardaga	20
Vegetable cultivation	ATMA, Sitamarhi	24
Multitier cropping system in horticulture	ATMA, Lohardaga	20
Mushroom cultivation	ATMA, Lohardaga	25
Cultivation of seasonal and off-season al vegetables	ATMA, Lohardaga	25
Integrated nutrient management in vegetable crops	ATMA, Loherdaga	22
Integrated insect pest and disease management in horticulture crops	ATMA, Loherdaga	15
	Total	1080

Table 95. Training Programmes for Rural Youth at KVK, Buxar

Topic	Total
Poultry production	10
Goat production (2 numbers)	28
Bee keeping : A source of income generation	10

Table 96. Off-campus training programmes conducted at KVK, Buxar

Topic	Total
Pod borer and pod fly damage in arhar and their control measure	20
Microbial pesticide and their use in plant protection	20
IPM in mango leaf hopper & mealy bug	20
Identification and utilization of bio-control agent in *rabi* season (rai, mustard, cabbage, cauliflower, lentil, gram etc.)	20
Collection and utilization of neem seeds in plant protection	20
Seed borne diseases of cereals and pulses and their management	20
Insects and disease management in wheat	20
Storage pest of cereals and their control measure	20
Management of insect pest by cultural practices in summer season	20
Management of diseases and insects through soil solarization in nursery	21
Insect pest and disease management in jowar and bajra	20
Integrated pest management in rice nursery	20
Damage caused by plant hopper in rice and their management	22
Termite damage and their control measure	20
Insect and disease management in oil seed crop	33
Insect and disease management in mentha	20
Importance of seed treatment in cereals and pulses crop	21
Microbial pesticide and their use in plant protection	31
Integrated insect pest management in rabi vegetables (cabbage, cauliflower, pea, brinjal, tomato)	26
Conservation of natural enemies in rice ecosystem biocontrol of pest	22
Damage caused by aphid in mustard, lentil & their control measure	24
Early and late blight disease of tomato and potato and their management	20
Nursery management of paddy	20
Seed production of paddy	20
Seed production of maize	20
Seed production techniques of pigeon pea	20
Quality seed production of okra	20
Quality seed production of paddy	20
Quality seed production of chickpea	23
Seed production techniques of lentil	22
Seed production techniques of potato	25
Seed production techniques of mustard	21
Seed production of tomato	20
Seed production of pigeon pea	20
Manure & fertilizer management in japani pudina	26
INM in onion	23
Foliar application of micronutrient in mango	23
Manure and fertilizer management in cucurbits	21
Manure and fertilizer management in sugarcane	22
Crop residue management for increasing soil fertility	31
Water management in summer vegetable	20
Method of in-situ rain water management & its importance	20
Rasing bund height around the rice field	20
Method of bunding & its importance	24
Method of soil and water sample collection	20
Integrated nutrient management in rice	22
Inoculation of rhizobium culture in *kharif* pulses (pigeon pea)	21
Method of rhizobium culture inoculation and sulpher in *rabi* pulses	21
Method of INM in cauliflower	20
INM in potato	32
Nitrogen management in paddy by leaf color chart (LCC)	23
Fertilzer management in pearl millet	23
Scientific cultivation of cucumber	20
Layout and management of orchard	20
Scientific cultivation of cucumber	20
Scientific management of guava orchard	21
Production technology of elephant foot yam	21
Layout and management of fruits garden	20
Production technology of garden pea	25
Production technology of year round cultivation of radish/tomato	20
Production technology of cauliflower, cabbage and broccoli (cole crops)	20
Integrated nutrient management in maize	20
Integrated crop management in rajmash	20
Nutrient management in sunflower	20
Seed production techniques of green gram	20
Improved management techniques for rice nursery production	20

Topic	Total
Integrated plant nutrient supply for sustainable production of pigeonpea	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 pigeonpea	20
Integrated crop management of green gram production	20
Crop production techniques of pearl millets and sorghum	20
Reproductive problems in cattle: control and management	22
Feeding of animals during scarcity	27
Proper disposal of dead carcass	26
Year round health protection practices for sheep and goat	23
Mastitis in dairy cows	21
Biosecurity	23
First aid for animals	22
Polyculture fish farming	21
Hygienic milk production	29
Vaccination in poultry	22
Vaccination in cattle	22
Control of parasitic diseases in dairy animals	33
Reproductive problems in cattle: control and management	21

Table 97. Vocational training programme conducted by KVK, Buxar

Topic	Total
Bee keeping: A source of income generation (2 programmes)	60
Microbial pesticide and their use in plant protection	31
Identification and utilization of bio-control agent in *rabi* season (rai, mustard, cabbage, cauliflower, lentil, gram etc.)	23
Seed production okra	20
Production technology of vermicompost	15
Seed production techniques of wheat and gram	17
Seed production techniques of hybrid rice	20
Production of organic input	20

Table 98. ON-campus training programmes conducted at KVK, Buxar

Topic	Total
Integrated insect pest management in summer vegetables	20
Integrated disease management in summer vegetables (Bottle gourd, sponge gourd, ridge gourd etc.)	20
Disease management in rice crop	20

Table 99. Training programmes for extension functionaries conducted at KVK, Buxar

Topic	Total
Organic insecticide: classification, properties and their recommendation in plant protection	20
Biological control: Importance and utilization of bio-agents in agriculture	20
Physical, mechanical and cultural control	20
Quality seed production of chick pea	25
Production technique of vermicompost	10
Resource conservation techniques in rice-wheat cropping system	15
Sustainable production techniques of rabi pulses	17

FLDs, OFTs and Kisan Mela Organized by KVK, Buxar

Table 100. OFTs conducted at KVK, Buxar

OFT Topic	Area (ha.)/ No.	No. of Beneficiaries	Place
Management of brown plant hopper in rice	1.0	6	Jagdishpur, Vikshrampur
Thrips management of onion	1.5	6	Sisaudha, Patakhwalia, Jagdishpur
Varietal performance of okra (var. Kashi Pragati & var. Arka Anamika)	0.4	10	Kukurah, Bijhaura, Pawni
Different dosages of Sulphur	0.4	10	Dalsagar, Nidhawb, Pawni
Varietal performance of Tomato (var. Swarn Lalima & var. Kashi Amrit)	0.02	10	Dalsagar, Pawni, Lalganj
To assess the SRI method for transplanting of Rice for the higher yield.	0.6	10	Pawni
Efficacy of newly released herbicides against weed flora in Transplanted rice.	0.5	5	Jagdishpur, Boxa
Assessment of new released chickpea varieties for Buxar district.	0.5	5	Jagdishpur, Boxa
Mastitis in cattle	3	10	Mahadah, Bijhaura, Kukurha, Dalsgar, Simari
Use of GnRH to induce ovulation in cattle	3	20	Dalsagar, Bijhaura, Mahdah

Table 101. Intervention/Technology demonstrated at Village Kukurha under NICRA (2013-14)

Intervention/ Technology	Crop/variety	No of farmers	No/area (ha)
Deep summer ploughing	-	06	4.0
Raising bund height around the rice field	Rice	08	4.0
Green manuring of mungbean for paddy	Rice / MTU7029	12	1.25
Brown manuring in rice for maintaining soil health	Rice	04	1.58
Soil test based nutrient management in paddy	Rice	40	15.25
Pulses production on farm bund	Narendra Arahar 2	12	0.50
Vermi-compost making	Vermi bed	06	06
Rainwater harvesting structure-cum-secondary reservoir	-	02	0.15
Crop residue management through happy seeder in wheat	Wheat	03	1.54
FIRBS	Wheat-HD 2824	06	02
Zero till drill in chick pea.	Chick pea-Pusa 372&362	30	04

Intervention/ Technology	Crop/variety	No of farmers	No/area (ha)
Demonstration of mid-duration var Rajendra Sweta of paddy	Rice/ Rajendra Sweta	08	3.25
Demonstration of drought tolerant var Naveen of paddy	Rice/Naveen	16	6.60
Advance planting of *rabi* crop. timely sowing & harvesting date 09.11.2013 & 30.03.2014	PBW 502	04	2.5
Raised community nursery Paddy (750 m^2)	Rajendra Sweta, PRH 10	10	2.61
Demonstration of zero till drill in wheat	Equipment	17	11.87
IPM in chickpea	Pheromone trap loaded with lure	04	01
High yielding var.	Paddy Pusa-44	03	01
Heat tolerant variety	Wheat-WR 544	04	1.75
Demonstration of short duration vegetable as contingent crop	Vegetable pea var. Kashi uday	20	02
Heat tolerant wheat var.	WR544	04	1.75
Demonstration of drumstick for nutritional security		175	300 plant
Demonstration of MP Chari for green fodder production	MP Chari	18	02
Deworming of ruminant and small ruminant animal	Animal	51	205 (animal)
Animal health checkup	Animal	50	255 (animal)
Vaccination (HS& BQ)	Animal	51	205 (animal)
Quality fodder production	Oat variety JHO-822	38	04
Rural backyard poultry production	Kuroiler day old chicks	39	378
Fodder production	MP chari	29	2.90
Fish farming	Policulture	04	0.60
Custom hiring from timely operation	MB Plough	08	04
Raising community nursery in different interval	Rice/Naveen, Rajendra Sweta	750m^2	08
Community irrigation from community rain water structure	Paddy	58	40
Agro-advisory services	Paddy, wheat & lentil	175	
NICRA, awareness companion	A forestation	46	02
In-situ moisture conservation	-	52	01
Crop residue management for improving soil health	T &V	29	01
Cultivation of vegetable pea		25	01
Year round cultivation of radish		20	01
Quality seed production of radish		20	01
Application of sulphur and rhizobium culture in *rabi* pulses		21	01
Methode of INM in cauliflower		20	01
IPM in cucurbits		20	01
Degnalla disease in cattle		21	01
Production technology of vermi compost		34	01
Exposure visit of DSR field area	DSR	33	01
Exposure visit of showcasing of innovative Agril. Tech. at ICAR-RCER, Patna	Innovative agril tech.	40	01
Agro-advisory services	Paddy,wheat, pulses, and livestock production	373	----
World earth day (22.04.14)	NRM	51	01
Word environment day (05.06.13)	Global Warming	100	

Table 102. FLDs conducted at KVK, Buxar

Demonstration	Area (ha.)/ No.	No. of beneficiaries	Village covered
Rice (var. Rajendra Shweta)	2.0	10	Dullahpur, Mahdah, ataon, Bharchakia, Nandan
Pigeon pea (var. Narendra arhar-2)	5.0	24	Pawni, Dhakaich, Dullahpur, Sondhila
Peral millet	2.0	07	Pawni, Nidhuaa, Dhullahpur, Chanda, Phuli
Pheromone trap in chick pea	10.0	40	Kukudha, Vikshrampur, Ataon, Boxa, Pawni
Biopesticide in chickpea and lentil	5.0	30	Ataon, Simri, Boxa, Pawni, Kamarpur, Ktharkhurd, Dhakaich, Kukudha, Milki, Govindpur
Okra (var. Pusa A-4)	1.0	10	Kukurah, Bijhaura
Okra (var. Kashi Pragati)	0.5	10	Pawani, Kanpura, Bijhaura
Okra (var. Kashi Kranti)	0.5	07	Pawani, Kanpura, Bijhaura
Vegetable pea (var. Kashi Uday)	2.0	21	Kukurah, Pawani
Onion (var. Pusa Red/ Arka Niketan)	1.0	15	Dalsagar, Pawni, Nidhawan
Tomato (var. Swarn Lalima)	0.01	03	Dalsagar, Kukurah
Pigeon pea (var. Narendra Arhar-2)	1.0	4	Nagpura, Balihar, Dumari
Mustard (var. NDR 8501)	3.0	11	Pavni, Khairahati, Manikpur, Sardahpur, Surodha, Vikarm English, Pandey patti, Basudhar, Simari,

Demonstration	Area (ha.)/ No.	No. of beneficiaries	Village covered
Chick pea (var. PUSA 362 & PUSA 256)	5.0	32	Vikaram englis, Kailakh, Surodha, Pandeypatti, Dakaich, Dallahpur, Raghunathpur, Basudhar, Kamarpur, Pavni, Karhar, Turkpurva, Vishrampur, Kashiya, Natt, Jagdishpur, Majharia, Bharchakia, Bhabuwar
Lentil (var. HUL 57)	5.0	20	Natt, Pavni, Bhabuvar, Simari, Lalgunj, jagdishpur, Vishrampur, Majaria, Bharchakia, Gosaipur, Kanpura, Dallahpur , Kasiya.
FLD on fingerlings	2125 nos.	6	Kukurha, Bhitiara, Bijhaura, Pauni
FLD on Ducks	60 nos.	4	Itaunha, Bharchakiya, Bijhaura, Kukurha
FLD on M.P. Chari	2.9 ha	29	Pauni, Sangrampur, Nidhuan, Nuaon, Bhitiara, Indore, Dalsagar, Bairi,
FLD on Kuroiler	510 nos.	45	Turkpurwa, Lalganj, Kukurha
FLD on Berseem (Bundel Berseem 2& 3)	0.9 ha	14	Badki Sarimpur, Vikram English, kukurha, Nadaon,
FLD on Oats (Kent)	1.14 ha	19	Nadaon, Kukurha, Vikramganj English, Badki sarimpur, Diwanka Badka Gaon, Parmanpur, Jagdishpur, Bharchakiya, Bijhaura, Darahpur, Nidhuan, Pauni
FLD on Oats (JHO-822)	5.0 ha	38	Kusurpa, Gheuriya, Kukurha, Suraundha

Training-cum-Workshop on Real Time Mango Pest Surveillance

A two day training-cum-workshop on "Real Time Pest Surveillance of Mango Pests" was organized during 7th and 8th March, 2013 at ICAR, RCER, Research Centre, Ranchi. The programme was participated by PIs, Co-PIs, RAs, SRFs and data entry operators from lead centre as well as all cooperating centres (NCIPM, New Delhi; IIHR, Bengaluru; CISH, Lucknow; FRS, Sangareddy; RFRS, Vengurle and AES, Paria). This programme was organized under NICRA funded project on "Understanding the changes in host-pest interactions and dynamics in mango under climate change scenarios". During the programme, review of project activities and hands on training on finer identification of pests were provided to participants.

Fig. 154. Training cum workshop on real time mango pest surveillance

■ OTHER ACTIVIES

Agri Summit-2013

The Agri Summit 2013: A Step Towards Second Green Revolution, was inaugurated by Sh. Narendra Singh, Hon'ble Agriculture Minister, Govt. of Bihar on April 8, 2013 at ICAR Research Complex for Eastern Region, Patna. It was attended by Dr. R. S. Paroda, Chairman, Haryana Kisan Ayog and former DG, ICAR; Sh. Niraj Kumar Babloo, MLA, Bihar Legislative Assembly; Sh. Alok Kumar Sinha, Agriculture Production Commissioner, Govt. of Bihar; Dr. A. K. Singh, Vice Chancellor, Rajmata Vijayaraje Sindhiya University, Gwalior; Dr. H. S. Gupta, Director, IARI, New Delhi; Prof. Anwar Alam; Dr. Abidi; various representatives of State Govts from all the eastern states of the country, representatives of ICAR institutes of around 27 institutions of eastern region, Dr. B. P. Bhatt, Director, and all the scientists of ICAR-RCER, Patna. The summit was organized to discuss necessary measures for bringing second green revolution from eastern states of the country.

During the summit, Dr. R.S. Poroda, said that the second green revolution definitely will come from the eastern region. He also opined that ushering second green revolution, all the three cradles-policy support and political will, Institutional

Fig. 155. Release of the technical bulletin on Livelihood Improvement during Agri Summit 2013

support for developing capable human resources and new innovation/technology are required to be strengthened. He stressed on reorientation in agriculture from cropping system mode to farming system mode and diversification in agriculture for increasing per unit productivity. Dr. Paroda also said that hybrid maize, micro irrigation and protected cultivation will play an important role in bringing 2nd green revolution in eastern region states.

Visit of the US Ambassador at CSISA Experimental Farm

The US Ambassador to India, Nancy J. Powell visited the project experimental site of the Cereal Systems Initiative for South Asia (CSISA) on 13th May, 2013 and interacted with scientists from CSISA and ICAR, Subject Matter Specialists (SMS) of State Agriculture Department, Govt. of Bihar, women farmers of Muzaffarpur and Samastipur districts and service providers from Bhojpur and Buxar districts of Bihar. During interaction with various stakeholders, she tried to get feedback on Conservation Agricultural (CA) being adopted by the farmers. Demonstrations on laser land leveling, unpuddled rice transplanting through machine and direct seeding of green gram through zero tillage in wheat residue were also demonstrated in presence of august gathering.

Fig. 156. Interaction with women farmers during the visit of the US Ambassador

Review Meeting of ICAR Institutes and Regional Centres of Bihar

Shri Tariq Anwar, Hon'ble Union Minister of State for Agriculture and Food Processing Industries, Govt. of India reviewed the activities of ICAR Institutes and Centres located in Bihar on 3rd August, 2013. Hon'ble Minsiter urged the scientists

Fig. 157. Dr. A. K. Sikka DDG (NRM), apprising ICAR initiatives in eastern states

to work for the betterment of small and marginal farmers in respect of food security, profitability and sustainability. He asked the scientists to join hands with the state department in dissemination of technologies developed by the institutes.

Farmers' Fair cum Training Programme on Makhana Cultivation

Shri Tariq Anwar, Hon'ble Union Minister of State for Agriculture and Food Processing Industries inaugurated farmers training programme on "Improve cultivation techniques in Makhana" at ICAR Research Complex for Eastern Region, Makhana Research Centre, Darbhanga on 16th September, 2013. Seven makhana growing progressive farmers from Darbhanga, Madhubani and Katihar districts were also felicitated on this occasion. Around 1250 farmers, representatives from SBI, NABARD, KVKs, NGOs participated in the training programme.

Fig. 158. Farmers Fair cum Training Programme on Makhana Cultivation

Felicitation of Innovative Farmers of Eastern States

Farmers Innovation Day was organized on 5th October, 2013 by the institute, which was attended

Fig. 159. **Inauguration of Farmers Innovation Day and felicitation of the progressive farmers.**

Fig. 160. **Inauguration of programme and felicitation of a farmwoman by Dr. Mangala Rai during the technology showcasing**

by the farmers of Jharkhand, Bihar, West Bengal, Odisha and Chhattisgarh.

Dr. Mangala Rai, Agriculture Advisor to Chief Minister of Bihar and former DG, ICAR graced this occasion as Chief Guest and felicitated 21 progressive farmers of various eastern states for their innovative work in the field of crop, horticulture, animal husbandry, fishery, integrated farming and natural resource management.

Showcasing of Agricultural Technologies from Seven states of the Eastern India

Showcasing of "Agricultural Technologies 2013" was inaugurated by Dr. Mangala Rai, Agricultural Advisor to Chief Minister, Govt. of Bihar at ICAR Research Complex for Eastern Region, Patna, on 6th December 2014. The two-day programme (6-7th December, 2013) was jointly organized by the institute and Directorate of Knowledge Management in Agriculture (DKMA), ICAR, New Delhi. On the occasion, 70 farmers and agri-entrepreneurs from the eastern states were felicitated for their significant contribution in the field of agriculture and allied sector.

During the showcasing event, Assam Agricultural University, Jorhat; Bihar Agricultural University, Sabour; BIAF, Bihar; Cereal Systems Initiatives for South Asia; KVKs of Ambala, Patiala and Ludhiana; and seventeen ICAR institutes and their centres (NIRJAFT, Kolkata, DWM, Bhubaneswar, DRWA, Bhubaneswar; CPRS, Patna, CIBA, Kakdwip, CNRG, Mathura; IARI Regional Centre, Pusa, CHES, Bhubaneswar; NDRI Eastern regional centre, Kalyani; CRIJAF, Barracpore; IVRI Regional Centre, West Bengal; CIFRI, Barracpore; DSR, Mau; IIVR, Varanasi; NIRG, Ranchi; DKMA, New Delhi and ICAR RCER, Patna participated and showcased their activities, latest technologies and products. More than one thousand farmers, farmwomen, entrepreneurs, extension workers, development functionaries from different parts of eastern region participated and shared their rich experiences during the function.

Fig. 161. **Demonstration of Makhana seed grading machine**

Farmers' Fair-cum-Farmers-Scientists Interaction Organized at Katihar

Shri Tariq Anwar, Union Minister of State for Agriculture and food processing industries inaugurated 2-day Farmers' fair-cum-farmers-scientist interaction meet at Katihar on 25th December, 2013. Sri Anwar insisted scientists for speedy dissemination of the latest farmers' friendly technologies to the stakeholders so as to increase the production and income.

Fig. 162. Inauguration and address by chief guest

14th Foundation Day of ICAR Research Complex for Eastern Region, Patna

The 14th Foundation Day was celebrated on 22nd Feb., 2014 at ICAR Research Complex for Eastern Region (ICAR RCER), Patna. Padmabhushan Shri Chandi Prasad Bhatt, a noted environmentalist, social activists and Magsaysay Award Winner graced this occasion as Chief Guest. During the Foundation Day Lecture, he shared his experience about Chipko Movement and his journey from the Himalayas to the Gangetic basin. He cautioned the scientists about the possible impact of climate change and deforestation on agriculture in the Gangetic basin. He felt the need of establishing Glacier Monitoring Agency in the country.

Fig. 163. Inauguration of book and felicitation of the staff by Padmabhushan Shri Chandi Prasad Bhatt Ji

Agricultural Education Day

Agricultural Education Day was celebrated on 10th December, 2013 in which 80 students from different schools of Patna participated. The programme consisted of field and laboratory visits, interaction with scientists followed by lecture on Importance of Agricultural Education in India. A documentary film on activities and achievements of the institute was also shown to the students. A debate on the topic "Agriculture is the main stay of Indian Economy" was organised in which a fairly good number of students from various schools participated. In addition to this a quiz completion on general topic was also organised among the schools as team events. The winners of the competitions were awarded with prizes.

Fig. 164. Agricultural Education Day

Celebration of World Environment Day

World environment day was celebrated on 5th June 2013 at Kukurha village under NICRA project in the presence of more than 100 farmers to create awareness on role of changing climate and their impact on crop growth, yield potential, diseases and insect pest, and livestock.

ICAR-Industry Meet

The institute organized ICAR Industry Meet at its Research Centre, Ranchi on 16th November, 2013. The meet was organized in collaboration with Indian Institute of Natural Resins and Gums (IINRG), Ranchi; Birsa Agricultural University (BAU), Ranchi and Zonal Technology Management Unit, Kolkata.

The technologies regarding low energy water application, Instant Swarna Mushroom Soup Mix and Elite line of capsicum HACAV 271 were also displayed in the exhibition. Improved varieties of different crops developed by ICAR-RCER *viz*., Swarna Vaidehi in makhana, Swarna Anmol in tomato, Swarna Prafulya in chili, Swarna Atulya in capsicum, Swarna Sneha in bottle gourd, Swarna Yamini in bitter gourd were also released by the Institute Variety Release Committee of ICAR RCER. Swarna Vaidehi is the first variety of makhana to be released in the country.

Visit of Dr. K. Kasturirangan, Member, Planning Commission, Govt. of India

Padma Vibhushan, Dr. K. Kasturirangan visited ICAR-RCER, RC, Ranchi on 3rd May 2013 and discussed about the technology developed at ICAR-RCER, RC, Ranchi.

Fig. 165. Visit of Padmavibhushan Dr. K. Kasturiranjan

Workshops, Seminars, Symposium, Meetings, Farmer's Day Organized

- Farmers' awareness programme on 'Livelihood promotion through value addition' was conducted at ICAR-RCER, Research Centre Ranchi in association with Krishi Vikash Kendra, Nalanda (Bihar) during March 2013. Around 80 farmers participated in the programme and got acquainted with the importance of post harvest management and value addition of horticulture and forest produce.
- Summer school on "Horticulture based diversification options for livelihood security in tribal areas" was organized by Dr. A.K. Singh, Principal Scientist, ICAR RCER Research Centre, Ranchi for 21 days on at ICAR RCER Research Centre, Ranchi from 21st May to 10th June, 2013.
- Seminar was organized on "*Baudhik Sampada Ke Adhikar*" on 12th Sept, 2013 at, ICAR RCER Research Centre, Ranchi.
- IVRC meeting was held on 14th Nov., 2013 at ICAR RCER Research Centre, Ranchi, where proposals and release of seven varieties were presented and submitted.
- Project Advisory Committee meeting for VDSA project organized on 9th July, 2013.

Fig. 166. Summer School on "Horticulture based diversification options for livelihood security in tribal Areas at ICAR RCER, Research Centre, Ranchi

Exposure Visits

- To Central Rice Research Institute, Cuttack, from 31.08.2013 to 06.09.2013 in which 40 farmers (20 each from Durgapur and Dumariya villages) participated.
- To Indian Institute of Vegetable Research, Varanasi, from 10.08.2013 to 17.08.2013 in which 40 farmers (20 each from Inai and Susari villages) participated.

Technology Transfer for Commercialization

Process technology for production of "Dried Instant Swarna Mushroom Soup Mix" has been transferred on non-exclusive basis for commercial production to M/s Natural Resources Integrated Development Foundation, Durga College Complex, Shop No. 10, 1st Floor, Maudhapara, Raipur, Chattisgarh-492001

- Swarna Vaidehi variety of makhana seed (486 kg) was distributed among farmeres, KVKs, CFTRI Mysore, CIPHET, Ludhiana and fishery deptt, Faizabad.
- Two batches of farmers (25 each) from Lathehar, Jharkhand have been trained on improved technique on Makhana cultivation and processing.
- Two national level seminars on Makhana processing were organized.

Education and Training of Staff Under-taken in India/Abroad

India

A. Chakrabarti attended a training programme on 'Fundamentals of Livestock Meteorology' at Kerala Veterinary and Animal Sciences University, Mannuthy during December 02-22, 2013

Abdul Haris participated and assisted the Director in organizing Brainstorming workshop on Precision Agriculture in Nutrient Management" at ICAR, RCER Patna on 19/11/13.

A. Upadhyaya participated in Integrated Model Development Workshop of Koshi Basin Programme Phase-I at ICIMOD, Kathmandu, Nepal during June 18-20, 2013.

Bharati, R.C. attended training programme under NAIP subproject entitled "Developing, Commissioning, Operating, and Managing an online system for NET/ARS-Prelim Examination in ASRB, ICAR" at ASRB New Delhi during November 21-22, 2013.

Deokaran, Ramkewal, Mandhata Singh, Harigovind and R. C. Verma attended a training progrmamme on Nutrient Management "Nutrient Expert" at ICAR RCER Patna organized by IPNI during 09th May 2013.

Mandhata singh attended one day training programme on "Hermetic storage system" at ICAR RCER,Patna dated 27th May 2013.

Ramakrishna Roy attended a training cum sensitization workshop on NFTD at IGFRI, Jhansi during September 22-23, 2013.

Reena Kumari Kamal has undergone professional attachment training in Hatchery Unit of Bihar Veterinary College from November 19, 2013 to February 18, 2014.

S.K. Barari attended a training programme on Database Management System at IASRI, New Delhi during April 8-12, 2013.

Sarfaraj Ahmad attended "Orientation Program of Programme Assistant (Computer) of KVKs at Bihar Agriculture University, Sabour, Bhagalpur, Bihar during July 8-11, 2013.

Sarfaraj Ahmad attended training programme under the NAIP sub-project entitled "Developing, commissioning, operating and managing an online system for NET/ARS-PRELIM in ASRB, ICAR" at ASRB/IARI, New delhi during November 21-22, 2013.

Abroad

Mandhata Singh participated in a foreign Training on Rice, Post Production to Market held at International Rice Research institute (IRRI) Philippines during fromOctober 28to November8, 2013.

Santosh Kumar participated in a foreign training-cum-workshop on "Characterization of Rice Growing Environments for Dissemination of Stress Tolerant Varieties in South Asia"held at Kathmandu, Nepal 24-26 July, 2013.

Shanker Dayal attended advanced training programme on 'Transcritome profiling of adipogenic progenitor cell of cattle" at Washington State University, Pullman, USA from 30th September to 28 December, 2013.

Linkages and Collaboration in India/Abroad

- AAU, Khanapara, Assam
- ACIAR
- Animal and Fishery Resource Department, Govt. of Bihar
- ATMA (Buxar)
- BAIF, Bihar
- Bihar Agriculture Management Extension and Training Institute (BAMETI), Patna
- Bihar Veterinary College, Patna
- Birsa Agricultural University, Ranchi
- CIMMYT, Mexico
- CIPHET, Ludhiana
- CIRB, Hisar
- COMFED, Patna

- CRRI, Cuttack
- Department of Agriculture (Govt. of Bihar)
- Department of Biotechnology, Govt. of India
- Department of Horticulture (Govt. of Bihar)
- District level programme management group on Nutri farm
- DRR, Hyderabad
- IARI New Delhi
- IARI Regional Research Station Pusa Samastipur
- IFFCO, Buxar
- IGFRI, Jhansi
- IRRI, Philippines
- IVRI, Izatnagar and Kolkata
- Jay Prabha Mandal buxar (NGO)
- KVK, Darbhanga
- KVK, Katihar
- KVK, Purnea
- KVK, Saharsa
- KVK, Supaul
- Ministry of Water Resources, Govt. of India
- NABARD, Darbhanga
- NABARD, Madhubani
- NGO, Dhamthari, Chhatisgarh
- NRC on Pig, Guwahati
- R.K. Sevashram, Bhadrak, Odisha
- Rajendra Agricultural University, Pusa, Samastipur, Bihar
- UBKV, Coochbehar, West Bengal
- Water Resources Department, Govt. of Jharkhand

Participation in Conference/ Seminar/ Workshops/ Symposia/ Meetings

Bhavana, P. attended "ICAR Industry Meet 2013" organised by ICAR RCER & IINRG at ICAR RCER Research Centre, Ranchi on Nov.16, 2013.

Bhavana, P. attended Hindi workshop on "Intellectual Property Rights" at ICAR RCER Research Centre, Ranchi on 12th Sept., 2013.

Bhavana, P. attended National Symposium on "Abiotic and Biotic Stress Management in Vegetable Crops" at IIVR, Varanasi during April 12-14, 2013.

Bhavana, P. attended Sensitization Workshop for ERP Solution and Data Templates under NAIP sub project "Implementation of MIS including FMS in ICAR" organized by IASRI, CRIJAF & IINRG at IINRG, Ranchi on 31st October, 2013.

Bhavana, P. attended Summer School on "Horticulture Based Diversification options for Livelihood Security in Tribal Areas" at ICAR RCER Research Centre, Ranchi from 21st May -10th June, 2013.

Bhavana, P. attended workshop on "Sophisticated Analytical Instruments" at IINRG, Ranchi from 18-23 February, 2013.

Chakrabarti, A. attended National Workshop on "Need and nature of Basic / Strategic Research in Agriculture" at NIRJAFT, Kolkata during 23-24th August, 2013.

Choudhary, J.S. attended winter school on NAIP-NABG Subject Training on "Bioinformatics: *in vitro* to *in silico* Approaches in Entomology" at NBAII, Bengaluru from 18-30 November, 2013.

Das, Bikash attended "BRICS Climate Change Seminar on Agriculture" held at Moulderdrift, South Africa during 23rd - 25th October, 2013.

Dayal, Shanker 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.

Deokaran participated in National Seminar on "Sustaining Soil Health in Ensuring Food Security" organized by Fertilizer Association of India, Eastern Zone, Kolkata at NIRJAFT, Kolkata from 21-22 November, 2013.

Deokaran participated in Review Workshop of NICRA Project organized by Zonal Project Directorate, Zone-II, Kolkata at UBKVK, Cooch Bihar (W.B.) from 4-5 November, 2013.

Deokaran participated in training on Direct Seeded Rice, organized by NICRA, CRIDA, at CRURRS, Hajaribagh, Jharkhand from 27-28 September, 2013.

Govind, Hari participated in Sensitization workshop on "Plant Protection Verities and Farmers Right (PPV&FRA)" organized by Zonal Project Directorate, Zone-II, Kolkata in collaboration with PPV & FR Authority, New Delhi at BCKV, Kalyani, Nadia (W.B.) on 17th December, 2013.

Gupta, V.K. and Singh, I.S. attended Annual workshop-cum-CAC Meeting on "Sustainable Livelihood Improvement through Need-Based Integrated Farming System Models in Disadvantageous Districts of Bihar" at ICAR RCER, Patna on 10th April, 2013.

Gupta, V.K. and Singh, I.S. attended meeting on "Demonstration of Integrated Model of Fish,

Duck and Quail" organized by Deputy Superintendent of Police, Biraul, Darbhanga at Biraul, Darbhanga on 16th January, 2014.

Gupta, V.K. and Singh, I.S. participated in "Agri Summit-2013: A step Towards Second Green Revolution-2013" at ICAR RCER, Patna on 8-9 April, 2013.

Gupta, V.K.; Kumar, Lokendra and Singh, I.S. attended Subdivisional Level Workshop on "Shree Vidhi Maha Abhiyaan-2013" organized by ATMA, Darbhanga at Sabhagaar Ayukt Karyalaya, Darbhanga on 29th April, 2013.

Kumar, Abhay participated in the "Annual Workshop of NAIP Comp. 3 Sub-projects", organized at BAU, Varanasi during 15-16 March, 2013.

Kumar, Lokendra; Gupta, V.K. and Singh, I. S. attended International Conference on "Impact of Technological Tools on Food Security under Global Warming Scenario (ITTFS-2012)" organized by Hi-Tech Horticultural Society, Merrut, U.P. at SHOBHIT University, Modipuram, Merrut, on 11-12 May, 2013.

Kumar, S.; Das, B. and Choudhary, J. S. attended Training Cum Workshop on "Real Time Mango Pest Surveillance under NICRA Project" organized at ICAR Research Complex for Eastern Region, Ranchi from 7-8 March, 2013.

Kumar, S.; Das, B. and Choudhary, J.S. attended 2nd Annual Workshop of NICRA Project organized by CRIDA, Hyderabad at IARI, New Delhi during 17-19 June, 2013.

Kumar, Sanjeev participated in International Workshop on "Crop-manager/nutrient Manager for Rice-Wheat Cropping System," organized by CSISA (CIMMYT) along with IRRI, ILRI and IFRI at ICAR-RCER, Patna on 20th August, 2013.

Kumar, Sanjeev participated in the meeting " National Mission on Sustainable Agriculture for Preparation of Proposal Draft and Discussion organised by Deptt. of Agri. Govt. of Bihar at Patna on 16th November, 2013.

Kumar, Sanjeev participated in the National Group meeting on "AICRP-IFS" organized by PDFSR, Modipuram and ICAR Research Complex for N.E.H. Region, Umiam held at ICAR-RC (NEH) Region, Umiam, (Meghalaya) from 4-6 December, 2013.

Kumar, Sanjeev participated "Annual Workshop-cum-CAC Meeting of NAIP" Component-3 at ICAR- RCER, Patna on 10th April, 2013.

Kumar, Sanjeev participated in "31st Group Meeting of AICRP on Potato", organized by CPRI, Shimla at CPRS, Patna from 20-22 Sept., 2013.

Kumar, Sanjeev participated in the meeting "Kharif Utpadan Karyakram 2013-14" organised by Dept. of Agril., Govt. of Bihar at Patna on 2nd March, 2013.

Kumar, Sanjeev participated in the meeting "Formation of Unique Cost Committee" held at Patna on 31st October, 2013.

Kumar, Sanjeev participated in the meeting "National Food Security Programme" held at Patna on 19th September, 2013.

Kumar, Sanjeev participated in the meeting of Scientific Advisory Committee of K.V.K., Sitamarhi held at KVK, Sitamarhi on 11th March, 2013.

Kumar, Sanjeev participated in the workshop "Building Awareness About the Need and Nature of Basic/Strategic Research in Agriculture" organized by National Fund for Basic/strategic and Frontier Application Research in Agriculture (NFBSFARA) held at NIRJAFT, Kolkata from 23-24 August, 2013.

Kumar, Sanjeev participated in the workshop on "Nutrient Expert" organized by International Plant Nutrition Institute-South Asia Program held at ICAR- RCER, Patna on 9th May, 2013.

Kumar, Santosh participated in the "7th International Rice Genetics Symposium" held at Manila, Philippines during 5-8 November, 2013.

Kumar,Santosh participated in "Review Meeting for Foreign Aided Projects under NRM Division" held at Pusa, New Delhi on 4th February, 2013.

Kumar, Santosh participated in "48th Annual Rice Research Group Meeting", held at SKUAST, Srinagar during 13-16 April, 2013.

Kumar, Santosh participated in "52nd All India Wheat and Barley Research Workers Meet", held at CSAUA&T, Kanpur during 1-4 September, 2013.

Kumar, Santosh participated in a foreign training-cum-workshop on "Characterization of Rice Growing Environments for Dissemination of Stress Tolerant Varieties in South Asia" held at Kathmandu, Nepal 24-26 July, 2013.

Kumar, Santosh participated in "Annual Review and Planning Workshop for India and Nepal (STRASA Phase 2)" held at NASC Complex, New Delhi during 09-11 April, 2013.

Kumar, Ujjwal and Sarma, Kamal participated in training on "Agricultural Innovation Systems" Organized by Centre for Research on Innovation and science Policy (CRISP) & Australian Centre for International Agricultural Research (ACIAR) at Patna during 12-14 November, 2013.

Maurya, S. attended "Indian Mushroom Conference 2013" at PAU, Ludhiana during 16-17th April, 2013.

Maurya, S. attended "National Symposium of Indian Phytopathological Society (EZ)" at CRURRS, Hazaribag during 24-25th October, 2013.

Mondal, S.K. attended workshop on "Crop Nutrient Manager for Rice-Wheat Cropping Systems" at ICAR-RCER, Patna on 20th August, 2013.

Mondal, S.K. participated in Brainstorming Workshop on "Precision Agriculture in Nutrient Management-Present Status and Future Need in Eastern India" organised by International Plant Nutrition Institute (IPNI) at ICAR-RCER, Patna on 19th November, 2013.

Mondal, S.K. participated in workshop on "Nutrient Expert for Hybrid Maize and Wheat-A Nutrient Decision Support Tool" at ICAR-RCER, Patna on 9th May, 2013.

Naik, S. K. attended Brain Storming session on "Precision Agriculture in Nutrient Management" at ICAR Research Complex for Eastern Region, Patna on 19th November, 2013.

Pan, R.S. attended "XXXI AICRP (Vegetable Crops) Group Meeting" at CSK HPKV, Palampur, H.P. on 2-5 May, 2013.

Pan, R.S. attended Seminar on "Eastern Region Chapter on IPR in Agriculture" at ICAR RCER RC, Ranchi during 27-28 February, 2014.

Pan, R.S. attended State Level Workshop on "Impact of National Agricultural Innovation Projects and Strategies for their Sustainability" at Birsa Agricultural University, Ranchi on 4th January, 2014.

Pan, R.S. attended Workshop on "Intellectual Property Rights" at ICAR RCER Research Centre, Ranchi on 12th Sept., 2013.

Ramkewal participate in "Kissan Goshthi" at Gandhi Maidan in Bihar Diwas organized by Dept of Agriculture, Govt. of Bihar from 22-24.3.13.

Ramkewal participated in "Agricultural Science Congress" organized by NAAS, New Delhi at OUAT Bhubaneswar, Odisha from 7-9 February, 2013.

Ramkewal participated in seminar on "Enhancing Farmers Income through Value Addition and Efficient Marketing" organized by Bihar Industries Association, Patna at Patliputra Ground, Patna from 14-17 March, 2013.

Roy, Ramakrishna attended training cum sensitization workshop on "National Initiative on Fodder Technology Demonstration" at Indian Grassland and Fodder Research Institute, Jhansi from 22-23rd September, 2013.

Roy, Ramakrishna attended workshop for reviewing the lessons of "Diploma in Commercial Poultry Production" at National Institute of Open Schooling, Noida.

Sarma, Kamal attended Annual workshop cum CAC meeting on "Sustainable Livelihood Improvement through Need Based Integrated Farming System Model in Disadvantage Districts of Bihar" on 10th April, 2013.

Sarma, Kamal attended "Final Review Workshop of Component-3, Sub-projects" organized at NASC Complex, New Delhi during 3-4 February, 2014.

Sarma, Kamal attended workshop on "Improving Rural Livelihood through Access to Water, Energy and Marke" organized by International Water Management Institute (IWMI) at Patna on 10th May, 2013.

Sarma, Kamal participated in National workshop on "Business Opportunities in Freshwater Fisheries" organized by Zonal Technology Management-Business Planning and Development Unit, South Zone in association with Directorate of Fisheries, Bihar at Patna on 23 March, 2013.

Shinde, R. attended the "ICAR Industry Meet" organized by ICAR Research Complex for Eastern Region at Research Centre, Ranchi in collaboration with IINRG, Ranchi, Birsa Agricultural University (BAU), Ranchi and Zonal Technology Management Unit, NIRJAFT, Kolkata on 16th November, 2013.

Shinde, R. attended the Seminar on "Baudhik Sampada Ke Adhikar" organized by ICAR RCER Research Centre, Ranchi on 12th September, 2013.

Shivani participated in Brainstorming Workshop on "Precision Agriculture in Nutrient Management: Present Status & Future Need in Eastern India" organized by CIMMYT, ICAR RCER, IPNI, CGIAR & CCAFS at Patna on 19th November, 2013.

Singh, A.K. attended "Management Development program on Leadership Development at NAARM, Hyderabad from 26th August, 2013-6th September, 2013.

Singh, A.K. attended "31st Group Meeting of AICRP (VC)" at CSKHPKV, Palampur from 2-5 May, 2013.

Singh, R.D. participated in meeting on "Contingency Planning for Deficient Rainfall Districts in Bihar and Jharkhand-*Kharif*, 2013" organized by CRIDA Hyderabad and ICAR-RCER, Patna on 13th August, 2013.

Singh, R.D. participated in "Orientation Programme for K.V.K. Programme Co-ordinators and Assistant Professors" organized byR.A.U., Pusaon 27th September, 2013.

Singh, R.D. participated in "State level Meeting for Approval of RKVY Programme under Livestock and Fishery Development in the State" on 6th January, 2014.

Singh, R.D. participated in "Vetting Workshop of District lLevel Contingency Plan (DLCP)" at Birsa Agricultural University, Kanke, Ranchi on 29th June, 2013.

Singh, R. D. participated in "Vetting Workshop of District Level Contingency Plan (DLCP)" organized by Rajendra Agricultural University, at Pusa, Samastipur on 16th December, 2013.

Sundaram, P.K. attended in "47th Annual Convention of ISAE and International Symposium on Bio Energy" organised by Indian Society of Agricultural Engineering (ISAE) at DRR, Hyderabad from 28-30 January, 2013.

Sundaram, P.K. attended Brainstorming Session in "Farm Mechanisation, Processing Technology and Value Addition for Enhancing Profitability" organised by College of Agricultural Engineering, RAU, Samastipur from 6-7 April,2013.

Sundaram, P.K. participated in travelling seminar on "Conservation Agriculture" organized jointly by ICAR-CIMMYT from 16-25 September, 2013.

Upadhyaya, A. attended "Management Development Programme on Leadership Development" at NAARM, Hyderabad during 26th November -7th December, 2013.

Upadhyaya, A. attended Consultancy Workshop on "Conservation and Management of Wetlands of Bihar" at ICAR-RCER, Patna on 23rd February, 2013.

Upadhyaya, A. participated in "India Water Week" organized at Vigyan Bhawan New Delhi during 8-12 April, 2013.

Upadhyaya, A. participated in International Conference on "Water Quality Management for Climate Resilient Agriculture" at Jalgaon during 28-30 May, 2013.

Upadhyaya, A. participated in International Workshop on "Moving from Water Problems to Water Solutions: Research Needs Assessment for the Eastern Gangetic Plains" at New Delhi during 6-9 May, 2013.

Upadhyaya, A. participated in Workshop on "Enhancing Water Use Efficiency in Yamuna Basin" held at NASC, New Delhi on 30th August, 2013.

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

New entrants

Mrs. Reshma Shinde joined as Scientist (Soil Science) at ICAR-RCER, RC, Ranchi w.e.f 06.05.2013

Dr. Reena Kumari Kamal joined on 9th October, 2013 as Scientist (Livestock Production and Management).

Mr. Ravi Chatterjee, Stenographer, Gr. III joined KVK, Buxar on 25th November, 2013.

Mr. Hari Govind Jaiswal, SMS (Plant Breeding) joined KVK, Buxar on 20th March, 2013 on transfer from KVK, Chiniyalisaur, Uttarkashi, Uttarakhand.

Mr. Ramesh Chandra Verma, SMS (Horticulture), joined KVK, Buxar on 1st April, 2013 on transfer from KVK, Ranipur, Sikkim

Mr. Vikas Kumar, Programme Assistant (Computer) joined KVK, Buxar on 26th September, 2013 on transfer from KVK, Deoria, Uttar Pradesh.

Promotion

Dr. Bikash Das promoted to Senior Scientist (RGP 9000, PB-IV) w.e.f 22.06.2012

Shri Y. N. Pathak promoted to Asst. Chief Technical Officer w.e.f 20.11.2011

Shri Shashi Kumar Azad promoted to Technical Asst.(Farm) w.e.f 16.02.2011

Retirements

Dr. Janardan Jee, Pr. Scientist w.e.f.31.12.2013

Dr. Shivendra Kumar, Pr. Scientist and Head w.e.f 31.01.2014.

Dr. A.R. Khan, Pr. Scientist w.e.f. 31.03.2014

20. Publications

Research Papers

National

Haris, A., Abdul; Bhatt, B. P.; Chhabra, V.; Biswas, S. and Elanchezhian, R. (2013). Climate change impacts on yields of phenologically different rice varieties over a sub-humid climatic environment. *Agricultural Research*, **2**(4): 319-329.

Haris, A., Abdul; Chhabra, V. and Bhatt, B.P. (2012). Agroforestry in climate change adaptation and mitigation. *Agriculture Situation in India*, **69**(8): 405-408.

Haris, A., Abdul; Chhabra, Vandna and Biswas, Sandeep (2013). Carbon sequestration for mitigation of climate change- a review. *Agri. Reviews,* **34**(2): 129-136.

Ajay, P.; Raval, A.P.; Yogesh, M.; Gami; Kumar, S.; Devchand, A.; Sadrasaniya, S.; Bhagwat, R. and Kumari, Rajni (2013). Effect of probiotics supplementation on nutrient utilization, production performance and economics of feeding in lactating kankrej cows. *Indian Journal of Animal Nutrition*, **30**(2): 113-118.

Chandran, P. C.; Pandian, S. J.; Ray, P. K.; Dey, A.; Barari, S. K. and Kaushal, D. K. (2014). Selective breeding Black Bengal goats for improving productivity. *Indian Journal of Animal Sciences*, **84**: 78-81.

Chandran, P. C.; Verma, S. B.; Mandal, K. G.; Singh, R. K. and Kumar, B. (2013). Characteristics and role of shahabadi sheep in elevating the socio-economic status of farmers in Bihar. *Indian Journal of Animal Sciences*, **83**: 971-975.

Choudhary, C. S.; Jain, S. C.; Kumar, R. and Choudhary, J. S. (2013). Efficacy of different fungicides, biocides and botanical extract seed treatment for controlling seed-borne *Colletotrichum* sp. in chilli (*Capsicum annuum* L.). *The Bioscan*, **8**(1): 123-126.

Dayal, S.; Kumar, P. and Kaushik, P. (2013). Breed effect on serum lysozyme activity in indigenous breed of sheep. *Journal of Animal Research,* **3**(1): 43-45.

Dwivedi, S. K.; Arora, A., Singh, S. D.; Singh, G. P.; Nagar, S. and Kumar, S. (2013). PGRs improve carbohydrate metabolism and yield attributes in wheat (*Triticum aestivum*) under water deficit condition. *J. Wheat Res.,* **5**(2): 12-17.

Dwivedi, S. K.; Arora, Ajay; Singh, S. D.; Singh, G. P.; Nagar, S. and Kumar, Santosh (2013). PGRs improves carbohydrate metabolism and yield attributes in wheat (*Triticum aestivum* L.) under water deficit stress condition. *J. Wheat Res.,* **5**(2): 1-62.

Elanchezhian, R.; Kumar, S.; Singh, S. S.; Dwivedi, S. K.; Shivani and Bhatt, B. P. (2013). Plant survival, growth and yield attributing traits of rice (*Oryza sativa* L.) genotypes under submergence stress in rainfed lowland ecosystem. *Indian Journal of Plant Physiology,* **18**(4): 326-332.

Gupta, J. J.; Singh, K. M.; Bhatt, B. P. and Dey, A. (2014). A diagnostic study on livestock production system in eastern region of India. *Indian Journal of Animal Sciences,* **84**(2): 198-203.

Kamal, R. K.; Dutt, Triveni; Singh, Mukesh; Kamra, Nandan, Devki; Patel, Manjunath; Choudhary, Lal Chandra; Agarwal, Neeta; Kumar, Sanjay; and Islam, Manzarul (2013). Effect of live *Saccharomyces cerevisiae* (NCDC-49) supplementation on growth performance and rumen fermentation pattern in local goat. *Journal of Applied Animal Research*, **41**(3): 258-288..

Khan, A.R.; Rahman, A. and Singh, R.D. (2013). Influence of soil surface manipulation on soil temperature in relation to peanut production. *Journal of Applied and Natural Science*, **5**(1) : 53-57.

Kothyari, U.C.; Kumar, A. and Jain, R.K. (2013). Influence of cohesion on river bed scour in wake region of piers. *J. of Hydraulic Eng.* **140**(1): 1-13.

Krishnan, P.; Balasubramaniam, M.; Roy, S.D.; Sarma, K.; Hairun, R. and Sunder, J. (2014). Characterization of the antibacterial activity of bacteria associated with *Stylissa* sp., a marine sponge. *Adv. Anim. Vet. Sci.,* **2**(1): 20-25.

Krishnan, P.; Veeramani, S.; Roy, S.D.; Sarma, K.; Pavel, K. and Sunder, J. (2014). Antimicrobial activity of *Ircinia* sp.; a marine sponge and its associated bacteria from Andaman coast. *Adv. Anim. Vet. Sci.,* **2**(1): 37-41.

Kumar, D.; Kumar, A.; Singh, A.K. and Tripathi, H. S. (2013). Induction of resistance in field pea against rust disease through various chemicals/micronutrients and their impacts on growth and yield. *Plant Pathology Journal*, **12**(2): 36-49.

Kumar, Rajesh; Pandey, A. K.; Singh, Anil Kumar and Verma, A. K. (2013). Extent and pattern of rice root phenology under low land conditions. *Envi. & Ecol.,* **31**(4): 1797-1800.

Kumar, Rajesh; Pandey, A. K.; Singh, Anil, Kumar and Verma, A. K. (2013). Performance of rice genotypes under low land ecosystems of Jharkhand. *Envi. & Ecol.*, **31**(4): 1801-1805.

Kumar, Rajesh; Pandey, A.K.; Singh, Anil, Kumar and Verma, A.K. (2013). Extent and pattern of rice (*Oryza sativa* L.) leaf phenology under low land conditions of Jhanrkhand as influenced by genotype. *Envi. & Ecol.*, **31**(4A): 1810-1815.

Kumar, Rajesh; Pandey, A.K.; Singh, Anil, Kumar and Verma, A.K. (2013). Magnitude of rice (*Oryza sativa* L.) performance as influenced by genotypes under low land agro-ecosystem. *Envi. & Ecol.,* **31**(4A): 1816-1822.

Kumar, S.; Dwivedi, S. K.; Elanchezhian, R.; Singh, S. S.; Singh, O. N.; Arora, A. and Bhatt, B. P. (2013). Influence of aerobic condition on physiological traits and yield attributes of rice (*Oryza sativa* L.) genotypes under rainfed lowland ecosystem. *Indian Journal of Plant Physiology,* **18**(3): 263-269.

Kumar, S.; Elanchezhian, R.; Singh, S. S.; Singh, A. K.; Mall, A. K.; Sangle, U. R. and Sundaram P. K. (2013). Field screening of rice genotypes for resistance against bacterial leaf blight and brown spot under aerobic condition. *Journal of Plant Disease Sciences,* **8**(2): 148-152.

Kumar, Santosh; Elanchezhian, R.; Singh, S. S.; Singh, Anil, Kumar; Mall, A. K.; Sangle, U. R. and Sundaram, P. K. (2013). Field screening of rice genotypes for resistance against bacterial leaf blight and brown spot under aerobic condition. *J. Plant Disease Sci.*, **8**(2): 148-152.

Kumari Anjali; Kumar, R.; Maurya, S.; Choudhary, J.S. and Kumar, S. (2013). Antifungal efficacy of aqueous extracts of neem cake, karanj cake and vermicompost against some phytopathogenic fungi. *The Bioscan*, **8**(1): 1-10.

Kushwaha, P.K.; Singh, M.K. and Singh, Mandhata (2013). Integrated weed management in black gram (*Vigna mungo* L.) under custard apple and guava based agri-horti system in vindhyan region of eastern Uttar Pradesh. *Environment and Ecology*, **31**(4): 1651-1653.

Manibhushan; Patel, N.; Sahoo, G. and Singh, A.K. (2013). Image classification for different land use and land covers using Fuzzy Logic for improvement of accuracies. *Journal of Agricultural Science*, **5**(3): 278-283.

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21. On-going Research Projects

Sl. No.	Project code	Project title	Name of PI & CO-PI	Start year	Comp. year	Funding agency
Theme 1. Farming System Research Including Climate Resilient Agriculture						
1	**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 M. Idris	June 2010	Dec 2012 Ext. March 2014	PDFSR, AICRP (Externally funded)
1.2	ICAR-RCER/ RCM/2011/ 25(ii)	Development of makhana based Integrated Farming System models for low land ecosystem	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, S. Maurya A. K. Thakur, J. S. Choudhary	June 2011	May 2014	ICAR RCER
1.4	ICAR-RCER/ EF/ NAIP/2008/08	Developing sustainable farming system models for prioritized micro watersheds in rainfed areas of Jharkhand	R. S. Pan B. R. Jana	2008	March, 2014	PIU, NAIP (Externally funded)
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 A. K.Singh	April 2012	March 2015	ICAR RCER
2	**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. Choudhary	June 2011	May 2014	ICAR RCER
2.2	ICAR-RCER/ IFAD/ DCR/EF/ 2011/27	Accelerating RCTs adoption to improve food security and rural livelihoods while reducing adverse environ-mental impacts in Indo-Gangetic Plains (IFED)	Sanjeev Kumar S. S. Singh, U. Kumar P. K. Sundaram Shivani	June 2011	April 2013	IRRI (Externally funded)
3.	**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. Haris A. 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 M. Idris, U. R. Sangle	July 2012	June 2015	ICAR RCER
3.3	ICAR-RCER/ EFP /NAIP/2009/19	Modeling the performance of a new major cropping system in eastern India in the light of projected climate change (NAIP)	S. S. Singh, R.C. Bharati	Jan. 2009	Ext. 2013	NAIP

Sl. No.	Project code	Project title	Name of PI & CO-PI	Start year	Comp. year	Funding agency
3.4	ICAR-RCER / RC R / E.F./2011/29	Understanding the changes in host-pest interactions and dynamics in mango under climate change scenario (NICRA) (2011 -2013)	S. Kumar, Bikash Das, S. S. Mali, J. S. Choudhary	Jan. 2011	Jan. 2014	NICRA (Externally funded)
3.5	ICAR-RCER /DLWM/ 2012/126	Land suitability classification for different crops using remote sensing and GIS	Manibhushan Surajit Mondal A. K. Singh, A. Upadhyaya	Jan. 2013	Dec. 2015	ICAR RCER
Theme 2. Genetic Resource Management and Improvement of Field, Horticultural and Aquatic Crops						
4	**Varietal Development**					
4.1 (a)	ICAR-RCER/ DCR/ 2010/ 84	Management of abiotic stress in rice through biotechnological approaches Management of submergence tolerance through biotechnological approaches in rice grown in lowland ecosystem	Santosh Kumar Shivani	July 2010	June 2014	ICAR RCER
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, M. Idris U. R. Sangle	July 2011	June 2014	IRRI (Externally funded)
4.4	ICAR-RCER/ EF/IRRI/ 2012/33	Improved rice based rainfed agricultural system (IRRAS) in Bihar state, India	S. S. Singh, S. Kumar A. K. Singh, U. R. Sangle	July 2012	June 2015	IRRI (Externally funded)
4.5	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
4.6	ICAR RCER/ RC Ranchi/ EF/2011/ 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 (Externally funded)
4.7	ICAR-RCER/RC Ranchi/ 2010/ 83	Characterization of bacterial wilt resistance in brinjal using conventional and molecular approaches	P. Bhavana, A. K. Singh J. P. Sharma	Jan. 2010	March 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, P. Bhavana	2006	Ext. 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, Bikash Das S. K. Naik	2006	Ext. 2014	ICAR RCER
4.10	ICAR-RCER / RC Ranchi/ 2012/ 128	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. 2016	ICAR RCER
4.11	ICAR-RCER / HARP/ 2001/ 03	Plant genetic resource and improvement of 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	Aug. 2015	ICAR RCER

Sl. No.	Project code	Project title	Name of PI & CO-PI	Start year	Comp. year	Funding agency
4.13	ICAR-RCER/RCR/ 2012/132	Collection, characterization and evaluation of potentials wild edibles including tuber crops	R. S.Pan Bikash Das	Apr 2013	March 2018	ICAR RCER
4.14	ICAR-RCER/ DCR/2013/136	Characterization of wheat (*Triticum aestivum* L.) genotypes for terminal heat stress tolerance	S. K. Dwivedi Santosh kumar S. S. Singh	July 2013	June 2016	ICAR RCER
Theme- 3. Improved Production and Protection Technologies for Agri-Horti Crops						
5. Production Technologies						
5.1	ICAR-CER / DLWM/ 2010 /88	Evaluation of different weeding technologies for direct seeded rice-maize cropping system	P.K. Sundaram A. K. Singh, A. Rahman	June 2011	June 2014	ICAR RCER
5.2	ICAR-RCER/ DCR/ 2011/ 92	Optimization of method of transplanting and fertilizer application in transplanted maize	Sanjeev Kumar U. R. Sangle, N. Chandra	Oct. 2011	June 2014	ICAR RCER
5.3	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
5.4	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
5.5	ICAR-RCER/DLWM/ 2012/130	Evaluation of vegetable varieties under different irrigation methods	Shivani, A. K. Singh R. D. Singh, M. Idris	Sept. 2012/ Initiated in 2013	Aug. 2016	ICAR RCER
5.6	ICAR-RCER/R C Ranchi/ 2012/129	Development of methods for processing and extending shelf-life of selected vegetable legumes	A. K. Thakur, R. S. Pan S. Maurya	Jan. 2013	Dec. 2015	ICAR RCER
5.7	ICAR-RCER/ DLWM/ 2013/137	Design and performance evaluation of low cost green house suitable for vegetable roduction in Bihar and Jharkhand	Bikash Sarkar A. Upadhyaya P. K. Sundaram	2013	2014	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-pulses-onion cropping system in Bihar state	Janardan Jee M. Idris	July 2011	June 2014	ICAR RCER
6.1 (b)	ICAR-RCER/ R.C. Ranchi/ 2012/131	Survey and surveillance of pest complex and their natural enemies on selected horticultural crops	J. S. Choudhary S. Maurya	Jan 2013	Dec. 2015	ICAR RCER
6.2	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
6.3	ICAR-RCER/ DCR/ 2011/ 114	Development of bio-insecticides module for management of gram pod borer (*helicoverpa armigera*) (Hubner) in chickpea crop	U. R. Sangle M. Idris, Sanjeev Kumar	Dec. 2011	April 2014	ICAR RCER
6.4	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
6.5	ICAR-RCER/ RC Ranchi/ 2011/ 97	Biology, seasonal incidence and management of stink bug (*Tessaratoma* sp.) on litchi in eastern plateau and hill region	J. S. Choudhary M. Idris	June 2011	June 2014	ICAR RCER
Theme- 4. Integrated Land & Water Management						
7.0 Land & 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

Sl. No.	Project code	Project title	Name of PI & CO-PI	Start year	Comp. year	Funding agency
7.2	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 (Externally funded)
7.3	ICAR-RCER / DLWM/ 2011/102	Refinement of LEWA for its better performance	Ajay Kumar A. Upadhyaya	July 2011	June 2013 ext. Dec. 2013	ICAR RCER
7.4	ICAR-RCER / DLFM / 2010/ 118	Diversification of fish farming system to maximize the water productivity	B. K.Choudhary	April 2012	March 2015	ICAR RCER
7.5	ICAR-RCER / DLWM/ 2011 /119	Solar energy utilization in agriculture	A. Rahman P. K. Sundaram	Aug. 2011	July 2014	ICAR RCER
7.6	ICAR-RCER/ DLWM/ 2011/121	Evaluation of developed Decision Support Tool in participatory mode	A. Upadhyaya	Jan. 2012	Dec. 2013	ICAR RCER
7.7	ICAR-RCER/ DLWM/ 2013/138	Rice fallow management	Abdul Haris A. S. K. Singh K. M. Singh S. Mondal, Manibhushan Pankaj Kumar, Ajay Kumar, R. S. Pan S. K. Naik A. Upadhyaya	2013	2016	ICAR RCER
Theme- 5. Livestock & Fisheries Management						
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 S. Dayal, D. K. Kaushal K. M. Singh, Rajni Kumari S. Bandopadhyay	Apr. 2011	Mar. 2015	ICAR RCER
8.2	ICAR-RCER / DLFM / 2011/ 91	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 and prolificacy gene for improvement of growth performance traits in Black Bengal goat	S. Dayal, S.P. Sahu Rajni Kumari	Aug. 2011	July 2014	ICAR RCER
8.4	ICAR-RCER / DLFM / 2011/ 106	Formulation of area specific mineral mixture for Bihar based on soil-plant-animal continuum	A. Dey, J. J. Gupta Manoj Kumar Bipin Kumar, S. K. Naik	Aug. 2011	July 2015	ICAR RCER
8.5	ICARRCER /DLFM /2011/ 99	Chronic exposure effect of carbofuran and chlorpyrifos in ducks and role of vitamin C and vitamin E in its amelioration	Pankaj Kumar, Rajni Kumari	Aug. 2011	July 2014	ICAR RCER
8.6	ICAR-RCER/ DLFM/ 2010/107	Field bailing of crop residues for animal feeding	A. Dey, A. Rahman Deokaran	Aug. 2011	July 2014	ICAR RCER
8.7	ICAR-RCER/ EF/DBT/ 2012/34	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 (Externally funded)
8.8	ICARRCER/DLFM/ EF/2011/ 31	Buffalo improvement	S. Dayal, A. Dey A. Chakrabarti, Pankaj Kumar	June 2012	Dec. 2016	Earlier it was Externally funded project (CIRB, Hissar) but now as Instt. project

Sl. No.	Project code	Project title	Name of PI & CO-PI	Start year	Comp. year	Funding agency
8.9	ICARRCER/DLFM/ 2011/109	Adaptability and management study of rabbit in Bihar	A. Chakrabarti J. J. Gupta	Jan. 2012	Dec. 2014	ICAR RCER
8.10	ICAR-RCER / DLFM / 2010/103	Adoptability and management study for poultry species in Bihar (Turkey, Quail and Vanaraja) in Bihar	A. Chakrabarti J. J. Gupta	April 2012	March 2015	ICAR RCER
8.11	ICAR-RCER/ DLFM/ 2012/122	Evaluation of nutraceuticals supporting therapy for subclinical mastitis in peri-urban cattle	Pankaj Kumar J. J. Gupta, S. Dayal Rashmi R. Kumari S. Kumar, P. Kumar	Feb 2013	Jan 2016	ICAR RCER
8.12	ICAR-RCER/ DLFM/ 2012/123	Serological epidemiology of major viral pathogen of caprine in Bihar	Pankaj Kumar P. C. Chandaran R. K. Roy, K. K. Rajak Manoj Kumar, P. Shekhar	Mar. 2013	March 2016	ICAR RCER
8.13	ICAR-RCER/ DLFM/ 2012/124	Health monitoring and disease surveillance of farm animals	Pankaj Kumar P. C. Chandran Purushottam	Mar. 2013	Feb. 2016	ICAR RCER
8.14	ICAR-RCER/ DLFM/ 2013/135	Characterization of lesser known breeds of farm animals in eastern India	P. C. Chandran Shankar Dayal Rajni Kumari, K.G. Mandal	July 2013	June 2017	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 K. Sarma, D. K. Kaushal	June 2011	June 2014	ICAR RCER
9.2	ICAR-RCER/ DLFM/ 2012/133	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
Theme- 6. Socio-Economics, Extension and Policy Research						
10.0 Socio-economic Research						
10.1	ICAR-RCER/ SEET/ 2011/ 108	Impact assessment of adopted technologies	N. Chandra, R.C. Bharati P. K. Thakur, A. K. Singh	July 2011	July 2014	ICAR RCER
10.2	ICAR-RCER/ SEET/ 2011/111	Risk proneness of major crops of eastern India	R.C. Bharati, B.P. Bhatt 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	Bill & Melinda Gates foundation (Externally funded)
10.4	ICAR-RCER/DSEE/ 2012/127	Technology out-scaling for sustainable food production and livelihood improvement	Ujjwal Kumar K. Sarma, A. Haris A. A. Dey, B. K. Choudhary	Sept. 2013	Aug. 2015	ICAR RCER
10.5	ICAR-RCER/ DSEE/ 2012/134	Tribal farming system in eastern India	M. S. Meena, K. M. Singh B. P. Bhatt, A. K. Thakur R. S. Pan, Abhay Kumar B. K.Choudhury Bikash Sarkar	Jan. 2013	Dec. 2015	ICAR RCER
10.6	ICAR-RCER/ DSEE/ 2012/135	Impact assessment of agriculture technology in eastern India	M.S. Meena, K. M. Singh B. P. Bhatt, U. Kumar	Jan. 2013	Dec. 2015	ICAR RCER
10.7	ICAR-RCER/ NAIP/ 2008/11	Sustainable livelihood improvement through need based integrated farming system model in disadvantaged district of Bihar	Abhay Kumar B. K. Jha, R. S. Sharma M. K. Jha, R.P. Ray	2008	2013	NAIP

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Scientists

Dr. K. M. Singh, Pr. Scientist (Agril. Econ) & Head
Dr. Abhay Kumar, Pr. Scientist (Agril. Stat.)
Dr. Ujjwal Kumar, Pr. Scientist (Agril. Extn.)
Dr. R. C. Bharati, Pr. Scientist (Agril. Stat.)
Dr. N. Chandra, Sr. Scientist (Agril. Econ.)

Technical Officers

Sh. V. K.Tiwari, Technical Officer (T-5)
Sh Sanjay Rajput, Technical Officer (T-5)

Performance Monitoring and Evaluation Cell

Scientists

Dr. R. D.Singh, Pr. Scientist (Agron) and Head
Dr. (Mrs) Shivani, Sr. Scientist (Agron.)

Technical Officer

Sh. Kishan Singh, Technical Officer (T-7-8)
Sh. Sarfaraj Ahmad, Prog. Asstt. Computer (T-4)

Farm Section

Dr. A. K. Khan, Farm Manager (T-9)
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

Dr. S. Kumar, Pr. Scientist (Plant Pathology) & Head
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)
Er. S. S. Mali, Scientist (CWC) (on Study leave)
Ms. R. Shinde, Scientist

Technical Officers

Sh. Y. N. Pathak, Technical Officer (T-6)
Sh. D. K. Sah, Technical Officer (T-6)
Sh. Paul Sanjay Sircar, Technical Officer-Computer (T-6)
Sh. Om Prakash, Technical Officer (T-5)
Sh. Gokul Baraik, Technical Officer (T-5)
Sh. Chandrakant, Technical Officer (T-5)
Sh. Ganga Ram, Technical Officer (T-5)
Sh. Birendra Prasad Mishra, Technical Officer (T-5)
Sh. Arun Kumar, Technical Officer (T-5)
Sh. M. K. Pandey, Technical Officer- Library (T-5)
Sh. Kushal Kesariar, Technical Officer (T-5)
Sh. Dhananjay Kumar, Technical Officer (T-5)
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)
Sh. Kishore Kumar, Technical Officer (Driver) (T-5)

ICAR RCER, Research Centre Makhana, Darbhanga

Scientists

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

Subject Matter Specialist

Dr. V. Dwivedi, Programme Coordinator
Dr. Deokaran, SMS (Soil Sci.)
Dr. Ramakrishna Roy, SMS (Animal Sci.)
Dr. R. C. Verma, SMS (Hort.)
Mr. Ramkewal, SMS (Plant Protection)
Dr. Hari Govind Jiswal, SMS (Plant Breeding)
Dr. Mandhata Singh, SMS (Agronomy)

Technical

Sh. Arif Parwez, Farm Manager

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