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भाकृअनुप
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ICAR Research Complex for Eastern Region

To undertake strategic and adaptive research for efficient integrated management of natural resources to enhance productivity of agricultural production system comprising of field, agriculture and horticultural crops, aquatic crops, agro-forestry, livestock, avian and fisheries in different agro-ecological zones of the eastern region.

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annual report 2014-15

ICAR Research Complex for Eastern Region

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

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Guidance
B.P. Bhatt
Director

Editors
Janki Sharan Mishra
Sant Kumar Singh
Shivani
Naresh Chandra
P.C. Chandran
Santosh Kumar
Santosh Kumar Gupta
Tshering Lhamu Bhutia

Secretarial Assistance
Sarfaraj Ahmad

Photography
Sanjay Rajput

Published by
Director
ICAR Research Complex for Eastern Region
ICAR Parisar, P. O. : Bihar Veterinary College
Patna-800 014, Bihar
Tel.: +91-612-2223962, Fax: +91-612-2223956

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Preface

It gives me immense pleasure to bring out the 14th Annual Report of ICAR Research Complex for Eastern Region, Patna. The institute undertakes multi-commodity and multi-disciplinary research to enhance the productivity of agricultural production systems and efficient management of natural resources in diverse agro-climatic zones of Eastern States.

For achieving the goal of food and nutritional security, emphasis was given on conservation agriculture, rainwater harvesting, water productivity enhancement, ground water recharge, rehabilitation of waterlogged areas, solar energy application in agriculture, restoration of degraded lands and cropping patterns. Models of integrated farming systems have been developed for rainfed, irrigated, hill and plateau and waterlogged situations. These models have been found ecologically and economically viable. In order to improve upon the livelihood security of tribal folk, the production system has been integrated with swine husbandry and backyard poultry farming at Ranchi Centre of the Institute. Development of climate resilient farming system models is yet another priority of the institute since simulation studies have indicated significant decline in yield of wheat and rice in future time periods. Under climate change scenario, studies on host-pest interaction and its dynamics in mango have been studied in different states *viz.*, Jharkhand, Uttar Pradesh, Karnataka, Gujarat, Maharashtra and Telangana.

During the period under report, first ever variety of makhana have been developed and released by Central Variety Release Committee. Further, improved variety of paddy (for rainfed upland situation), 3 varieties of faba bean (for rainfed, irrigated and plateau region), 3 varieties of tomato, 2 varieties of chilli, and 1 variety of each capsicum, bottle gourd, ridge gourd, bitter gourd, lima bean and leaf amaranth have been developed and released through State Variety Release Committee, Bihar and Jharkhand. To strengthen the plant genetic resource management, promising genotypes of different fruits like mango, litchi, bael, sapota, solanaceous vegetables and cucurbits have been identified and maintained. In the field of agro-diversity conservation, 201 germplasm of potential wild edibles including tuber crops have been collected from Jharkhand, Chhattisgarh, Odisha and West Bengal. Wheat genotypes have been evaluated for late sown heat stress condition. Five cropping systems have been developed for rice-fallow management and dessiminated in an area of 150 ha covering the states of Jharkhand, Assam, Odisha, West Bengal and Bihar. Further, 4.2 t truthfully levelled seed, 54000 nos. of quality planting material of various fruits and vegetables and 5.5 t of mushroom spawn have been produced. Makhana cultivation has also been introduced in Assam, Chhattisgarh, Odisha and Eastern UP during the period under report.

Different feeding experiments on pig, poultry, goat and cow have been conducted during this period. Murrah breed of buffalo is being reared at the Institute level so as to improve the local buffalo through artificial insemination.

A total of 168 training programs, 32 Front Line Demonstrations, 20 On Farm Trials have been conducted for the farmers and the state government officials. During the period under report, the Institute published 65 nos. of research papers in the journal of national and international repute, 03 books, 03 training manuals, 07 technical bulletins, and 08 popular articles. The team of scientist has also received the Fakhruddin Ali Ahmed Award 2013 for Outstanding Research in Tribal Farming Systems during 2014-15.

I acknowledge the consistent support, keen interest and guidance received from Dr. S. Ayyappan, Secretary DARE and Director General, ICAR in order to plan and implement various research and extension activities. The guidance and support rendered by Dr. A. K. Sikka, Dr. B. Mohan Kumar, and Dr. S.K. Chaudhari, from Subject Matter Division is duly acknowledged. All Heads of the Divisions/ Research Centres deserve appreciation for submitting their research findings in time. The editorial assistance rendered by Dr. J. S. Mishra and his team, and secretarial assistance by Sarfaraj Ahmad in bringing out the report is also appreciated.

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

Contents

1 Executive Summary

- Improved variety of paddy 'Swarna Shreya' has been developed and released through State Variety Release Committee (SVRC) for cultivation in rainfed upland situation with a production potential of 4.5-5.0 t/ha.
- Five cropping/farming situations have been developed for rice-fallow management. Demonstration of rice-fallow management was taken up in an area of 150 ha covering the states of Jharkhand, Assam, Odisha, West Bengal and Bihar.
- Thirty two rice genotypes were evaluated for multiple stages drought tolerance. Six genotypes (IR84899-B-179-16-1-1-1, IR88964-24-2-1-4, IR83387-B-B-27-4, IR83373-B-B-25-3, REWA 842 and RP5212-56-12-9-3-2-1-1) were found promising for cultivation in stress environment.
- Forty rice entries were evaluated under aerobic condition out of which IR83929-B-B-291-3-1-1, IR88964-24-2-1-4, IR83929-B-B-291-2-1-1-2, IR84899-B-179-16-1-1-1, IR77298-14-12-130-2, IR88964-11-2-2-3, IR84899-B-179-13-1-1-1, IR84899-B-183-20-1-1-1, IR84887-B-158-7-1-1-4 and IR88966-43-1-1-4 were found promising with higher grain yield.
- Wheat genotypes NW 1012, Raj 4238, Kundan, GW273, HI 1563 and HD 2987 performed better as compared to checks (DBW 14 and Halna) and high yielding cultivars (HD 2733 and HD 2967) under late sown heat stress conditions.
- Grain yield of wheat, rice and system productivity in terms of rice equivalent yield, soil aggregation parameters and aggregate associated organic carbon increased significantly in complete CA- based (zero-till) rice-wheat-mungbean system over conventional rice-wheat system.
- Ecologically and economically viable integrated farming system models have been developed for irrigated, rainfed, Hill and Plateau and flood plain wetlands. The net monetary gains ranged from Rs. 35,000-60,000 per acre of land.
- Studies on application of solar energy in agriculture has been initiated by the institute. Solar ground water pumping, solar aerator, solar operated livestock washing system, solar operated humidifier have been demonstrated during the period under report.
- During the period under report, 12 varieties of tomato 'Swarna Anmol' (protected cultivation), 'Swarna Kanchan' (processing type) and 'Swarna Ratan' (open field condition); chilli 'Swarna Praphulya' and 'Swarna Tejashwi' (pickle purpose); sweet pepper 'Swarna Atulya'; bottle gourd 'Swarna Sneha'; bitter gourd 'Swarna Yamini'; satputia 'Swarna Sawani'; lima/butter bean 'Swarna Poshan'; leaf amaranth 'Swarna Raktim' and faba bean 'Swarna Safal' have been developed and released through SVRC for cultivation in Hill and Plateau region of Eastern India.
- First ever variety of Makhana, 'Swarna Vaidehi' have been released by Central Variety Release Committee. The improved variety has the production potential of 3.0 t/ha compared to the productivity of local cultivars (1.4-1.6 t/ha).

- Improved varieties of Faba bean have been developed and released by SVRC for irrigated (Swarna Gaurav) and rainfed (Swarna Suraksha) ecologies with a production potential of 5.5-6.0 t/ha (Swarna Gaurav) and 4.0-5.2 t/ha (Swarna Suraksha), respectively.
- Real time pest dynamics data of mango recorded from 20 orchards in Jharkhand, Uttar Pradesh, Gujarat, Maharastra, Karnataka and Telangana indicated high incidence of blossom blight in Uttar Pradesh and Jharkhand.
- For management of stink bug in litchi, spray of lambda cyhalothrin+diclorvos (DDVP) @ 0.5+1.0 ml/litre of water in the last week of December month, spray of dimethoate @ 0.05% in second week of February on immigrated population after panicle emergence and before flower opening, spray of imidacloprid @ 0.005% against first instar nymphs at 100% fruit setting stage and fourth spray of acephate @ 0.1% at pea stage of fruits was found effective and economically viable.
- The horticulture production system was integrated with swine husbandry. The daily weight gain of Tamworth & Desi cross was recorded to be 600-650 g in farming system mode compared to 150-200 g/day in traditional swine husbandry practices.
- In order to improve the livelihood of resource poor farmers, poultry production system has also been developed by the institute involving the rearing of Vanaraja and Gram Priya. The poultry production system is being integrated with different cropping/ farming situations of the region.
- The non-descript breed of buffalo is being improved through AI of improved germplasm of Murrah with a conception rate of 40%.
- Growth hormone gene had significant effect on adult body weight in Black Bengal goats. Goat having AC genotypes had 65% more weight than the goat having CC genotypes. Fec B gene is responsible for prolificacy in goat and sheep. Screening of Fec B gene in Black Bengal goat revealed three genotypes namely AA, AG and GG. GG genotypes exhibit 31% more litter size than the animal having AG genotypes (1.6 kids/kidding). Seven gene sequences on growth and prolificacy have been submitted to NCBI, USA and accession numbers have been obtained.
- Feeding of aqueous extracts of *Murraya koenigii* (curry plant) leaf and *Trigonella foenum-graecum* (Fenugreek/Methi) seeds was found effective in controlling subclinical mastitis in cattle.
- Based on soil-plant-animal continuum, area specific mineral mixture (Swarna Min) has been developed for livestock of Bihar.
- Feeding of concentrate mixture @ 1.5 percent of body weight increased dry matter intake (9.9%), average daily gain (28.3%) and digestible crude protein (8.2%) in heifers as compared to heifers fed concentrate mixture @ 1% of body weight.
- Phytase supplementation @ 20 g/ kg feed increased body weight by 15% in growing pigs fed kitchen waste based ration.
- It was observed that use of harvester followed by burning of wheat straw emitted 2500 kg of carbon dioxide per ha of wheat area as compared to 54 kg when harvester followed by baling was used.
- Six integrated farming system models (cattle-cum-fish, buffalo-cum-fish, goat-cum-fish, poultry-cum-fish, pig-cum-fish and duck-cum-fish) have been studied by the institute to improve upon the fish production. The average fish production was ranged high 2.86 t/ha and low 2.37 t/ha after seven months of growth.
- During the year under report, the Institute published 65 nos. of research papers in the journal of national and international repute, 03 books, 03 training manuals, 07 technical bulletins, and 08 popular articles
- Further, total of 168 training programmes, 32 Front Line Demonstration and 20 On Farm Trials have been conducted for the farmers and the state government officials.

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 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 two KVKs. 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	1598.00	0.00	1558.21
T.A.	23.39	9.00	23.39	9.00
HRD	5.11	0.00	5.11	0.00
Works	64.60	219.16	64.60	218.99
Other charges	221.90	651.09	221.90	628.70
Total	315.00	2477.25	315.00	2414.90

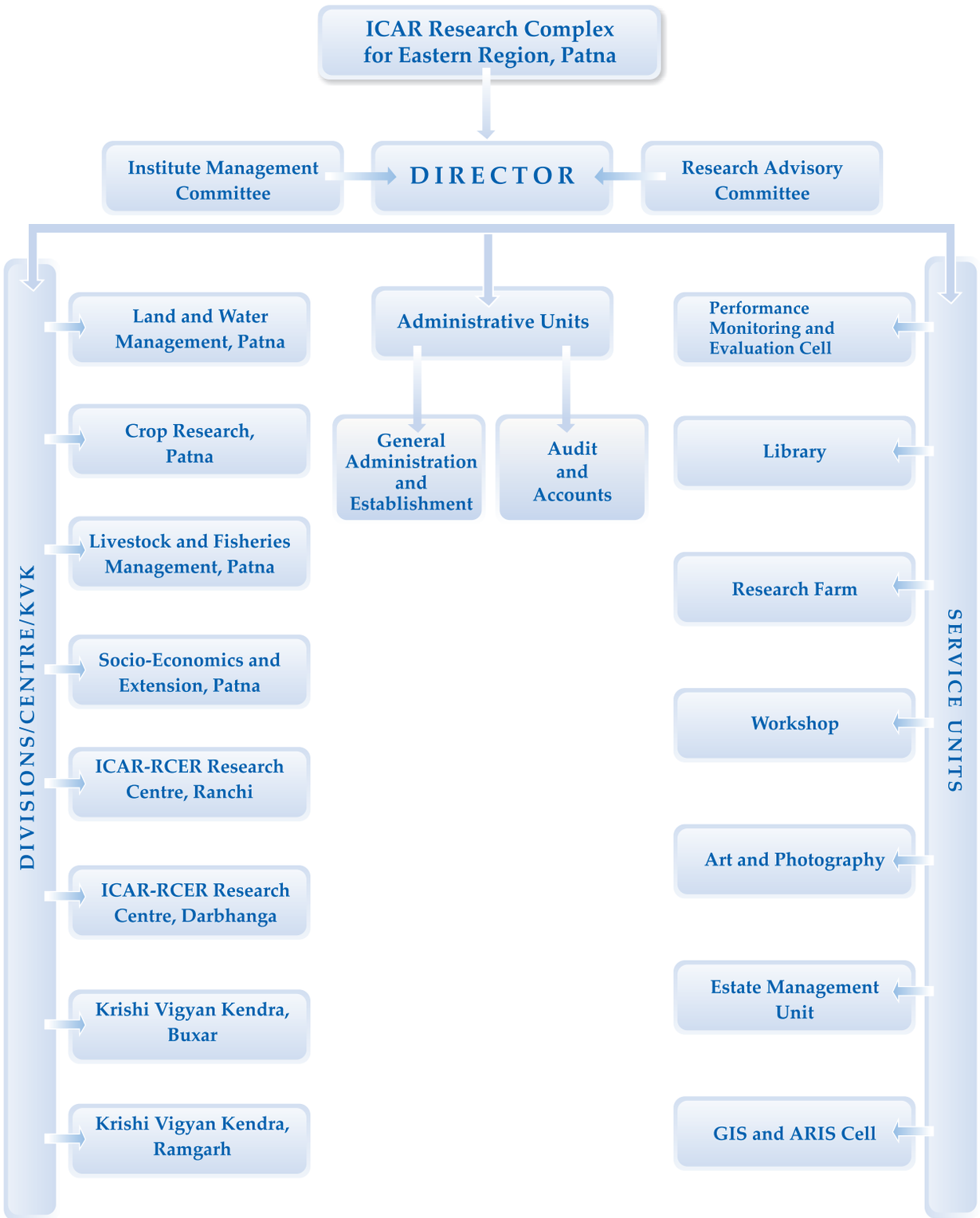


Fig. 1. Organogram of ICAR Research Complex for Eastern Region, Patna

3 Weather

Weather parameters *viz.* air, temperature, humidity, rainfall, wind speed, wind direction, solar radiation, soil temperature and leaf wetness at hourly interval were recorded at Patna and Ranchi.

At Patna, the total annual precipitation received in 2014 was 1071.4 mm. It was slightly less than the normal. The distribution of rainfall over time and intensity in the rainy season was erratic. The monsoon rainfall (June-September) was low (878.5 mm) as compared to normal (951.9 mm). Except February, March, May, and August all other monsoon months received low rainfall than the normal. February and August months received very high rainfall. The mean maximum temperature varied from 18.76°C in January to 38.14°C in May while the mean minimum temperature varied between 10.13°C in December to 26.73°C in July. The average relative humidity and sunshine hrs were 70.0% and 5.04 hrs, respectively. Summary of the monthly meteorological data for the year 2014 is presented in Table 2. Trends in monthly variation of temperature and rainfall is presented in Fig. 2.

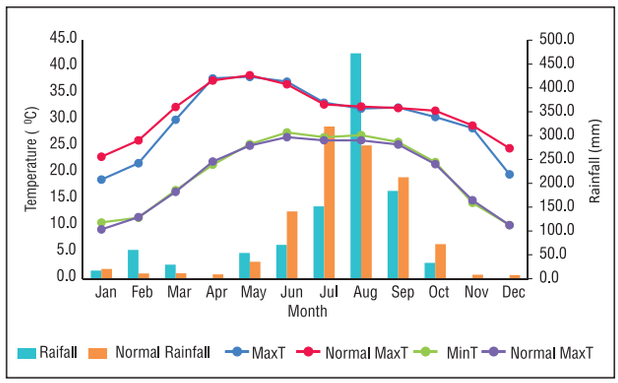


Fig. 2. Monthly variation of temperature and rainfall during 2014 at Patna

At Ranchi, the total annual rainfall during the year under report was 920 mm of which about 87.1% (801 mm) was received during the monsoon months. The annual rainfall was about 592 mm less than the long-term normal rainfall recorded at the centre. Month of August received the highest rainfall of 306 mm. During this year the rainfall of all the months, except March, was below the normal. A plot of monthly rainfall for the year 2014 and long-term average monthly rainfall is presented in Fig. 3. December was the coldest month with mean monthly minimum temperature of 7.6°C while April was the hottest month with maximum temperature of 36.1°C. The

Table 2. Monthly meteorological data of Patna, 2014

Month	Temperature (°C)				Avg. RH (%)	Avg. sunshine (hrs/day)	Total rainfall (mm)		Rainy days	Pan Evaporation (mm)
	Max.	Normal	Min.	Normal			Observed	Normal		
January	18.7	23.0	10.6	9.3	80.57	1.84	16.8	20.4	3	29.15
February	21.8	26.1	11.5	11.6	74.79	5.30	60.2	11.1	4	49.08
March	30.0	32.4	16.7	16.4	59.19	8.14	29.1	11.4	1	159.40
April	37.8	37.4	21.5	22.1	41.62	8.55	0.0	9.0	0	269.00
May	38.1	38.4	25.4	25.1	48.98	7.13	53.6	35.6	3	313.50
June	37.2	36.7	27.6	26.7	67.37	5.15	70.7	141.0	7	228.10
July	33.2	32.9	26.7	26.1	80.21	3.85	151.4	319.0	11	134.70
August	32.1	32.5	27.1	26.1	81.97	3.40	472.4	279.3	11	133.90
September	32.3	32.2	25.8	25.3	82.78	5.10	184.0	212.6	11	115.20
October	30.5	31.7	22.0	21.6	78.21	5.66	33.0	72.3	3	89.30
November	28.4	28.9	14.3	14.8	64.98	5.13	0.0	8.2	0	85.00
December	19.7	24.6	10.1	10.1	79.81	1.18	0.2	7.4	0	35.00
Annual	30.0	31.4	19.9	19.6	70.04	5.04	1071.4	1127.3	54	1641.3

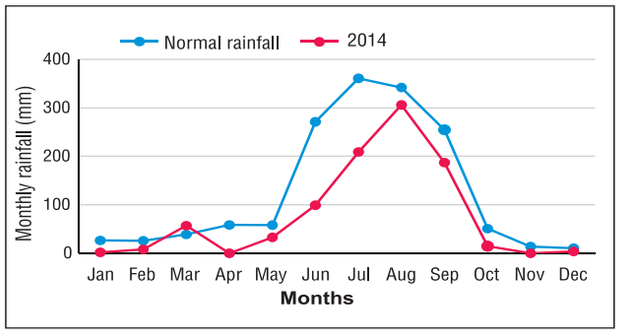


Fig. 3. Comparison of monthly normal and monthly rainfall for 2014

relative humidity (RH) ranged from 78.8 to 91.3%. Summary of the monthly climatic parameters is presented in Table 3. Trends of weekly maximum and minimum temperature and relative humidity is presented in Fig. 4.

Table 3. Mean monthly climatic parameters at ICAR-RCER, RC, Ranchi

Month	Average temperature (°C)		Relative humidity (%)	Total rainfall (mm)
	Minimum	Maximum		
January	8.4	23.3	84.2	2
February	10.7	25.8	85.4	8
March	15.7	29.4	82.5	57
April	20.3	36.1	78.8	0
May	23.8	35.8	89.7	33
June	26.6	34.9	90.7	99
July	24.7	29.5	89.3	209
August	24.5	29.9	89.6	306
September	23.0	30.2	91.3	187
October	19.0	28.3	87.8	15
November	11.0	26.9	84.9	0
December	7.6	24.4	83.3	4
Total rainfall (mm)				**920**

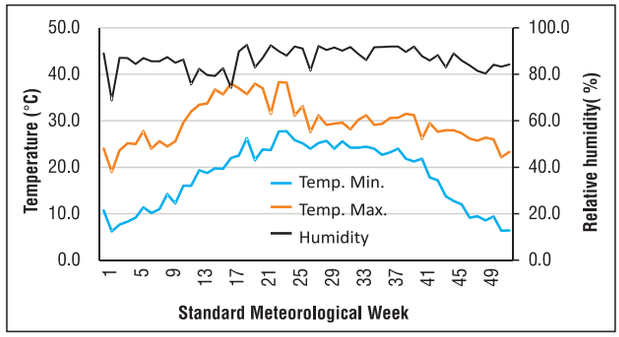


Fig. 4. Trend of weekly maximum and minimum temperature and RH for the year 2014

4 Climate Change

Characterization of Wheat Genotypes for Terminal Heat Stress Tolerance

Forty one wheat genotypes *viz*., C306, HW 2004, HD 3120, HD 1500, Halna, Kundan, K 1907, HD 2833, Monal, CBW 38, HP 1939, PBW 373, Baaz, HW 5210, GW 273, Seric. 2496, HI 1563, Babax, Sonalika, HD 3093, WH 760, Raj 4238, Berkut, HD 2985, NW 2036, Raj 3765, HI 1544, HI 1531, HD 3121, HD 3072, HD 3043, HD 2932, Chiriya 7, DBW 14, DBW 17, HD 2987, NI 5439, NW 1012, NW 1014, HD 2733, HD 2967 and HW 711 were evaluated for heat stress tolerance during *rabi* season 2013-14 based on morpho-physiological traits, yield attributes and yield. Heat stress was imposed by different dates of sowing (2 December, 20 December 2013 and 5 January 2014) (Fig. 5 & 6).

Since canopy temperature depression (CTD) and chlorophyll content of leaf are important indicators for heat stress tolerance, higher CTD was observed in Raj 4238, Kundan, HI 1563 NW 1012, GW 273 and checks (DBW 14 and Halna), while lower CTD value was observed in high yielding cultivar HD 2733, particularly under late sown conditions (Fig. 7).The chlorophyll content showed a declining trend from timely sown (3.81 mg/g DW) to very late sown (2.84 mg/g DW) across the genotypes. Wheat genotypes Raj 4238, Kundan, HD 2987, GW 273, DBW 14 and HI 1563 had higher chlorophyll content under late sown heat stress condition. The yield attributing traits (ear length, tiller no./m^2, test weight, grain weight/ear), which directly contribute to grain yield showed that NW 1012, Raj 4238, Kundan, GW 273, HI 1563 and HD 2987 performed better as compared to checks (DBW 14 and Halna) and high yielding cultivars (HD 2733 and HD 2967) under late sown heat stress conditions (Table 4).

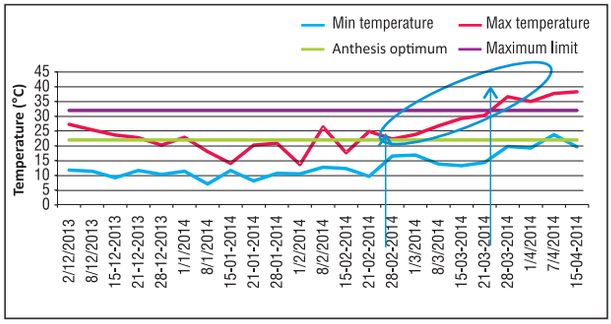


Fig. 5. Variation in minimum and maximum temperature (^{0}C) during crop duration of wheat genotypes

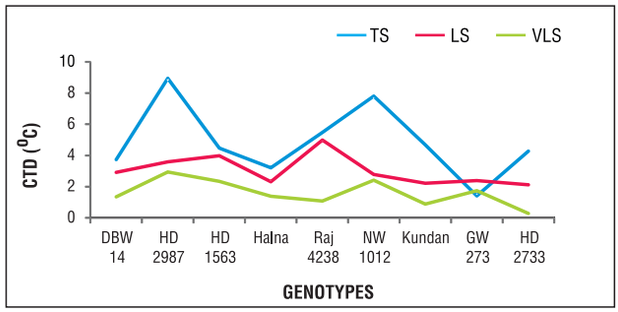


Fig. 7. Canopy temperature depression (CTD) of promising heat tolerant genotypes along with checks (DBW 14 and Halna) and high yielding cultivar (HD 2733)

Fig. 6. Performance of wheat genotypes under timely (2.12.2013), late (20.12.2013) and very late sown (05.01.2014) conditions

Table 4. Yield and yield attributes of promising wheat genotypes under different sowing dates

Sowing condition	Ear length (cm)			No. of grains/ear			Test weight (g)			Grain yield (t/ha)		
	TS	LS	VLS	TS	LS	VLS	TS	LS	VLS	TS	LS	VLS
Genotypes												
HI1563	10.00	10.50	7.75	41.0	37.0	31.0	41.3	39.5	36.3	4.2	3.7	2.8
HD2987	9.25	10.75	9.75	46.5	45.0	38.0	40.6	37.9	35.0	4.8	4.7	3.3
KUNDAN	11.8	11.00	9.05	48.5	37.5	33.5	41.9	39.1	36.0	4.1	3.8	3.2
Raj4238	8.65	8.20	8.95	38.0	35.0	31.5	41.4	37.8	33.5	4.0	3.7	3.2
GW 273	11.85	11.00	10.1	49.5	37.5	30.5	43.2	41.5	33.4	3.9	3.8	3.1
NW 1012	09.15	08.90	9.15	50.5	44.5	35.5	43.0	36.1	30.2	4.2	4.0	3.2
DBW 14	10.50	10.75	7.75	50.5	45.5	37.5	41.5	40.7	32.8	2.9	2.6	2.2
HALNA	8.50	12.15	9.25	39.5	43.0	34.5	37.0	38.2	32.5	3.2	3.1	2.8
HD2733	8.95	08.85	7.65	33.5	30.0	27.5	43.7	40.6	34.2	3.4	3.2	2.7
HD 2967	11.65	10.50	8.05	48.5	39.5	29.5	42.8	38.5	33.3	3.7	2.8	2.1
Mean	10.03	10.26	8.75	44.6	39.45	32.9	41.64	38.99	33.72	3.84	3.54	2.86
Factors	Date of sowing (D)	Genotype (G)	D x G	Date of sowing (D)	Genotype (G)	D x G	Date of sowing (D)	Genotype (G)	D x G	Date of sowing (D)	Genotype (G)	D x G
SEm±	0.140	0.256	0.443	0.706	1.288	2.231	0.386	0.7052	1.221	0.030	0.055	0.096
CD (P=0.05)	0.287	0.553	0.905	1.443	2.634	4.563	0.790	1.442	2.498	0.062	0.113	0.196
CV (%)		4.57			5.72			3.20			2.81	

TS: Timely sown, LS: Late sown, VLS: Very late sown

Impact of Elevated CO_2 and Temperature on Growth and Yield of Rice and Wheat under Predicted Climate Change Scenario

Four rice genotypes (Rajendra Bhagwati, IR64, IR83376-B-B-24-2 and IR84896-B-127-CRA-5-1-1) were evaluated under open top chambers (OTCs) during *kharif* season 2014 to assess the impact of elevated CO_2 and temperature (2°C > ambient) on morpho-physiological traits and yield. The OTC treatments include: OTC1: ambient CO_2 (400 ppm), OTC2: 25% higher CO_2 (500 ppm), OTC3: higher CO_2 and temperature (500 ppm+2°C > ambient temperature) and OTC4: higher temperature (2 °C > ambient temperature). Results revealed that all the genotypes of rice showed positive response with elevated CO_2 and negative response with elevated temperature. Physiological and biochemical traits like photosynthetic rate, stomatal conductance, protein and starch contents were improved under elevated CO_2 concentration (Fig. 8 & 9). The grain yield increased with elevated CO_2 but declined with elevated temperature across the genotypes. Rice genotype IR83376-B-B-24-2 (4.81 t/ha) followed by Rajendra Bhagwati (4.52 t/ha) resulted into higher yields at 25% higher CO_2 conc. (500 ppm) than other two varieties. (Table 5).

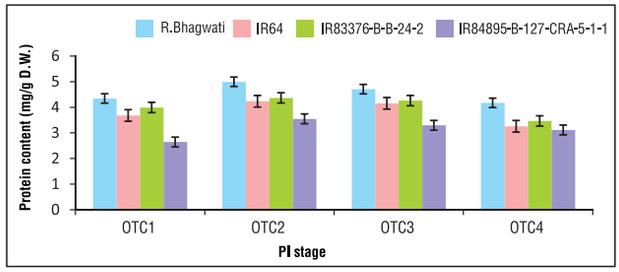


Fig. 8. Protein content (mg/g D.W.) of rice genotypes at panicle initiation stage

Fig. 9. Effect of elevated CO_2 and temperature on growth of rice genotypes in open top chambers and field condition

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

Under the changing climate scenario, studies on phenological behavior of mango in Jharkhand

Table 5. Yield and yield contributing traits of rice inside OTCs condition in *Kharif* 2014

Cultivar	Treatment	Plant height (cm)	Panicle length (cm)	Grains/ panicle	1000 grain weight (g)	Grain yield (t/ha)
Rajendra Bhagwati	Ambient CO_2	130	28.12	199	22.19	3.91
	Elevated CO_2 (25% higher > Ambient)	137	30.48	215	23.90	4.52
	Elevated CO_2 + Elevated Temp (2^0C)	158	29.94	208	22.91	4.26
	Elevated Temp (2^0C) >Ambient	149	27.96	194	17.48	3.19
IR64	Ambient CO_2	132	28.56	219	23.68	3.78
	Elevated CO_2 (25% higher > Ambient)	142	30.74	243	25.03	4.23
	Elevated CO_2 + Elevated Temp (2^0C)	161	29.46	220	24.14	4.02
	Elevated Temp (2^0C) >Ambient	157	28.6	198	18.69	3.42
IR83376-B-B-24-2	Ambient CO_2	154	31.32	228	24.09	4.18
	Elevated CO_2 (25% higher > Ambient)	167	35.14	245	27.01	4.81
	Elevated CO_2 + Elevated Temp (2^0C)	178	32.16	234	25.08	4.49
	Elevated Temp (2^0C) >Ambient)	170	28.96	231	20.52	3.9
IR84895-B-127-CRA-5-1-1	Ambient CO_2	94	19.88	109	21.77	3.56
	Elevated CO_2 (25% higher >Ambient)	96	20.42	115	22.07	3.88
	Elevated CO_2 + Elevated Temp (2^0C)	105	20.14	113	22.04	3.70
	Elevated Temp (2^0C) >Ambient	104	19	104	17.10	2.91
SEm±		1.87	0.57	4.57	0.49	0. 09
CV (%)		4.12	6.64	7.53	2.23	2.47

conditions indicated hastening of different floral stages during 2014 (Fig. 10). This can be attributed to low and delayed rainfall during 2013. The altered phenophases might have contributed towards changes in pest population than the previous year.

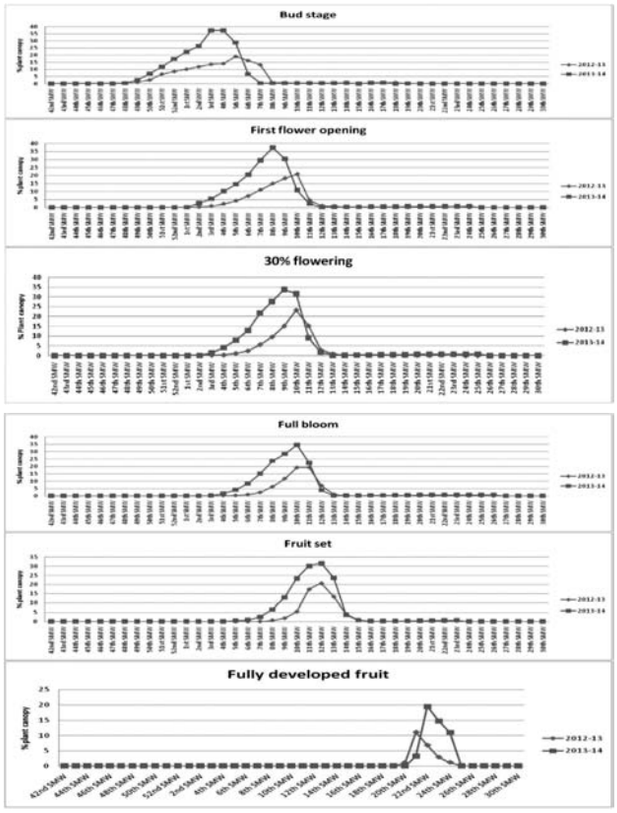


Fig. 10. Floral phenology of mango under Jharkhand conditions

Real time pest dynamics of mango

Real time pest dynamics (RTPD) data of mango recorded from 20 orchards in Jharkhand, Uttar Pradesh, Gujarat, Maharastra, Karnataka and Telangana indicated high incidence of blossom blight in Uttar Pradesh and Jharkhand in 2014 (Fig. 11 & 12). The overall observed per cent disease intensity (PDI) was 64.1% in Jharkhand and 53.08% in Uttar Pradesh. The disease appeared as burning of the full bloom panicles and caused significant loss in entire fixed and roving surveyed orchards. The incidence of disease was attributed to abrupt changes in weather phenomena. Sudden decrease in average temperature for a very short period and low intensity rains in the month of February-March were the prime cause of disease initiation, whereas severity of disease increased with rising temperature in both the regions.

Shoot gall psylla (*Psylla cistellata)* was major problem in *Tarai* area of Uttar Pradesh and parts of Bihar, Jharkhand and West Bengal. However, in recent years, the insect has attained the status of major pest even in plain areas of Uttar Pradesh. Screening of mango genotypes indicated that Amrapalli, Mulgoa hill, Himayuddin, Sammar Bahist Chausa, Jhappatta, Benisan, Amini

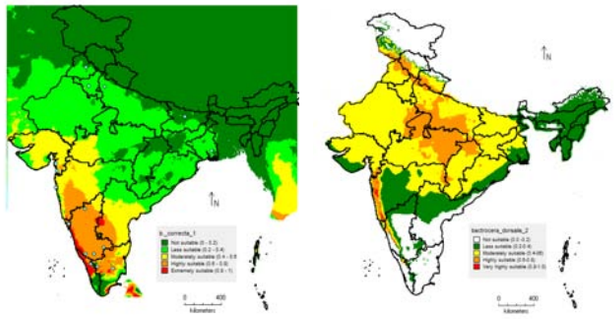
Fig. 11. Blossom blight affected panicle of mango

Fig. 12. Severe infestation of mango blossom blight

and Lucknow Selection were moderately to highly resistant against gall formation.

Forecasting of mango pest scenario

A potential prediction geographic distribution of major fruit flies species of mango in India based on MAXENT ecological niche model was studied and demonstrated with use of presence-only data (Fig. 13). Downscaled data of the SRES A_2 emission scenario for the year 2050 was used to project future changes in climatic conditions. While fruit fly *Bactrocera correcta* has been projected maor pest in southern mango growing states, *B. dorsalis* is major pest in northen parts of India. Western part major mango growing area in Maharashtra and Gujarat were found moderately suitable for *B. correcta* and less suitable for *B. dorsalis* by 2050.



Bactrocera correcta *Bactrocera dorsalis*

Fig. 13. Potential geographic distribution of major fruit flies species of mango in India based on MAXENT Ecological Niche model

Assessment of genetic diversity of mango fruit fly in India

Genetic diversity of mango fruit fly *B. dorsalis* and population structure of 12 populations of major mango growing regions India were analysed for better understanding of pest population dynamics and future consistency of pest in respect to changing climate scenarios. Studied based on *CO1* and *nad1* mitochondrial markers showed greater nucleotide substitution rates and more variation than other mitochondrial genes. The analysis of mtDNA sequences of *B. dorsalis* demonstrated high level of genetic diversity as exemplified by high observed values of *Hd*, *k* and π from both markers sequences analysis (Table 6). It is showed that when value of haplotype (*Hd*>0.5) and nucleotide (π>0.005) diversity are high, the analyzed population is stable with long evolutionary history. The MJ networks of both genes, showed haplotypes sampled from region appears randomly distributed (Fig. 14). MJ networks did not display any fundamental structure which could not be

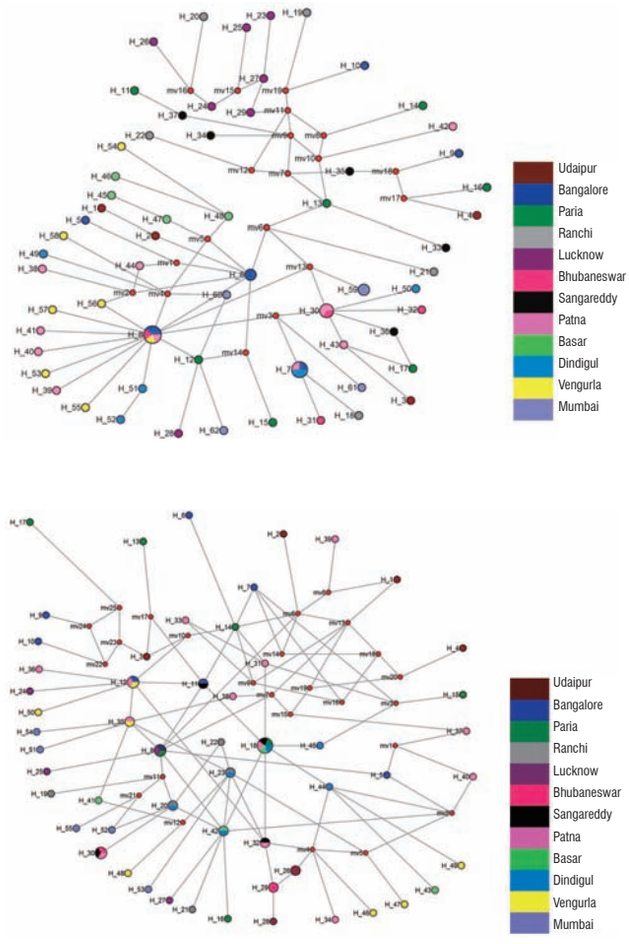


Fig. 14. mtDNA haplotypes median joining networks. A: Network of CO1 haplotypes, B: Network of nad1 haplotypes. Network of nad1 haplotypes. Each circle represents a haplotype, and circle diameter is relative to haplotype frequency. Colours represent the geographic origin of specimens and also indicate the proportion of individuals sampled in different populations within the study area. Smallest red squares represent median vectors.

Table 6. Genetic diversity indices among *CO1* and *nad1* sequences

Location	CO1				nad1			
	H	Hd	K ± SD	π ± SD	H	Hd	K ± SD	π ± SD
Patna	10	0.981	4.436364±2.3689	0.006722±0.004049	11	1.000	4.254545±2.283848	0.006775±0.004103
Bangalore	6	0.928	8.678571±4.4878	0.013149±0.007746	8	1.000	5.107143±2.769311	0.008132±0.005023
Paria	7	1.000	13.714286±7.0278	0.020779±0.012198	7	1.000	9.142857±4.794115	0.01456±0.008745
Ranchi	5	1.000	14.400000±7.8039	0.021818±0.013823	5	1.000	2.800000±1.768560	0.004459±0.003292
Lucknow	7	1.000	10.476190±5.4459	0.015873±0.009452	6	0.952	4.761905±2.647175	0.007583±0.004829
Vengurle	7	1.000	3.619048±2.0836	0.005483±0.003616	7	1.000	4.761905±2.647175	0.007583±0.004829
Sangareddy	5	1.000	7.600000±4.2751	0.011515±0.007573	5	1.000	2.200000±1.450315	0.003503±0.002700
Udaipur	4	1.000	13.16667±7.5440	0.01995±0.013649	4	1.000	8.000000±4.715269	0.012739±0.008966
Basar	4	1.000	3.500000±2.2411	0.005303±0.004055	4	1.000	2.833333±1.871311	0.004512±0.003558
Dindigul	5	0.933	5.533333±3.0969	0.008384±0.005418	6	1.000	1.933333±1.269296	0.003079±0.002334
Bhubaneswar	4	1.000	3.166667±2.0564	0.004798±0.003721	3	0.833	2.833333±1.871311	0.004512±0.003558
Mumbai	4	0.900	5.800000±3.3387	0.008788±0.005914	5	1.000	5.800000±3.338760	0.009236±0.006215

H, **Number of Haplotypes;** *Hd*, **Haplotypes diversity;** *K*, **Average number of nucleotide differences;** π, **Nucleotide diversity;** *SD*, **Standard deviation**

allowed to identify a Phylogenetic haplogroup but have a distinctively star-like structure, typical of expansion demographic processes. Data with high genetic, ineffectiveness of local barriers and typical of expansion demographic processes, suggests that the *B. dorsalis* may be the key pest in all parts of India in next decades in changing climate scenarios even where it is found seasonally for short span of period time.

Use of gut bacteria for management of mango fruit fly

Gut bacteria of fruit fly, *Bactrocera zonata* were isolated and isolates being attractive to fruit fly adults were characterized. Characterization was done based on morphological, biochemical and 16S rRNA analyses. Morphological, biochemical and 16S rRNA sequences revealed that three major gut bacterial species of *Bactrocera zonata* were characterized and identified as *Klebsiella* spp., *Microbacterium* spp. and *Rhodococcus* spp. Data of three bacterial isolates showed that bacterium, *Klebsiella* spp. was found to attractive to both male and female adults of *B. zonata* after 24 hrs interval of trap placing in mango field (Table 7). Population kinetics of these three bacterial isolates showed characteristics sigmoid growth curve in respect to age of adult flies (Fig. 15).

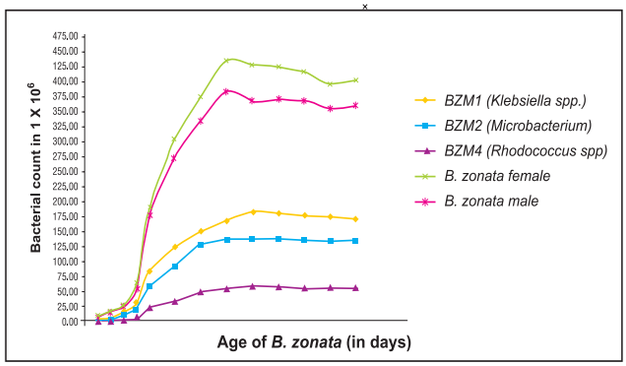


Fig. 15. Growth curves of three bacterial symbionts and over all bacterial population growth within male and female of *B. zonata* adults

Table 7. Attraction of peach fruit fly, *B. zonata* to various bacterial culture isolates and their combinations

Bacterial isolates	Numbers of fruit flies attracted at different time intervals					
	24 hrs		48 hrs		72 hrs	
	Female*	Male*	Female*	Male*	Female*	Male*
BZM1 (*Klebsiella* spp.)	8.33	6.67	5.67	3.67	3.33	1.33
BZM2 (*Microbacterium* spp.)	5.33	4.33	3.33	2.33	2.33	1.00
BZM4 (*Rhodococcus* spp.)	4.33	2.67	2.33	1.67	1.67	0.33
BZM1+BZM2	6.67	4.67	3.33	2.00	2.33	1.33
BZM1+BZM4	6.33	4.33	3.33	1.67	1.33	0.67
BZM2+BZM4	3.33	1.33	2.00	1.00	1.00	0.00
Media Blank	1.33	0.67	0.67	0.33	0.33	0.00
Methyl Eugenol Trap	0.00	36.00	0.00	42.00	0.00	34.00

*Mean of three replications

5 Cereals

RICE

Drought is considered as one of the main constraints that limits rice yield in rainfed and poorly irrigated areas. Eastern states accounts for 27.26 million ha area under rice, of which 16.2 million ha is rainfed and nearly 4.28 million ha area is prone to frequent drought. Rice productivity in these drought prone areas is poor and unstable. Reproductive stage drought is one of the major factors limiting grain yield, mainly because of mono-modal distribution of rainfall which ceases at about 1st or 2nd week of September.

Screening and identification of rice genotypes for drought tolerance

Thirty two rice genotypes comprising of elite breeding lines and checks were evaluated during *kharif* 2014 under dry direct-seeded condition for drought tolerance at various growth stages (Fig. 16). Under stress condition, only one irrigation was given at five days after sowing to ensure proper germination and thereafter the crop was left rainfed. Crop faced approximately 7, 11, 14, and 15 days water stress at seedling, vegetative, reproductive and physiological maturity stages, respectively. The non-stress control was maintained by applying irrigations as and when required (irrigated). Result revealed that irrespective of the genotypes, there was significant reduction in grain yield of rice under stress condition compare to non-stress condition. Among genotypes, IR 84899-B-179-16-1-1-1, IR 88964-24-2-1-4, IR 83387-B-B-27-4, IR83373-B-B-25-3, REWA 842 and RP 5212-56-12-9-3-2-1-1 were found promising under multiple stages drought stress condition than checks (**Table 8**). Grain yield of different genotypes varied from 0.11 to 2.91 t/ha and 2.79 to 5.05 t/ha under drought stress and non-stress conditions, respectively. Irrespective of genotypes, drought stress at various growth stages caused significant

Fig. 16. Screening of rice genotypes under drought stress condition

reduction in grain yield (75.8%), plant biomass (66.13%), Relative Water Content (RWC) (22.7%), leaf area (50.7%) and fertility (16.04%), and increase in grain sterility (52.6%), however, the response varied among genotype. Minimum yield reduction (33.2%) was observed in IR 84899-B-179-16-1-1-1 and maximum in IR 64 (93.4%).

Table 8. Performance of promising rice genotypes under drought stress and non-stress conditions.

Rice genotypes	Dry biomass (g/plant)		RWC (%)		Test weight (g)		Grain yield (t/ha)	
	S	NS	S	NS	S	NS	S	NS
IR 84899-B-179-16-1-1-1	27.32	70.14	72.18	89.56	22.5	23.6	2.91	4.36
IR 88964-24-2-1-4	24.65	62.17	73.86	95.03	23.7	25.9	2.26	5.05
IR 83387-B-B-27-4	23.62	52.15	74.34	94.94	21.6	22.9	2.02	3.81
IR83373-B-B-25-3	16.22	62.2	74.22	87.58	23.8	25.3	1.82	4.11
RP 5212-56-12-9-3-2-1-1	15.33	42.15	70.57	86.82	21.6	23.6	1.48	3.13
REWA 842	16.65	53.11	67.58	84.58	21.3	22.4	1.47	3.92
IR84899-B-183-CRA-19-1	28.68	70.12	72.28	84.19	21.9	22.8	1.35	3.59
Sahbhagi	22.63	58.12	69.24	86.47	21.2	23.2	1.23	3.71
Rajendra Sweta	17.61	42.90	65.18	82.58	19.7	22.8	0.36	4.11
IR64	9.17	50.12	62.14	88.54	20.3	24.5	0.27	4.01
Mean	19.26	56.94	67.81	87.85	21.7	23.6	0.84	3.46
LSD (P=0.05)	3.99	9.15	4.30	4.63	1.2	1.3	0.47	0.52
CV (%)	10.2	7.88	3.11	2.59	2.6	2.7	7.78	7.34

S=Stress, NS= Non-stress

Characterization and Evaluation of Advanced Breeding Lines and High Yielding Varieties of Rice for Aerobic Condition

Forty rice genotypes comprising of early, medium and late maturity were evaluated during *kharif* season, 2014 under direct-seeded aerobic and irrigated control conditions (Fig. 17). In the aerobic field, surface irrigation of about 5 cm was applied twice in a week at the vegetative stage and an interval of 2-3 days at the reproductive stage. Ten promising rice genotypes (IR83929-B-B-291-3-1-1, IR88964-24-2-1-4, IR83929-B-B-291-2-1-1-2, IR84899-B-179-16-1-1-1, IR77298-14-1-2-130-2, IR88964-11-2-2-3, IR84899-B-179-13-1-1-1, IR84899-B-183-20-1-1-1, IR84887-B-158-7-1-1-4 and IR88966-43-1-1-4) were identified promising as compared to check varieties (IR64, MAS 946, Rasi, PA6129 and Rajendra Bhagwati) (Table 9). Grain yield of different genotypes from 1.25 to 5.35 t/ha and 3.17 to 5.97 t/ha in aerobic and control conditions, respectively. Maximum grain yield was recorded in IR83929-B-B-291-3-1-1 (5.36 t/ha) followed by IR88964-24-2-1-4 (5.22 t/ha), IR83929-B-B-291-2-1-1-2 (5.0 t/ha). The water productivity (irrigation applied+ rainfall) varied from 0.10 to 0.45 kg/m^3 and 0.24 to 0.45 kg/m^3 in aerobic and irrigated conditions, respectively.

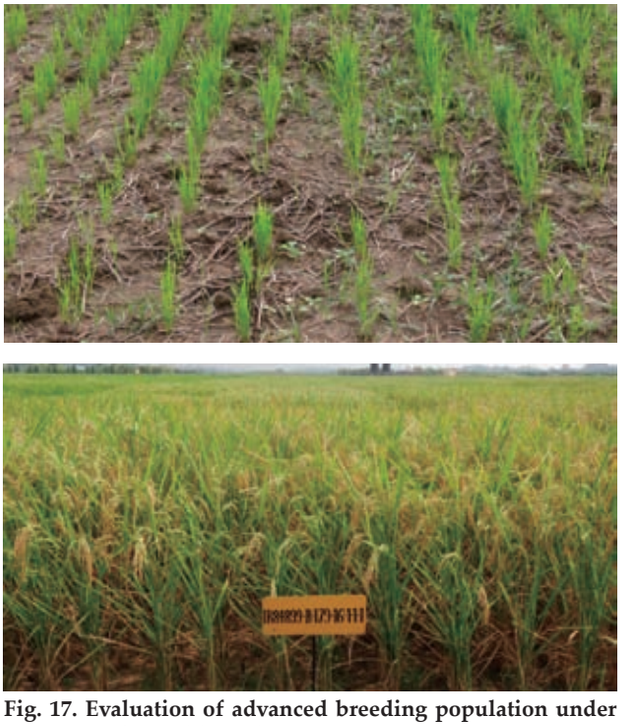


Fig. 17. Evaluation of advanced breeding population under aerobic field condition

Table 9. Performance of advanced breeding rice genotypes under aerobic and control conditions

Name of Rice genotypes	Yield (t/ha)		Water productivity (kg/m^{-3})	
	Aerobic	Irrigated	Aerobic	Irrigated
IR83929-B-B-291-3-1-1	5.35	5.83	0.45	0.44
IR88964-24-2-1-4	5.22	5.97	0.44	0.45
IR83929-B-B-291-2-1-1-2	5.00	5.84	0.42	0.44
IR 84899-B-179-16-1-1-1	4.78	5.95	0.40	0.45
IR 77298-14-1-2-130-2	4.61	5.25	0.39	0.39
IR88964-11-2-2-3	4.60	5.50	0.39	0.41
IR84899-B-179-13-1-1-1	4.25	4.97	0.36	0.37
IR84899-B-183-20-1-1-1	4.19	4.85	0.35	0.36
IR84887-B-158-7-1-1-4	4.15	4.62	0.35	0.35
IR88966-43-1-1-4	4.15	5.40	0.35	0.41
IR 64	3.00	4.60	0.25	0.35
MAS 946	3.10	4.00	0.26	0.30
Rasi	1.75	4.17	0.15	0.24
Sahbhagi Dhan	3.52	4.75	0.31	0.39
PA6129	3.85	5.03	0.32	0.38
Rajendra Bhagwati	3.47	5.55	0.29	0.42
Mean	3.37	4.70	0.28	0.35
LSD (P=0.05)	0.76	1.32	0.07	0.10

Evaluation and Development of Drought Tolerant Rice for Eastern Region (STRASA Phase-III)

Fifty two rice genotypes received from IRRI along with some local varieties were evaluated for drought tolerance at reproductive stage stress condition during *kharif* season 2014 (Fig. 18). Fifty five days old crop was subjected to drought by withholding irrigation and withdrawing water from the field. Thereafter the crop was left rainfed and there was no standing water in the field till maturity. Grain yield varied from 5.76-9.93 t/ha and 3.08-6.42 t/ha under non-stress (irrigated) and stress (drought) conditions, respectively. Drought stress at reproductive stage caused significant reduction in grain yield (39.6%), plant height (23.5%), plant biomass (25.8%), leaf areas (34.2%) and fertility (10.4 %), and increase in grain sterility percentage (32.7%) in rice genotypes; however, the responses varied among genotype (Table 10 and 11).

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

Name of rice genotypes	Grain yield (t/ha)		Test weight (g)
	Stress	Non-stress	
IR91648-B-85-B-1-1	5.12	7.60	23.4
IR91648-B-58-B-7-3	5.10	7.35	22.1
IR96321-1232-238-B	5.06	6.38	21.4
IR91648-B-58-B-10-2	4.79	5.76	21.6
Swarna Sub1	3.73	7.10	20.2
Swarna	3.87	6.84	17.3
Sambha Mahsuri	3.30	6.42	18.8
Mean	4.14	6.94	20.0
CV (%)	6.92	12.06	8.78
LSD (P=0.05)	0.46	1.41	2.84

DFF= Days to 50 % flowering, PH= plant height, HI= Harvest index

Table 11. Performance of promising genotypes of AYT 100-120 days under water stress condition

Name of rice genotypes	Grain yield (t/ha)		Test weight (g)
	Stress	Non-stress	
IR94313:18-4-1-4-1-B	6.42	8.14	26.9
IR92546-17-6-4-4	6.41	8.57	24.3
IR92546-17-6-4-3	6.07	9.93	23.4
IR92546-7-1-1-3	5.54	7.89	25.4
IR92545-54-6-1-4	5.78	8.97	27.4
IR 92527-6-2-1-2	5.81	7.83	25.9
IR 92545-23-2-1-1	5.71	9.27	27.3
Lalat	5.11	8.19	22.6
MTU1010	4.81	8.39	25.0
IR64	4.80	6.41	22.4
Mean	5.11	8.35	25.0
CV (%)	10.5	10.88	6.33
LSD (P=0.05)	0.89	1.52	2.67

DFF= Days to 50 % Flowering, PH= Plant Height, HI = Harvest Index

Fig. 18. Screening of rice genotypes under reproductive stage drought stress condition

Exploration and Collection of Wild Rice Germplasm from Flood-prone Ecosystem of Bihar

ICAR-RCER, Patna and ICAR-NBPGR, base Centre, Cuttack participated in a mission mode exploration programme for germplasm collection of wild *Oryza* species (*Oryza nivara and O. rufipogon*) from West Champaran, East Champaran, Sheohar and Sitamarhi districts of Bihar (Fig. 19). Twenty four wild rice germplasm were collected during this exploration programme. Passport data of collected germplasm was recorded.

Fig. 19. Collection of wild rice germplasm from flood-prone ecosystem of Bihar

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

In order to develop, validate, refine and demonstrate the best agronomic technologies for improved rice varieties alongwith complementary crops to increase the productivity and reduce the risk of rainfed rice-based systems, field experiments were conducted under IRRAS involving seven rice genotypes *viz*., 'Sahbhagi','Sushk Samrat','IR83387-B-B-40-1','IR83387-B-B-27-4','IR83376-B-B-24-2','IR82870-11' and 'Abhishek'. Results revealed that the grain yield of rice was significantly higher in puddle transplanted condition (3.68 t/ha) than that of un-puddle (2.78 t/ha). Sahbhagi Dhan yielded maximum (4.59 t/ha) followed by IR83387-B-B-27-4 (4.34 t/ha) under puddle condition whereas Abhishek (3.07 t/ha) followed by IR82870-11 (2.97 t/ha) and IR83387-B-B-27-4 (2.87 kg/ha) under un-puddle condition. Significantly higher weed density (182 nos./m^2) and weed biomass (128 g/m^2) were recorded in pendimethalin alone treated plots than in (pendimethalin fb bispyribac) + 2 HW plots (117 and 86 g/m^2). Grain yield was significantly higher in herbicide (pendimethalin fb bispyribac) + 2 HW plots (2.29 t/ha) as compared to pendimethalin alone plots (1.48 t/ha). Rice variety 'Abhishek' followed by IR83387-B-B-27-4 proved to be more weed tolerant and produced maximum grain yield (1.83 and 1.76 t/ha) under partial weedy (pendimethalin alone) condition.

Rice variety 'Sahbhagi Dhan' was evaluated under different seed rates (S_1:20, S_2:30 and S_3:40 kg/ha) and N-scheduling (F_1: 1/3 N and full P and K and $ZnSO_4$ as basal and 2/3 N at maximum tillering, F_2: 1/3 N and full P and K and $ZnSO_4$ as basal and 1/3 N at maximum tillering and 1/3 N at PI, F_3: Full P and K and $ZnSO_4$ as basal, 1/2 N at first shower/enough moisture availability preferably after first weeding and 1/2 N at maximum tillering, and F_4: Full P and K and $ZnSO_4$ as basal, 1/3 N at first shower after first weeding, 1/3 N at maximum tillering and 1/3 N at PI) in direct seeded drought-prone rainfed lowland ecosystem. Maximum paddy (4.79 t/ha) was harvested with 30 kg seed/ha and application of full P and K and $ZnSO_4$ as basal, 1/3 N at first shower after first weeding, 1/3 N at maximum tillering and remaining 1/3 N at PI stage.

Rice varieties 'Sahbhagi Dhan' and 'Swarna Sub1' were evaluated under different doses and timing of application of potassium for drought-prone and submergence-prone ecology, respectively. Combination comprising of 20 kg K_2O/ha (basal) + one foliar spray with KNO_3 (@1.0% solution) at PI stage with N-adjusted produced maximum 4.04 t/ha paddy yield, followed by 3.93 t/ha under 40 kg K_2O/ha (basal) under drought prone ecology. The K-management practices of 20 kg K_2O/ha (basal application) + 20 kg K_2O/ha at PI (top dressing) and 40 kg K_2O/ha (basal application) + 1% KNO_3 at PI (foliar spray with N-adjusted) were significantly better than other K-management practices for rice Swarna sub-1 under submergence stress for 16 days during early vegetative phase (10 days after transplanting). Biochemical traits like protein and total soluble sugar declined after submergence across the treatments, while antioxidants (CAT and SOD) activities enhanced.

Four rice varieties *viz*., Swarna- *sub1*, Samba Mahsuri- *sub1*, IR 64- *sub1* and Swarna were evaluated under two management practices i.e. BMP (Best management practices) and RCM (Rice Crop Manager) under submergence prone ecology. It was observed that after complete submergence for 16 days at early vegetative stage (crop age 44 days), Swarna *sub-1* exhibits high level of tolerance (71% survival under BMP as compared to 92% survival under Rice Crop Manager nutrient recommendation). Swarna, Sambha Mahsuri *sub-1* and IR 64 *sub-1* showed very poor submergence tolerance under both BMP and RCM practices up to 16 days of complete submergence. The treatment RCM maintained higher protein and TSS content as compared to BMP.

Evaluation of Rice Genotypes for Submergence Tolerance at Vegetative Stage

Sixteen elite rice genotypes were evaluated for submergence tolerance alongwith Swarna sub-1 as tolerant, and Swarna & IR42 as susceptible checks. After ten days of transplanting, the crop was completely submerged by filling water in the field. The crop was kept submerged under 75 cm to 1.0 m water depth for 16 days (Fig. 20) and thereafter, water was drained out from the field. The survival percentage was recorded on regenerated plants after 10 days of de-submergence.

Fig. 20. Evaluation of rice genotypes under submergence condition

The tolerant check Swarna sub-1 exhibited the highest survival (91.2%) whereas, IR42 as susceptible check showed the least survival (4.2%) under submergence. Among the test genotypes IR 10F365, IR 11F216 and IR 11F239 with the respective survival values of 81.4, 80.0 and 78.1% were found to be at par with the Swarna sub-1.

The regenerated crop was allowed to grow and observations on grain yield and other attributes were recorded (Table 12). The crop duration was found to get increased under submergence stress due to loss of vegetative growth prior to submergence and the additional time required for regeneration after submergence. IR 10F365 was found to be 12 days earlier than Swarna sub-1 with significantly high grain yield per plant.

Evaluation of Elite Rice Genotypes Under Rainfed Shallow Lowland

Thirteen elite rice genotypes developed at the International Rice Research Institute, Philippines were evaluated during *kharif* 2014 under rainfed shallow lowland along with Rajendra Sweta as local check. The crop at the early vegetative phase (10 days after transplanting) was exposed to water stagnation of 15-35 cm for one month due to rain water accumulation in the field. Grain yield of genotypes FFZ 1, (4.90 t/ha), HHZ 5-Y4-SAL1-Y1 (4.86 t/ha), HHZ 9-DT12-DT1-SUB1 (5.74 t/ha), HHZ 5-DT20-DT3-Y2 (5.85 t/ha) and HHZ 8-Y7-DT2-SAL1 (5.70 t/ha) were found to be significantly superior as compared to local check Rajendra Sweta (4.22 t/ha) (Table 13).

Table 12. Performance of genotypes after submergence stress for 16 days at vegetative stage

Genotypes	Survival %	Days to 50% flowering	Plant height (cm)	Grain yield / plant (g)
IR 07L320	44.2	126	123	30.5
IR 08L216	14.4	126	100	27.1
IR 09L204	47.0	130	93	29.3
IR 09L261	26.3	132	91	33.4
IR 09L311	30.9	131	104	30.3
IR 09L337	27.0	128	105	35.7
IR 09L342	40.7	129	109	33.9
IR 10F365	81.4	128	100	24.5
IR 10F602	54.7	130	93	20.6
IR 10L182	46.0	126	104	39.3
IR 11F190	57.9	139	108	14.9
IR 11F195	71.2	141	109	17.9
IR 11F216	80.0	141	103	11.7
IR 11F239	78.1	140	92	21.1
IR 55423-01	19.2	127	108	25.6
IR 42	4.2			
Swarna	29.4	144	79	8.8
Swarna *sub-1*	91.6	140	81	10.1
Mean	46.8	132.7	100.2	24.4
$CD_{(0.05)}$	14.4	4.5	6.2	7.1
CV %	18.6	2.04	3.7	17.5

Table 13. Performance elite rice genotypes under rainfed shallow lowland during 2014 *kharif*

Genotype	Days to 50% flowering	No. of fertile grain/ panicle	Grain yield (t/ ha)
FFZ 1	104	196	**4.90**
HHZ 12-DT10-SAL1-DT1	105	154	4.33
HHZ 12-SAL8-Y1-Y2	101	138	4.62
IR 50	91	126	3.22
Rajendra Sweta	106	198	4.22
HHZ 5-Y4-SAL1-Y1	106	163	**4.86***
HHZ 5-DT20-DT2-DT1	102	144	4.31
HHZ 9-DT12-DT1-SUB1	98	142	**5.74***
IRRI 119	119	120	3.72
SACG 4	101	162	5.06*
HHZ 5-DT20-DT3-Y2	102	162	**5.85***
HHZ 8-Y7-DT2-SAL1	101	150	**5.70***
HHZ 11-Y10-DT3-Y3	105	169	4.57
HHZ 5-SAL14-SAL2-Y2	103	192	4.70
Mean	103	158.5	4.70
CD (P=0.05)	3.9	50.75	0.52
CV%	2.31	19.09	6.62

Breeding Rice Genotypes for Rainfed Shallow Lowland

Generation advancement and selection: BC_1F_2 seeds of 63 crosses for the development of improved rice varieties for rainfed shallow lowland were received from Directorate of Rice Research, Hyderabad. The breeding nursery was raised during 2014 *kharif* and 1280 single plant selection were made based on the plant type, panicle and grain features, crop duration, field reaction to insect pests and diseases, tolerance to stagnant water at early vegetative growth phase and drought at reproductive stage under natural condition. The BC_1F_3 seeds have been retained for further evaluation and selection.

Maintenance breeding: The genetic purity of twenty three elite genotypes of rainfed lowland rice viz. IET 23193, IET 23654, IET 23591, IET 23918, IET 23603, IET 23593, CRL9-15-6-6-40-1, CRL80-193-1-PR-1-1, CRL16-66-18-2-PR-1, CRL67-27-2-14-1, CRL76-33-1-1-1-1, CRL73-69-1-2-1-1, CRL80-70-2-3-1-1, CRL76-96-2-1-1-1, CRL77-30-1-1-1-1, CRL77-10-1-1-1, CRL145-12-P, CRL145-21-P, CRL67-131-1-3-2-1, CRL68-141-1-3-1-1, CRL86-21-5-1-3-1, CRL76-48-1-2-1-1 and CRL145-26-P were maintained using panicle to row method during *kharif* 2014.

WHEAT

Comparative Evaluation of Wheat Varieties and Soil Configuration Methods under Rainfed Drought-prone Ecosystem (IRRAS)

The experiment was designed to evaluate the performance of five wheat varieties (K 9351, K 7903, HD 2967, DBW 14 and HI1563) under two tillage practices (zero and conventional) in rainfed drought-prone areas. The results revealed that tillage systems did not influence the performance of wheat genotypes, except the net returns, which was higher in zero tillage (₹ 25802/ha) than the conventional tillage (₹ 22479/ha). Among wheat genotypes, K 7903 was significantly superior in terms of ear length, no. of grains per ear head, grain yield, net returns and B : C ratio followed by HD 2967. Interaction of tillage practices x varieties was insignificant (Table 14).

Table 14. Grain yield and economic analysis of wheat varieties under zero tillage and conventional tillage

Treatment	Grain yield (t/ha)	Gross returns (₹/ha)	Net returns (₹/ha)
Tillage systems			
ZT	3.58 (5.46)	55473	25801
CT	3.44 (5.32)	53648	22478
CD (P=0.05)	NS (NS)	NS	3211
Varieties			
K9351	3.22 (4.71)	49514	19095
K 7903	4.28 (5.80)	67076	31656
HD 2967	3.96 (5.71)	62367	31944
DBW 14	2.73 (5.53)	42279	11859
HI 1563	3.35 (5.18)	58565	21145
CD (P=0.05)	0.44 (0.83)	6033	6035

Figures in parantheses indicate straw yield

6 Pulses

Crop Diversification with Faba bean

Field experiment was conducted to evaluate suitable faba bean cropping system. During *rabi* the crop diversification was done with inclusion of lentil, maize (cob), potato, and during summer / *zaid* crops were lady's finger, greengram and cowpea (fodder). Altogether five cropping systems *viz.*, (CS_1) rice – faba bean – lady's finger, (CS_2) rice-faba bean – greengram, (CS_3) rice – faba bean+ potato – cowpea (green fodder), (CS_4) rice-faba bean + maize – greengram and (CS_5) rice-faba bean + lentil – greengram (green fodder) were tested under rainfed (I_1) and irrigated (I_2) conditions especially during *rabi* season to evaluate degree of association with lentil crop.

During *rabi* (2013-14) season, faba bean seed yield ranged between 4.03 to 4.01 t/ha in irrigated situation, whereas under rainfed condition it varied from 1.99 to 2.07 t/ha. Yield of faba bean under intercropping system ranged from 1.41 t/ha (under faba bean + maize) to 2.11 t/ha (faba bean + lentil). Irrigation water productivity varied from 1.26 to 1.29 kg/m^3 for faba bean under sole cropping system (Fig. 21 and Table 15 & 16) .

Performances of intercrops with faba bean are presented in Table 16. Potato output was 19.6 and 10.2 t/ha under irrigated and rainfed conditions, respectively. Similarly maize green cob yield was

Table 15. Faba bean performance under different cropping system

Cropping System	Faba bean seed yield (t/ha)		Irrigation WP (kg/m^3)
	Irrigated	Rainfed	
Sole cropping			
Rice – faba bean – lady's finger (CS_1)	4.01	2.07	1.26
Rice – faba bean – greengram (CS_2)	4.03	2.01	1.29
Intercropping			
Rice – faba bean + potato – cowpea (GP) (CS_3)	1.91	1.41	7.27
Rice – faba bean + maize (cob) – greengram (CS_4)	1.37	0.95	2.71
Rice – faba bean + lentil – greengram (CS_5)	2.11	1.29	3.06

Faba bean + lentil cropping system

Faba bean + Maize cropping system

Faba bean + potato cropping system

Fig. 21. Lentil, maize and potato during *rabi* under faba bean based crop diversification

Table 16. Performance 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	19.6	10.2
Rice–faba bean + maize (cob) – greengram (CS_4)	Maize	57.5	29.5
Rice–faba bean + lentil – greengram (CS_5)	Lentil	1.03	0.46

Lady's finger under CS_1 cropping system

Greengram under CS_2 cropping system

Cowpea under CS_3 cropping system

Fig. 22. Lady's finger, greengram and cowpea in summer 2014 under faba bean based crop diversification

recorded at 57.5 and 29.5 t/ha under irrigated and rainfed conditions, respectively. However, lentil performance was not upto the mark being 1.03 and 0.46 t/ha in case of irrigated and rainfed conditions, respectively.

During summer season, lady's finger and cowpea (for vegetable purpose) and greengram (for dry seed consumption purpose) was cultivated and data have been depicted in Table 18.

Table 18. Performance of summer crops under faba bean based cropping system

Cropping System	Name of Intercrops	Yield (t/ha)
Rice–faba bean–lady's finger (CS_1)	Lady's finger	7.82
Rice–faba bean–greengram (CS_2)	Greengram	1.65
Rice–faba bean+ potato–cowpea (GP) (CS_3)	Cowpea (GP)	7.12
Rice – faba bean + maize (cob) – greengram (CS_4)	Greengram	1.54
Rice-faba bean + lentil – greengram (CS_5)	Greengram	1.59

Assessing the Response of Lentil and Chickpea to Bio-fertilizer Application

The experiments were conducted to assess the effect of microbial strains used as seed treatment on the performance of lentil (HUL 57) and chickpea (JG 14) under rainfed condition of Bihar. Results revealed that seed treatment with microbial *Trichoderma* strain produced higher grain yield, 1000-grain weight and harvest index as compared to other treatments. These treatments showed reasonably good rhizosphere microbial population and lower root rot/ wilt percentage compared to control.

Greengram

Eight germplasm of greengram received from AVRDC RCSA, Hyderabad were evaluated along with K-851 (Check) during *kharif* season. The lines/ varieties *viz.*, BARIMUNG-4 (1.61 t/ha), HASHA (1.55 t/ha) and VC-3890 A (1.55 t/ha) performed better than K-851 (1.47 t/ha) in respect of dry seed yield.

Blackgram

Twenty five germplasm of blackgram received from NBPGR Regional Station, Hyderabad were evaluated along with Uttara (Check) during *kharif* season. The lines IC-466852 (2.23 t/ha), IC-466765 (2.04 t/ha), IC-281986 (2.03 t/ha) and IC-466516 (2.01 t/ha) performed better than Uttara (1.91 t/ha) in respect of dry seed yield.

Horsegram

Twenty germplasm of horsegram received from NBPGR Regional Station, Akola were evaluated and maintained. Ten lines recorded seed yield greater than 1.5 t/ha. The line IC-139382 (1.95 t/ha) performed the best.

7 Fruits

MANGO

Plant Genetic Resource Management

Three new promising genotypes were collected from Namkum, Ranchi. Among the genotypes, Namkum Mango Selection-1 (Fig. 23) and Namkum Mango Selection-3 had regular bearing habit with high pulp (>70%) and TSS (>20°B) content in the fruit.

Fig. 23. Namkum Mango Selection – 1: Regular bearer, fruit wt - 321.0 g, TSS - 20.10B, pulp- 71.4%

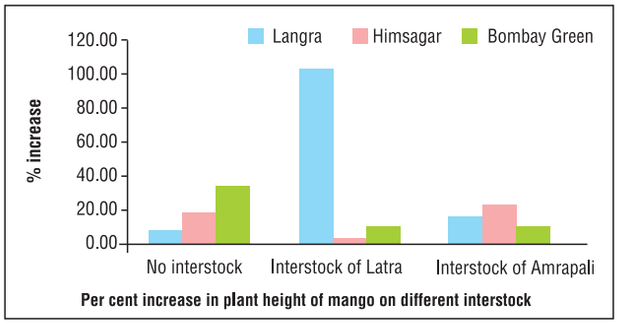
A total 151 number of mango genotypes were evaluated for fruit quality and yield. The average fruit weight ranged between 43.55 g (Illaichi) to 828 g (Alfazli); and 91 genotypes had fruit weight higher than 200g. The average pulp content ranged between 47.7% (Amin Prince) to 81.65% (Neelphanso) and 49 genotypes were found promising for high pulp content (>70%). The genotype 'Dilshad' recorded the highest TSS (28.13°B) and a total of 69 genotypes were found promising for high TSS content (> 20°B). The TSS/acidity ranged between 14.73 (Bhatuhi)-332.77 (Hathijhool) and a total of 25 genotypes recorded higher TSS/acid ratio (> 200). The average ascorbic acid content among the genotypes was 29.81 mg/100g and the genotype Bag-e-Bahar recorded the maximum content of ascorbic acid (187.81 mg/100g). The maximum fruit yield was recorded in case of Lucknow Selection (87.61 kg/tree) and yield of more than 40 kg/tree was recorded in 12 genotypes of more than 20 years' of age. Hence, based on fruit quality and yield, the genotypes Buponix, Himsagar, Lucknow Selection, Alampur Benisan, Neelphanso, Safed Maldah, CHM-5 and CHM-7 were found promising under eastern plateau and hill conditions (Fruit weight > 200g, Pulp content > 70%, TSS > 20°B,TSS : acidity > 200, Ascorbic acid content > 30 mg/100g and yield >40 kg/tree in plants of >20 years age) (Fig. 24).

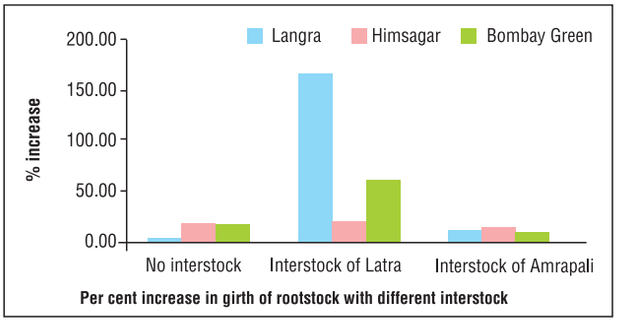
Fig. 24. Mango genotypes Lucknow Selection, Himsagar and Buponix found promising for fruit quality and yield

Further, 23 mango hybrids were evaluated for fruit quality and yield. Based on overall performance, the mango hybrid 'Jawahar' was found most promising under eastern plateau and hill conditions (fruit weight–279.1 g, Pulp content – 71.4%, TSS–25.72°B, TSS : acidity–211.62, fruit yield – 31 kg/plant).

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

The project was undertaken to test the feasibility of using interstocks for induction of dwarfing in vigorous and locally popular mango genotypes like Langra, Himsagar and Bombay Green. Two dwarf mango genotypes *viz.* Latra and Amrapali were used as interstocks. During the 4th year of experimentation, significantly lower values of plant height, girth of rootstock and girth of scion were recorded in case of plants with interstock than that without interstocks. The results clearly indicated reduced growth of vigorous mango cultivars on Amrapali as interstock. The higher rate of increase recorded in case of Latra as interstock can be attributed to Juvenility factor which is evident from the higher number of vegetative flushes recorded in case of plants with Latra as interstock (4.24 nos., Fig. 25).





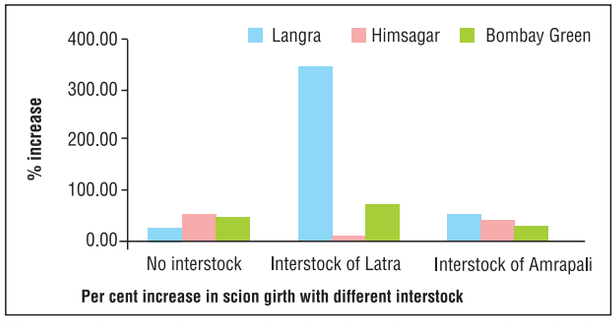


Fig. 25. Per cent increase in plant height, rootstock and scion girth with different interstock

JACKFRUIT

A new genotype promising for early bearing was collected from Namkum, Ranchi and conserved in the field gene bank of the institute. Seventy seven genotypes conserved in the field gene bank of the institute were evaluated for fruit quality. The average fruit weight ranged from 5.0-8.0 kg. The average pulp content ranged between 11.0% (ICARRCER JS-2-11/1) to 77.7(ICARRCER JS-2-3/5). The genotypes ICARRCER JS-1-10/1, 1-6/5, 1-1/5, 1-6/3, 1-3/8, 1-6/6, 1-10/2, 2-3/5, 2-7/4, 2-8/1, 2-13/4 were found promising for high pulp content (> 40%). The average TSS of pulp was 20.78°B and the genotypes ICARRCER JS-1-10/7, 1-5/1, 2-11/1, 2-14/2, 2-9/1, 2-4/6, 2-6/5, 2-18/4, 2-9/3, 2-17/1, 2-8/1, 2-7/4, 2-12/2, 2-6/7, 2-7/5, 2-4/7, 2-7/5, 2-7/3, 2-9/5 were found promising for high TSS content (> 22°B). Jackfruit seeds are rich source of carbohydrate and boiled seeds are generally consumed as vegetables. The average seed content of jackfruit genotypes was 10.80% and the genotypes ICARRCER JS-1-8/3, 1-10/1, 1-2/4, 2-11/1, 2-5/5, 2-3/7, 2-13/2, 2-14/1, 2-1/5, 2-4/7, 2-6/1, 2-9/3 had high seed content (>15%). Based on overall performance, the jackfruit genotype ICARRCER JS-2-8/1 was found to be the most promising for fruit quality (medium sized fruits, cylindrical shape, pulp content–51.57%, rind–33.7%, TSS – 23.4°B) (Fig. 26).

Fig. 26. Jackfruit genotype ICARRCER JS-2-8/1 found promising for fruit quality

SAPOTA

Performance of 12 sapota genotypes were evaluated for fruit quality and yield under eastern plateau and hill conditions (Fig. 27). The average fruit weight ranged between 74.0 g (Jhumakiya) to 121.4 g (Murrabba). The genotype 'Murrabba' recorded the highest pulp content (97.22%) whereas, the minimum average seed weight (0.27 g) was recorded in case of 'Mahayothi'. The genotypes, Kalipatti, Murrabba and Mahayothi were found promising for high TSS (>30^{0}B). The maximum yield (30.8 kg/plant) was recorded in the genotype Murrabba, followed by Bhuripatti (30.21 kg/plant). Phenological studies on flowering indicated three major peaks of flowering *viz.* May, July-August and January (Fig. 28). Among the genotypes, maximum number of flowers were recorded in the Kirtibatti (610/twig). Hence, keeping in view the fruit quality and yield, the sapota genotype Murrabba exhibited consistency in its superiority among the genotypes evaluated.

Fig. 27. Genotype 'Murabba' found most promising under eastern plateau and hill conditions

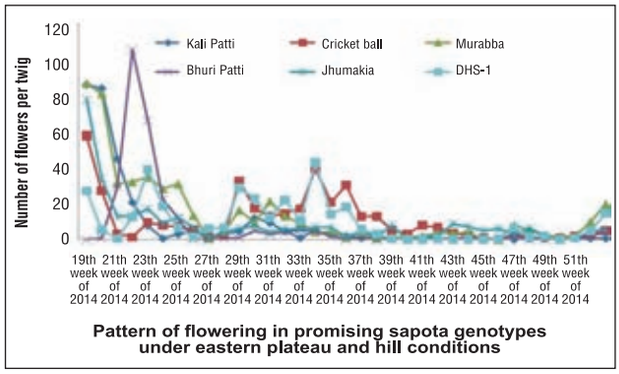


Fig. 28. Pattern of flowering in promising sapota genotypes under eastern Plateau and Hill condition

BAEL

A total of 41 bael genotypes including 4 varieties were evaluated for fruit quality and yield. The average fruit weight ranged between 0.34 (ICAR-RCER BS-2-10/5) to 1.99 kg (Pant Shibani) and 11 genotypes had fruit weight between 1.0-1.5 kg. The minimum skull content was recorded in Pant Shibani (12.55%) and 18 genotypes had low skull content (< 20%). The minimum skull thickness was recorded in Deoria collection (1.55 mm). The minimum seed content (1.31%) and seed size (0.16 g/seed) was recorded in Begusarai Collection and 16 genotypes were found promising for low seed content (< 3%). The maximum pulp content was recorded in Pant Shibani (85.76%) and 6 genotypes were found promising for high pulp content (> 80%). The maximum TSS was recorded in ICAR-RCER BS-2-8/1 (28.8°B) and 17 genotypes were found promising for high TSS content (>20^{0}B). The fruit yield per plant ranged between 34.61 kg/tree (ICARRCER BS-2-6/11) to 121.18 kg (Pant Aparna) and 11 genotypes were recorded yielders (>100.0 kg/tree).

Keeping in view the fruit quality and yield, the genotype Barabanki Collection was found promising during the year (average fruit weight – 1.01 kg, skull content – 13.87%, seed content – 2.03%, TSS – 21.4°B and yield – 113.6 kg/tree) (Fig. 29).

Fig. 29. Barabanki collection- A promising Bael genotype

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

Survey results during 2013-14 showed that complex of bael fruit borer, *Cryptophlebia*

(Argyroploca) illepide and fruit fly species *Bactrocera zonata* (Saunders) caused infestation to bael fruits. Surveillance data from research farm of ICAR RCER, RC Ranchi showed 35±5.0 per cent fruit infestation by this complexity. Newly transplanted plants were found to be infested with powdery mildew (Fig. 30) and maximum disease intensity (33%) was recorded in the month of September and October.

Fig. 30. Powdery mildew infested young plant of bael

LITCHI

Biology, Seasonal Incidence and Management of Stink Bug, (*Tessaratoma* spp.)

Two nos. of eco-friendly and economically management modules were formulated and validated under field conditions. In these modules some basic management aspects, i.e., mechanical destruction of hibernated population (Fig. 31) using kerosinized water and collection of egg masses (Fig. 32) for mechanical exclusion of natural enemies were kept common and made combinations of insecticides for proper stage of bug to kill. The module with spray of lambda cyhalothrin+diclorvos (DDVP) @ 0.5+1.0 ml/litre of water in the last week of December month, spray of dimethoate @ 0.05% in second week of February on immigrated population after panicle emergence and before flower opening, spray of imidacloprid @ 0.005% against first instar nymphs at 100% fruit setting stage and fourth spray of acephate @ 0.1% at pea stage of fruits was found effective and economically viable (Table 18).

Fig. 31. Hibernating population of bug on twigs

Fig. 32. Collected egg masses of stink bug

Table 18. Economics and assessment of losses caused by litchi stink bugs in litchi

Treatments	Yield (kg/ tree)	Total avoidable losses (kg/tree)	Percent avoidable losses	Yield increase over control (kg/tree)	Percent yield increase over control	Return of increased yield (₹)**	Total cost of module expenditure (₹)***	B:C ratio
Module I	24.1	2.78	10.35	7.83	48.13	391.5	320	1.22
Module II	26.88*	0	0	10.61	65.21	530.5	295	1.80
Control	16.27	10.61	39.47	0	0	0	0	0

*Highest yield in the module plots, ** Cost of litchi fruits in season was ₹ 50 per kg in market *** It includes module and labour charges

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

Based on surveillance data of incidence of different insect pests at different time, litchi pest calendar was made which could be useful for timely and efficient management of pests in the region (Fig. 33).

Flower thrips *Megalurothrips* spp. and *Haplothrips* spp. were observed on late flowered genotypes (Fig. 34). Out of 25 genotypes studied, China, Purbi, CHES-2; L-7/104, Surguja Sel-II and CHES-4 were found to be highly infested by the thrips. The maximum population of thrips (34 numbers per tap) was recorded in the month of March.

In search of natural enemies, decline in population of litchi looper, *Perixera illepidaria* was recorded in the month of September by viral disease infection (Fig. 35). The maximum mortality of looper larvae was recorded 65±5 per cent in the month of September 2014. The mortality was positively correlated with occurrence of rainfall.

Fig. 34. Thrips damaged flower of litchi

Fig. 35. Cadaver's of litchi looper, Perixera illepidaria in field due to virus infestation

PESTS	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
Tessaratoma spp.												
Leptocorisa ocuta												
Lymantria spp.												
Thrips												
Perixera illepidaria												
Platypephus aprobola												
Acerya litchi												
M. undecimpustlotus												
Myllocerus dorsatus												
Cryptocephalus spp.												
Bizura suppressaria												
Leptoglossus oppositus												
Conopomorpha sinensis												

Fig. 33. Litchi pest calendar

8 Vegetables

BRINJAL

AICRP (VC) trial

In brinjal round hybrid AVT-II, the highest yield was recorded in 2012/BRRHYB-2 (27.05 t/ha) which was better than the best check variety Swarna Mani.

Development of module for integrated pest management in brinjal

An experiment was conducted with eleven brinjal varieties/lines of institute to know their level of resistance or susceptibility against major biotic stresses. Based on the previous records and current survey data, brinjal fruit and shoot borer, *Leucinodes orbonalis* Guenee and bacterial wilt caused by *Ralstonia solanacearum* were recorded as major pest and disease of brinjal in the eastern plateu and hill region condition. Of the 11 varieties studied, 4 varieties (Swarna Ajay, S. Shyamali, S. Mani and S. Shakti) were resistant and 7 varieties were moderately resistant or susceptible for shoot infestation (Table 19). Observations on plant mortality by bacterial wilt at different days after transplanting indicated that S. Pratibha, S. Ajay and S. Mohit showed some level of resistant (Table 20). Plant mortality by bacterial wilt was observed maximum after 50 days of transplanting.

Table 19. Shoot infested caused by brinjal shoot and fruit borer, *L. orbonalis* at different days after transplantation (DAT)

Varieties/lines	25 DAT	35 DAT	45 DAT	50 DAT
	Per cent infestation of shoot borer			
Swarna Shree	31.65	18.86	12.79	4.88
Swarna Mani	13.12	2.78	2.78	0.00
Swarna Shyamali	6.27	4.17	4.17	2.08
Swarna Pratibha	31.85	18.15	7.78	4.07
Swarna Shoba	16.96	6.25	6.25	4.17
Swarna Avilambha	10.71	4.17	4.17	-
HABR-21	19.30	13.41	10.84	4.95
Swarna Ajay	9.48	3.81	3.81	3.81
Swarna Mohit	19.44	13.43	5.79	-
Swarna Shakti	12.25	4.04	4.04	1.96
Swarna Neelima	14.23	7.22	5.00	2.22
CD (5%)	N/A	N/A	N/A	N/A

Table 20. Plant mortality caused by bacterial wilt, *Ralstonia solanacearum* at different days after transplantation

Varieties/lines	30 DAT*	40 DAT	50 DAT	60 DAT
	Percent mortality of plants			
Swarna Shree	12.02	33.51	81.58	81.58
Swarna Mani	12.28	52.63	89.47	89.47
Swarna Shyamali	15.09	21.93	82.32	82.32
Swarna Pratibha	8.42	18.86	48.33	48.33
Swarna Shoba	11.75	20.35	74.56	74.56
Swarna Avil-ambha	12.04	24.07	65.74	63.89
HABR-21	10.76	40.92	86.23	86.23
Swarna Ajay	5.18	16.84	47.81	47.81
Swarna Mohit	5.00	16.67	45.00	45.00
Swarna Shakti	8.33	30.00	83.33	85.00
Swarna Neelima	10.00	33.33	78.33	78.33

*DAT - days after transplanting

TOMATO

AICRP (VC) Trial

In tomato determinate hybrid AVT-II, 2012/TODHYB-1 (20.63 t/ha) followed by 2012/TODHYB-5(14.98 t/ha) performed better than the best checks BSS-488 and DVRT-2.

In determinate varietal IET, 2014/TODVAR-5 (41.38 t/ha) followed by 2014/TODVAR-3 (29.69 t/ha) performed better than the best check H-86.

In determinate varietal AVT-II, 2012/TODVAR-2 (18.76 t/ha) followed by 2012/TODVAR-5 (14.81 t/ha) performed better than the best check H-86.

In tomato indeterminate varietal AVT-II, 2012/TOINDVAR-2 (16.71 t/ha) performed better than the best check variety Arka Vikas (9.38 t/ha).

Genetic Enhancement of Tomato for Nematode and Bacterial Wilt Resistance Through Molecular Markers

Evaluation of F_1 pair crosses for root knot nematode tolerance

HAT-310 x Swarna Lalima and HAT-311 x Swarna Lalima pair crosses were evaluated for nematode tolerance and susceptibility with artificial inoculation (Fig. 36-38). Out of these two crosses, HAT-311 x Swarna Lalima (4galls/plant & 0 egg masses/plant) was tolerant to root knot nematode. Among the eight bacterial wilt resistant and nematode tolerant crosses evaluated, HAT-296 x HAT-310 (6.2 galls/plant & 0 egg masses/plant), HAT-296 x HAT-311 (5 galls/plant & 0 egg masses/plant) and EC-596747 x Hat-311 (7.6 galls/plant & 0 egg masses/plant) were found nematode tolerant.

Evaluation of F_1 pair crosses for bacterial wilt

Four bacterial wilt resistant x bacterial wilt susceptible reciprocal crosses and four wilt resistant x nematode resistant reciprocal crosses were evaluated in wilt sick plot (48.67 $X10^6$cfu/g) with artificial inoculation. Among them HAT-296 x HAT-311(83.33%), HAT-296 x HAT-310 (80.52%), Swarna Lalima x HAT- 311 (81.2%), Swarna Lalima x HAT- 310 (80%) and HAT-296 x HAT-302 (81.3%) were found wilt resistant.

Evaluation of F_1 pair crosses for yield and yield characters

Among twenty crosses selected for fruit quality, the highest yield was recorded in EC-596743 x HAT-310 (64.71 t/ha) followed by HAT-296 x EC-596743 (64.30 t/ha), HAT-296 x EC-596742 (64.1 t/ha) and EC-596742 x HAT-305 (62.04 t/ha). Among the bacterial wilt resistant crosses, HAT-296 x HAT-302 (68.64 t/ha) recorded the highest yield followed by Swarna Lalima x HAT-310 (48.1 t/ha) and Swarna Lalima x HAT-311 (42.29 t/ha). HAT-311x Swarna Lalima (46.26 t/ha) followed by HAT-296 x HAT-310 (43.88 t/ha) recorded the highest yield among the nematode resistant crosses.

Survey and Surveillance of Pest Complex and their Natural Enemies on Tomato

Whitefly, vector of tomato mosaic virus was recorded major pest on rainy season tomato. Bacterial wilt was recorded as the significant biotic stress of tomato cultivation in the region. The disease appeared throughout the year but the intensity of disease was observed maximum in the month of September-October, 2014 (32.67). Besides bacterial wilt, tomato was also affected by *Septoria* and *Alternaria* blight. *Septoria* blight first appeared in the month of September and the highest disease intensity was recorded in the month of October and November, 2014. *Alternaria* leaf blight of tomato was observed in the month of November and there after it perpetuated on the crop (Fig. 39).

Fig. 36. HAT-310 x Swarna Lalima (Nematode susceptible)

Fig. 37. HAT-311 x Swarna Lalima (Nematode tolerant)

Fig. 38. HAT-296 x HAT-310 (Nematode tolerant)

Fig. 39. Alternaria blight infested tomato plant and fruits

CHILLI

AICRP (VC) Trial

In chilli varietal IET, the highest yield was recorded in 2014/ CHIVAR-8 (9.52 t/ha) followed by 2012/CHIVAR-5 (8.79 t/ha) and performed better than the best check varieties KA-2 (4.48 t/ha) and LAC-334 (2.32 t/ha).

Biochemical analysis of chilli lines

Bioactive compounds of different lines of chilli were analysed. Total capsaicinoids ranged from 0.02 g/100g (HC-25) to 0.61 g/100g (HC-68) at green stage and 0.02 g/100g (HC-25) to 0.42 g/100g (HC-68) at red ripe stage. Total Scoville heat Units ranged from 2427 (HC-25) to 98036 (HC-68) at green stage and 2829 (HC-25) to 66315 (HC-68) at red ripe stage. Capsaicinoids and SHU which is a measure of pungency in chilli showed decreasing values from green stage to red ripe stage. HC-68 had highest carotenoid content (313.99 mg/100g dryweight). Colour value measured in ASTA units ranged from 119.8 (HC-68) to 41 (HC-25). Among the lines analysed, HC-68 is recommended for green chilli and red chilli purpose and HC-25 for pickle purpose (Table 21).

Maintenance of genetic purity of released varieties

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

CUCUMBER

AICRP (VC) Trial

In cucumber varietal AVT-II, 2011/CUCUVAR-6 (11.52 t/ha) followed by 2011/CUCUVAR-3 (10.81 t/ha) and 2011/CUCUVAR-2 (10.48 t/ha) performed better.

Maintenance of genetic purity of released varieties

The genetic purity of Swarna Poorna, Swarna Sheetal, Swarna Ageti was maintained through nucleus seed production.

BITTER GOURD

AICRP (VC) Trial

- In bitter gourd hybrid AVT-I, 2012/ BIGHYB-6 (14.16 t/ha) performed better than the best check Pusa Hyb-2 (13.81t/ha)
- In bitter gourd hybrid AVT-II, the highest yield was recorded in 2011/ BIGHYB-5 (9.10 t/ha) followed by 2011/ BIGHYB-2 (8.96 t/ha) and 2011/ BIGHYB-1 (7.82 t/ha) and the best check Pusa hyb-2 (7.01 t/ha).
- In bitter gourd varietal AVT-I, the highest yield was recorded in 2012/BIGVAR-5 (12.19 t/ha) followed by 2012/BIGVAR-2(95.00 t/ha) and the best check PBRG-2 (8.36 t/ha).
- In bitter gourd varietal AVT-II, the highest yield was recorded in 2011/BIGVAR-4 (9.42 t/ha) followed by 2011/BIGVAR-6 (9.40 t/ha), 2011/ BIGVAR-2 (8.25t/ha), 2011/BIGVAR-3 (8.13 t/ha) and the best check Pusa Domoshmi (7.77 t/ha).

Table 21. Bioactive compounds in Chilli

Lines	Total capsaicinoids g/100g dry wt (Green stage)	Total capsaicinoids g/100g dry wt (Red ripe stage)	Total SHU (Green stage)	Total SHU (Red ripe stage)	Total carotenoids mg/100g dry weight	ASTA colour value
HC-68	0.61	0.42	98036	66315	313.99	119.8
HC-25	0.02	0.02	2427	2829	106.52	41.0
HC-69	0.31	0.20	50431	33723	211.87	81.2
HC-70	0.56	0.20	90194	31942	246.94	94.2
Swarna Praphulya	0.54	0.34	86807	53971	203.94	77.9

Maintenance of genetic purity of pre-released varieties

The genetic purity of released/pre-released varieties Swarna Yamini, HABG-21, HABG-22, HABG-29 was maintained through nucleus seed production.

SPONGE GOURD

AICRP(VC) Trial

In sponge gourd varietal AVT–II, 2011/SPG-VAR-6 (9.33 t/ha) followed by 2011/SPGVAR-1 (7.98 t/ha) performed better than the best check 'Pusa Chickni' (2.21 t/ha).

Maintenance of genetic purity of released varieties

The genetic purity of Swarna Prabha was maintained through nucleus seed production.

LONG MELON

AICRP(VC) Trial

In long melon, Varietal AVT-II, the highest yield was recorded in 2011/LGMVAR-2 (9.06 t/ha) followed by 2011/LGMVAR-4 (8.79 t/ha) as compared to the best check Arka Sheetal (5.81 t/ha).

TUBER CROPS & WILD EDIBLES

Total 201 germplasm collected through survey in Jharkhand, Chhattisgarh, Odisha and West Bengal were multiplied in the field for characterization and evaluation. These include germplasm of *Dioscorea* spp. (47), *Ipomoea batatas* (12), *Maranta arundinacea* (1), *Colocasia* spp. (67), *Amorphophallus* spp. (47), *Alocasia* spp. (15), *Manihot* spp. (7) and *Cucumis melo var agrestis* (5).

Sweet potato: Out of 12 lines including check evaluated, ACC-172, a collection from Rampur Bazar under Namkum block of Ranchi district of Jharkhand performed the best and recorded tuber yield of 48.22 t/ha with a yield increase of 57.94% over the check Sree Bhadra (tuber yield 30.53 t/ha).

Aerial/Potato yam: Out of four lines evaluated, ACC-129, a collection from Kotela village under Charama block of Uttar Bastar Kanker district of Chhattisgarh performed the best and recorded the aerial tuber (bulbil) yield of 15.28 t/ha.

Taro/Colocasia: Out of 11 lines including check evaluated, ACC-37, a collection from Barapalasi, village under Jama block of Dumka district of Jharkhand performed the best and recorded corm yield of 49.08 t/ha with a yield increase of 154.03% over the check Muktakeshi (corm yield 19.32 t/ha).

Yam bean: Out of five entries evaluated, DPH-101 recorded the maximum tuber yield of 35.25 t/ha with a yield increase of 24.73% over the check Rajendra Mishrikand-1 (tuber yield 28.26 t/ha).

VEGETABLE SOYABEAN

Under multi-locational trial initiated by the Directorate of Soyabean 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 (18.70 t/ha) with 50.70% recovery of shelled green beans (grains) (Fig. 41).

Fig. 41. Vegetable soyabean 'Swarna Vasundhara

Fig. 40. Sweet potato, colocasia and yam bean

Fertigation and Planting Geometry in Vegetables

An experiment was conducted to evaluate the efficacy of different growth stage based fertigation patterns and crop geometry for commercial cultivation of vegetables like tomato, broccoli, chili and sweet corn in acidic soil of eastern hill plateau region. The treatments comprised combination of 4 spacing and 3 fertigation levels were replicated thrice in a split plot design. There were four planting geometries and three fertilizer patterns for each winter crops, i.e., tomato, broccoli & chilli and summer crops, i.e., summer cauliflower, tomato & sweet corn.

The tomato and chilli 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 (BPR) 60 cm (Triangulated paired row system); S_3-PP 50 cm, RR 40 cm, BPR 60 cm (Triangulated paired row system) and S_4- PP 70 cm, RR 40 cm, BPR 70 cm (Triangulated paired row system).

In broccoli planting geometry was as S_1-PP 50 cm, RR 50 cm (Square with two rows per lateral system); S_2-PP 30 cm, RR 40 cm, BPR 60 cm (Triangulated paired rows per lateral system); S_3-PP 45 cm, RR 40 cm, BPR 60 cm (Triangulated paired row system) and S_4- PP 60 cm, RR 40 cm, BPR 70 cm (Triangulated paired row system).

The sweet corn seeds were sown as per the planting geometry as S_1-PP 15 cm, RR 50 cm (Rectangular with two rows per lateral system); S_2-PP 25 cm, RR 40 cm, BPR 60 cm (Triangulated paired rows per lateral system); S_3-PP 50 cm, RR 40 cm, BPR 60 cm (Triangulated paired row system) and S_4- PP 35 cm, RR 30 cm, BPR 70 cm (Triangulated paired row system).

The three fertigation levels were finalized as per the crop duration for tomato, chilli, broccoli and sweet corn. The recommended dose of 120:60:60, 50:60:60 and 150:60:60 kg of NPK were applied in tomato, chilli and broccoli, respectively (Fig. 42).

Effect of different treatments on tomato

The data revealed that the fertigation pattern FP_1 under crop geometry S_1 resulted into maximum fruit yield of 76.55 /ha followed by FP_2 under S_1 crop geometry (70.69 t/ha).

The water productivity was recorded highest in S_3 crop geometry (140.8 kg/m^3) and was at par with S_1 & S_2 crop geometry. In terms of monetary outputs, fertigation pattern FP_2 with planting geometry S_1 showed maximum water productivity of 157.1 Rs/m^3.

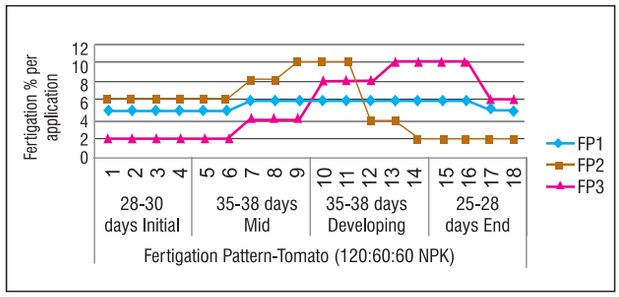


Fig. 42. Fertigation schedule of Tomato

Effect of different treatments on chilli

The planting geometry S_2 resulted into significantly higher yield (16.34 t/ha) as compared to other planting geometry. The fertigation pattern and their interaction with crop geometry, however, did not exhibit any significant effect on yield.

The crop geometry had significant effect on WUE in chilli. The plant geometry S_2 showed highest WUE and water productivity (5.4 kg/m^3 and ₹ 108.4/m^3, respectively).

Effect of different treatments on broccoli

The fertigation with FP_2 recorded highest curd yield of broccoli (35.07 t/ha) as compared to FP_3 but remained at par with FP_1 (32.51 t/ha).

The planting geometry S_2 showed the highest water use efficiency (21.1 kg/m^3) and water productivity of ₹ 211.3/m^3. The fertigation pattern and their interaction with crop geometry, however, did not show any significant effect on water use efficiency.

Effect of different treatments on sweet corn

The crop geometry S_1 recorded the highest yields of 16.76 t/ha and was statistically at par with S_2 and S_4. The fertigation pattern and their interaction with crop geometry, however, did not show any significant effect on yield.

The crop geometry S_1 recorded the highest WUE of 6.7 kg/m^3 and was statistically at par with S_2 and S_4. The fertigation pattern and their interaction with crop geometry, however, did not show any significant effect on WUE. The crop geometry S_3 recorded the significantly highest water productivity (₹ 242.4/m^3) and was statistically at par with S_2 and S_4.

9 Makhana

Assessment of Macro and Microelement Accumulation Capability of Aquatic Weeds Growin in Makhana Fields

Population density, biomass yield and protein content of certain aquatic weeds growing in association with makhana crop

The population density of different weed species was recorded from makhana fields. The highest number of plants was recorded with *Marsilea quadrifolia* (132 plants/m^2) while the lowest with *Eichhornia crassipes* (2 plants/m^2). The number of plants recorded with *Ceratophyllum demersum* and *Ipomoea aquatica* were 5 and 10, respectively.

The highest protein content was recorded in the biomass of *I. aquatica* (25.00%) followed by *Azolla pinnata* (22.50%). The other three weed species had recorded almost similar protein content in vegetative phase of growth.

On account of having a large vegetative body, *E. crassipes* recorded maximum biomass (200 kg/ha) on dry weight basis (Table 22). Thus, it adds an appreciable amount of organic matter to the soil which would certainly be beneficial in sustaining the fertility of the soil among the studied weed species. The *I. aquatica* was observed to be the second largest contributor of organic matter (130 kg/ha) to the soil whereas the lowest biomass was added by *C. demersum* (7 kg/ha).

Table 22. Population density, biomass yield and crude protein content of certain aquatic weeds growing in association with makhana crop

Weed	No. of plants/m^2	Crude protein (% dry weight)	Standing weed biomass dry weight (kg/ ha)
Marsilea quadrifolia	132	14.06	62
Eichhornia crassipes	2	15.35	200
Ceratophyllum demersum	5	18.20	7
Ipomoea aquatica	10	25.00	130
Azolla pinnata	-	22.50	120

Fig. 43. Heavy infestation of *I. aquatica* weed in makhana growing fields

Fig. 44. Heavy infestation of *M. quadrifolia* in makhana fields

Macronutrient content of weed species

Many weeds had nitrogen content above 2.20 per cent. Plant materials with a N content above 2.5 per cent when added to the soil induce an initial release of nitrogen. Besides being rich in N, and K, these weeds may be a good source of calcium, magnesium, sodium and sulphur to the plants (Table 23).

Table 23. Chemical analysis of inorganic elements (per cent) of certain aquatic weed species

Weed species	Organic carbon	Total N	Total P_2O_5	Total K_2O	C:N	C:P
M. quadrifolia	36	2.25	0.16	1.56	16:1	225:1
E. crassipes	42	2.40	0.13	2.85	17.5:1	323:1
C. demersum	30	2.78	0.30	2.52	10.8:1	100:1
I. aquatica	45	2.54	0.20	2.65	17.7:1	225:1
Azolla pinnata	29	3.6	0.08	0.67	8.05:1	362.5:1

The C:N and C:P ratios varied from 10.80 to 17.70 and 100 to 362.50. Plant residues having a C:N ratio above this when added to the soil will cause an initial immobilization of soil nitrogen. Below this, net release of inorganic nitrogen takes place. The majority of the weeds analysed had a C:N ratio below 20, and the C:P ratio for all the weeds was slightly above 200 except *C. demersum*. This study of the biological constants indicated that the addition of these weeds is likely to result in the microbial release of nitrogen, phosphorus and other plant nutrients.

Micro nutrient content in certain aquatic weed species

The aquatic plants growing in the study area exhibited different trace elements depending on the plant organ. Iron, manganese, zinc and copper contents of the weeds varied from 2225 to 2405, 492 to 1245 mg/kg, 90 to 195 mg/kg and 5.4 to 38 mg/kg, respectively (Table 24).

The present study revealed that *M. quadrifolia* and *C. demersum* possess greater accumulation ability for selected heavy metals. The maximum accumulation of Fe, Mn, Zn and Cu was made by *M. quadrifolia* followed by *C. demersum*. In present study very high accumulation of Cu was found in shoot system of *Marsilea quadrifolia* (38 mg/kg) which indicates that this species can be effectively used as phytoremediant for Cu contaminated water bodies.

Table 24. Micro-nutrient content in certain aquatic weed species

Weeds species	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
Marsilea quadrifolia	2400	840	195	38
Eichhornia crassipes	2225	1245	170	5.4
Ceratophyllum demersum	2405	492	182	28
Ipomoea aquatica	2300	700	90	27
Azolla pinnata	–	–	–	–

Introduction of Sweet Flag and Vegetable Alocasia with Makhana Under Wetland Ecosystem of North Bihar

Alocasia [*A.macrorhizos* L. (Schott;)] was planted during last week of March at a distance of 1.25 x 1.0 m. Two accessions of sweet flag namely Batch Sel-1 and 2, multiplied and maintained at the nuersry, were planted at the middle of terrace (0.75 - 1.0 m broad) of the pond where 5-10 cm of water was maintained throughout the year. Makhana nursery was prepared by sowing makhana seed on 15th December, 2014.

Fig. 45. Sweet Flag batch selection -2 at nursery

Fig. 46. Makhana nursery plot

10 Farming System Research

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

For the purpose of efficient farm-based resource recycling, increasing land productivity, sustaining soil health and fertility, securing nutritional security and enhancing livelihood of small and marginal farmers of the region, two integrated farming system models (one acre and two acre) were developed not only for increasing income of the farm family but also for round the year employment and continuous flow of income. Selection of the components and allocation of area for different components was done as per the requirement of the farm family, nutrient recycling within the system and availability of market.

One acre IFS model (crop + goat + poultry + mushroom) was developed for midland irrigated areas where more than 80 per cent farmers have an average land holding of 0.32-0.48 ha. Under crop components, rice-wheat, rice-maize, rice-chickpea and rice-mustard (cereal-based cropping system) and cowpea-okra- tomato, okra- pea-cabbage and okra - cauliflower/tomato - onion (vegetable-based cropping systems) were followed and nutrient recycling within the system was studied. All around the field bunds, pigeonpea was planted to enrich the field bunds and to supplement additional protein to the farm families. Cowpea - cauliflower-onion cropping system along with poultry + mushroom + goatry fetched the highest net income of ₹ 1,22,360/yr in comparison with other cropping systems in a farming system mode which was about four times higher over rice-wheat cropping system (₹ 25,475) in isolation. Net monetary gains of ₹ 60,044/- could be achieved from one acre of model (Table 25).

As a result of nutrient recycling study within the system 1.58 tones of vermicompost, 0.62 tones of goat manure and 2.08 tones of poultry manure were produced which was equivalent to 77.7 kg of Urea, 145.0 kg of SSP and 46.2 kg of MOP and were recycled within the system (Table 26). Due to continuous intensive farming, ninety two numbers of more man-days were also engaged by this system.

Table 25. Economic analysis of one acre IFS model (2013-14)

Farm produce	Gross area in m^2 (% of total area)	Cultivation cost (₹)	Net saving (₹)
Crop			
Cereals	2000 (50)	11085	1095
Green fodder	720 (18)	6250	-6250
Dry fodder	-	875	7545
Veg. waste	-	500	2090
Pulses	-	2000	400
Oilseeds	-	2000	-200
Hort. & Livestock			
Fruits	-	6264	256
Vegetable	-	20200	4800
Goatry (20+1)	185 (4.6)	54632	27,368
Mushroom	30 (0.75)	10400	400
Poultry	15 (0.37)	64920	25,980
Vermi-compost	-	6400	-4000
Goat manure	50 (1.25)	-	0
Poultry manure	-	0	1120
Land Ex.	100 (2.5)	0	0
Total	3100	1,85,526	60,044

Two acre IFS model (crop + dairy + fish) was developed for lowland irrigated areas (Fig. 47) in which livestock (2 cows + 2 calves), fishery ($1000m^2$), duckery (35 no.), vegetables and fruits ($1000m^2$) were integrated with rice-wheat, rice-maize, rice-lentil and rice-mustard cropping system. Different enterprises were evaluated against cropping systems for net returns and employment generation. Rice-wheat + vegetables + livestock + fisheries/ duckery integration fetched maximum annual return (₹ 2,18,476/-) with 218 no. of more man-days employment.

Table 26. Economic analysis of two acre IFS model (2013-14)

Farm produce	Gross area in m^2 (% of total area)	Cultivation cost (₹)	Net saving (₹)
Crop			
Cereals	4000 (50)	23195	11385
Green fodder	960 (12)	10800	5350
Dry fodder (wheat, rice)	–	1200	7500
Oil seed	1000	3200	700
Pulses	1000	3500	4100
Horticulture			
Fruits	440 (5.5)	11220	1800
Vegetable main Field	1000 (12.5)	29880	4670
Dairy (2 + 2)	160 (1.9)	62200	9200
Fishery	1000(12.5)	8800	22400
Duckry	–	18560	9865
FYM	120 (1.5)	500	1900
Veg. Waste		500	7400
Vermi-compost		7200	-4800
Land Ex.	320 (4.0)		–
Total	10,000	1,71,955	81,470

Again food and fodder requirement for farm family were analysed which revealed a net saving of ₹ 81,470/- as support for the family for other needs too.

Through this integration 7.0 tones of vermicompost and 3.0 tones of FYM and 1.3 tones of duck droppings were produced and recycled which added 38.4 kg of N, 33.1 kg of P and 43.0 kg of K in the soil and were equivalent to 159 kg of urea, 419 kg of SSP and 139 kg of MOP.

Different integrations were analyzed statistically and the most income sustainable farming system was selected as crop + fish + goat + poultry + mushroom (ISI: 0.7) and crops + dairy + mushroom (ISI: 0.46). Further, it was observed that due to waste recycling within the system there was sufficient increase in organic carbon upto 11.9 %, N 19.0 %, P 30.1 % and K 11.9 % in the soil over a period of six years.

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

An experiment was conducted for development of one acre location specific integrated farming system models for rainfed ecosystem

The soil pH of the experimental plot varied from 4.02-4.78, EC 0.010-0.02 EC ds/m, available carbon 0.22-0.45%. The available nitrogen varied from 138-170 kg/ha, available phosphorus 7.4-61.2 kg/ha and available potassium 269-526 kg/ha under different blocks of integrated farming system.

The details of economics of different enterprises under integrated farming system are depicted in Table 27. On average, net monetary gain of ₹ 44,957/- per acre of land could be obtained in system mode of food production system.

Table 27. Details of economics of integrated farming system of different enterprises

Particulars of interventions	Gross return (₹)	Net income (₹)
Pea + Vegetable Soyabean	23,310	10,024
Sweet Corn + Paddy	4,330	3,080
Guava	2,610	1,860
Gram + Cow Pea	1,380	880
Mustard + Groundnut	1,350	850
Sorghum	1,800	1,300
Fish	2,700	1,700
Milk	36,262	17,013
Vermicompost	3,000	2,250
Compost	8,000	6,000
Total	84,742	44,957

Fig. 47. A view of two acre IFS model

11 Soil Science

Evaluation of Different Production Systems for Carbon Sequestration Potential

Carbon sequestration potential in rice-wheat ecosystem

Different production systems were assessed for their carbon sequestration potential at Patna and Ranchi. At Patna, a long term field experiment with three crop sequences (C_1: rice-wheat, C_2: rice-maize, C_3: rice-lentil) and three tillage practices (T_1: conventional tillage without residue, T_2: reduced tillage without residue, T_3: reduced tillage with 30% residue) in factorial RBD is undergoing since June, 2012.

Bulk density, after rice harvest, was higher in reduced tillage than conventional tillage (Fig. 48). Lower bulk density in conventional tillage was due to regular disturbance of soil by tillage operation. In 10-20 cm soil layer, opposite trend was observed.

Total amount of residue added was highest in rice-maize crop sequence (22.19 q/ha) followed by rice-wheat (17.93 q/ha) while it was lowest in rice-lentil (14.53 q/ha) (Table 28). Similar trend was also noticed for total carbon addition from sequence. Residue addition and actual carbon addition was significantly higher in reduced tillage with residue (RT 30).

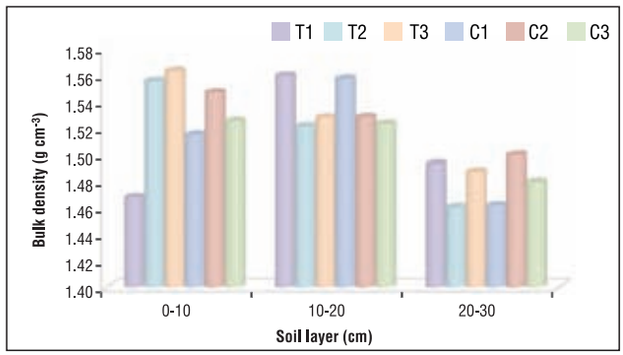


Fig. 48. Bulk density under different tillage and cropping system after rice harvest in 2014.

Aggregation characteristics of soils

The effect of different tillage and residue managements were prominent on soil aggregation. Mean weight diameter (MWD) was considerably higher in plots where reduced tillage was followed and crop residue (30%) was retained. Water stable aggregate (WSA) and geometric mean diameter (GMD) followed the similar trend (Table 29).

Table 28. Addition of crop residues and carbon (C) addition under different tillage and crop sequences

Treatments	*Kharif*			*Rabi*			Total C added from sequence (q/ha)
	Crop residue added (q/ha)	Potential C addition (q/ha)	Actual C added (q/ha)	Crop residue added (q/ha)	Potential C addition (q/ha)	Actual C added (q/ha)	
C_1 (R-W)	10.32	30.52	3.52	7.61	28.95	3.23	6.75
C_2 (R-M)	8.88	30.10	3.08	13.31	32.62	5.54	8.62
C_3 (R-L)	9.48	29.30	2.91	5.05	17.43	2.17	4.36
CD	NS	NS	NS	3.30**	3.03**	1.37**	-
T_1 (CT)	4.33	31.91	1.49	2.99	26.07	1.24	2.73
T_2 (RT)	3.99	29.41	1.38	2.90	27.44	1.24	2.62
T_3 (RT30)	20.36	28.60	6.64	20.08	25.49	8.46	15.1
CD (P=0.05)	4.70**	NS	1.33**	3.30**	NS	1.37**	-

Table 29. Aggregate associated organic carbon (AAOC) under different treatment in 0-10 cm soil layer (figures in parentheses represent the value for 10-20 cm soil layer).

Treatments	8-2 mm	2-0.25 mm	0.25-0.053 mm
T_1	0.89 (0.82)	0.85 (0.80)	0.78 (0.78)
T_2	0.75 (0.74)	0.84 (0.71)	0.83 (0.78)
T_3	0.90 (0.84)	0.71 (0.71)	0.85 (0.79)
T_4	0.92 (0.77)	0.83 (0.75)	0.83 (0.74)
T_5	0.88 (0.89)	0.93 (0.77)	0.90 (0.76)
T_6	0.92 (0.77)	0.89 (0.56)	0.83 (0.68)
T_7	1.04 (0.70)	1.12 (0.63)	1.08 (0.63)
T_8	0.97 (1.03)	1.00 (0.88)	0.93 (1.01)
T_9	1.02 (0.89)	1.06 0.73()	1.21 (0.75)
Mean	0.92 (0.83)	0.92 (0.73)	0.92 (0.77)

Aggregate associated organic carbon (AAOC) content in different sized aggregate was not much different in the upper 0-10 cm soil layer. Organic C content was at par in all aggregate size classes. In deeper soil layer (10-20 cm), however, the trend was different. Here larger sized aggregate accumulated higher amount of organic C in comparison to smaller sized aggregates (Table 30).

Rice-wheat system was superior in terms of yield. Biological and straw yield of paddy was significantly higher in conventional tillage. Highest harvest index was observed in tillage with residue addition. System productivity was not significantly different with respect to tillage treatments after *rabi* season.

Carbon sequestration potential of different orchards

At Ranchi centre of the institute, five years old orchards of litchi, mango an guava were evaluated for their carbon sequestration potential.

Among various parameters of biomass yield and carbon stock/ha, mango ranked first followed by litchi and guava as evidenced from the data shown in Table 31.

Table 31. Biomass yield and carbon stock/ha in five year old orchard (Non-destructive study)

Items	Biomass parameters/ha		
	Litchi	Guava	Mango
Growing stock, GS (m^3)	451.30 ± 28.92	329.46 ± 26.06	1146.22 ± 55.32
Above ground biomass, AGB (kg)	505.80 ± 32.41	369.24 ± 29.20	1284.65 ± 62.00
Below ground biomass, BGB (kg)	134.54 ± 8.62	98.22 ± 7.77	341.72 ± 16.50
Total tree biomass, TB (kg)	640.34 ± 41.03	467.46 ± 36.97	1626.37 ± 78.50
Dry weight (kg) (80% of TB)	512.27 ± 32.83	373.97 ± 29.58	1300.10± 62.80
Carbon (kg) (40 % of DW)	204.91 ± 13.13	149.60 ± 11.83	520.44 ± 25.12

Soil organic carbon content and stock

The soil organic carbon (SOC) content of different soil size fractions in five year old orchard showed significant difference throughout the soil profile (Table 32). Significantly the highest S_1 size soil fraction 0.47% was recorded in mango orchard. The SOC content of S_1 gradually decreased with the

Table 30. Different aggregation indices as affected by tillage and residue management in 0-10 cm soil layer

Treatment	WSA (%)	MWD (mm)	GMD (mm)	Macro Agg (%)	Micro Agg (%)	Agg. Stability	Agg. ratio
T_1 (RW-CT)#	37.7 (38.0)	1.5 (1.6)	0.4 (0.4)	37.7 (38.0)	22.3 (25.3)	0.4 (0.4)	1.7 (1.6)
T_2 (RL-CT)	46.8 (36.2)	1.8 (1.2)	0.5 (0.3)	46.8 (36.2)	20.6 (27.9)	0.5 (0.4)	2.5 (1.3)
T_3 (RM-CT)	39.0 (36.0)	1.6 (1.0)	0.4 (0.3)	39.0 (36.0)	20.6 (20.7)	0.4 (0.4)	1.9 (1.9)
T_4 (RW-RT)	49.1 (35.1)	2.0 (1.3)	0.6 (0.4)	49.1 (35.1)	24.4 (33.6)	0.5 (0.4)	2.1 (1.0)
T_5 (RW-RTR30%)	58.3 (41.7)	2.6 (1.8)	0.8 0.5()	58.3 (41.7)	22.5 33.9()	0.6 (0.4)	2.6 (1.3)
T_6 (RL-RT)	55.6 (38.2)	2.3 (1.3)	0.8 (0.4)	55.6 (38.2)	27.5 (30.7)	0.6 (0.4)	2.1 (1.3)
T_7 (RL-RTR30%)	64.6 (42.3)	2.8 (1.6)	1.1 (0.5)	64.6 (42.3)	25.1 (35.2)	0.6 (0.4)	2.6 (1.2)
T_8 (RM-RT)	50.6 (34.9)	2.1 (1.4)	0.6 (0.5)	50.6 (34.9)	18.6 (20.3)	0.5 (0.3)	2.9 (1.7)
T_9 (RM –RTR30%)	60.8 (39.0)	2.6 (1.5)	0.9 (0.4)	60.8 (39.0)	21.3 (27.3)	0.6 (0.4)	2.9 (1.4)
Mean	51.4 (37.9)	2.1 (1.4)	0.7 (0.4)	51.4 (37.9)	22.5 (28.3)	0.5 (0.4)	2.4 (1.4)

Figure in parenthesis represent the value for 10-20 cm soil layer

[#RW=Rice-Wheat, RL=Rice-Lentil, RM=Rice-Maize, RT=Reduced tillage, RTR 30%=Reduced tillage with 30% residue retention.]

Table 32. Soil organic carbon content of different size fractions in different orchards of 5 year old.

Type of orchard	Soil organic carbon (g/100g soil)			
	Depth of soil profile (cm)			
	0-15	15-30	30-45	45-60
S_1= 2000-200µ				
Control	0.312^{b}	0.242^{b}	0.208^{b}	0.163^{b}
Litchi orchard	0.417^{ab}	0.338^{ab}	0.341^{a}	0.268^{a}
Guava orchard	0.404^{ab}	0.353^{a}	0.351^{a}	0.333^{a}
Mango orchard	0.477^{a}	0.400^{a}	0.370^{a}	0.337^{a}
S_2= 200-53µ				
Control	0.158^{a}	0.140^{a}	0.131^{a}	0.120^{a}
Litchi orchard	0.164^{a}	0.113^{b}	0.078^{c}	0.053^{b}
Guava orchard	0.150^{a}	0.119^{b}	0.089^{c}	0.062^{b}
Mango orchard	0.170^{a}	0.149^{a}	0.109^{b}	0.050^{b}
S_3≤ 53µ				
Control	0.046^{a}	0.030^{a}	0.026^{a}	0.020^{a}
Litchi orchard	0.051^{a}	0.030^{a}	0.027^{a}	0.023^{a}
Guava orchard	0.040^{a}	0.038^{a}	0.036^{a}	0.027^{a}
Mango orchard	0.052^{a}	0.040^{a}	0.036^{a}	0.022^{a}
Total (≤ 2000µ)				
Control	0.516^{b}	0.412^{b}	0.365^{b}	0.303^{b}
Litchi orchard	0.632^{a}	0.481^{b}	0.446^{ab}	0.344^{ab}
Guava orchard	0.594^{ab}	0.510^{ab}	0.476^{a}	0.422^{a}
Mango orchard	0.699^{a}	0.589^{a}	0.515^{a}	0.409^{a}

increased profile depth. This clearly depicted that the organic carbon was well distributed throughout the soil profile depth of 60 cm in guava orchard followed by mango and litchi.

The SOC content of S_2 fraction was the highest (0.17%) in mango orchard in the surface soil. There was gradual decrease in SOC content of S_2 fraction in control than the orchards throughout the soil profile. The highest SOC content of S_3 fraction was 0.052% in mango orchard and was statistically at par with other orchards in the surface soil. The total SOC content by all the soil size fraction (≤2000µ) was significantly highest of 0.70% in mango orchard over control in the surface soil. Further, the SOC content registered 41.3, 45.5, 28.9 and 41.5% decrease at 45-60 cm depth over 0-15 cm depth in control, litchi, guava and mango orchard, respectively.

The bulk density of different orchard gradually increased with increasing profile depth. The bulk density in the surface soil varied from 1.52 to 1.57 Mg M^{-3} with least in mango orchard and the highest in the control (Table 33). The mango orchard recorded the highest SOC stock of 16 t/ha. The SOC stock gradually decreased with increased profile depth and registered 39.4, 28.5, 26.0 and 38 % decrease at 45-60 cm depth over 0-15 cm in control, litchi, guava and mango orchard, respectively.

Table 33. Soil organic carbon stock in the soil profile of five year old orchard

Type of orchard	Soil profile depth (cm)			
	0-15	15-30	30-45	45-60
Bulk densities (Mg M^{-3})				
Control	1.57^{a}	1.59^{a}	1.59^{a}	1.62^{a}
Litchi orchard	1.53^{a}	1.56^{a}	1.59^{a}	1.62^{a}
Guava orchard	1.55^{a}	1.57^{a}	1.60^{a}	1.61^{a}
Mango orchard	1.52^{a}	1.54^{a}	1.58^{a}	1.62^{a}
SOC stock (t/ha)				
Control	12.19^{b}	9.85^{b}	8.71^{b}	7.39^{b}
Litchi orchard	14.53^{ab}	11.26^{ab}	10.59^{ab}	8.39^{ab}
Guava orchard	13.80^{ab}	12.00^{ab}	11.41^{a}	10.21^{a}
Mango orchard	16.00^{a}	13.62^{a}	12.21^{a}	9.91^{a}

At Ranchi, the total organic carbon content under the five 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 litchi (0.60%) followed by mango (0.57%) and guava orchard (0.57 %) (Table 34). Among the different size fractions, OC was the highest in the 2000-200 µ size in all the orchards. The OC gradually decreased with increasing depth of soil. The carbon stock was highest in litchi orchard (10.87 t/ha) followed by guava (10.52 t/ha) and mango orchard (10.36 t/ha) after rainy season.

Table 34. Soil organic carbon content of different size fractions in different orchards (5 year old) after rainy season at Ranchi station

Soil Depth (cm)	Soil organic carbon (g/100g soil)			
	Particle size fraction			
	S1 (2000-200µ)	S2 (200-53µ)	S3 (≤53µ)	Total
Control (No orchard)				
0-15	0.311 ± 0.062	0.175 ± 0.032	0.050 ± 0.011	0.536
15-30	0.257 ± 0.054	0.172 ± 0.024	0.025 ± 0.008	0.454
30-45	0.225 ± 0.031	0.131 ± 0.018	0.025 ± 0.007	0.381
45-60	0.185 ± 0.036	0.120 ± 0.020	0.034 ± 0.006	0.339
Litchi orchard				
0-15	0.331 ± 0.053	0.234 ± 0.018	0.029 ± 0.010	0.594
15-30	0.287 ± 0.052	0.182 ± 0.011	0.017 ± 0.003	0.486
30-45	0.229 ± 0.025	0.126 ± 0.014	0.027 ± 0.006	0.382
45-60	0.200 ± 0.037	0.106 ± 0.019	0.011 ± 0.002	0.317
Guava orchard				
0-15	0.310 ± 0.034	0.232 ± 0.018	0.033 ± 0.006	0.575
15-30	0.293 ± 0.049	0.172 ± 0.022	0.027 ± 0.003	0.492
30-45	0.250 ± 0.045	0.129 ± 0.016	0.016 ± 0.002	0.395
45-60	0.162 ± 0.060	0.101 ± 0.027	0.013 ± 0.003	0.276
Mango orchard				
0-15	0.305 ± 0.023	0.225 ± 0.020	0.041 ± 0.007	0.571
15-30	0.277 ± 0.020	0.135 ± 0.020	0.037 ± 0.007	0.449
30-45	0.255 ± 0.045	0.119 ± 0.022	0.018 ± 0.003	0.392
45-60	0.145 ± 0.034	0.078 ± 0.009	0.015 ± 0.003	0.238

Microbial activities and biomass in the soils of different production systems

Culturable fungal and bacterial colonies varied in the annual (cereal) production system. Maximum culturable fungal colony forming units were recorded in the month of November (9.37 x 10^4/g soil) followed by December, January (Fig. 49). Moreover, in culturable bacterial colony forming units also observed maximum in the month of December, 13 followed by November, 13 and March, 14. (Fig. 50). However, the perennial production system indicated that maximum colony forming units were recorded in the month of January, 2014 in the soil near the guava plants (Fig. 51). In culturable bacterial colony forming unit in perennial production system, maximum cfu were observed in the month of November in the soil of guava plants (Fig. 52).

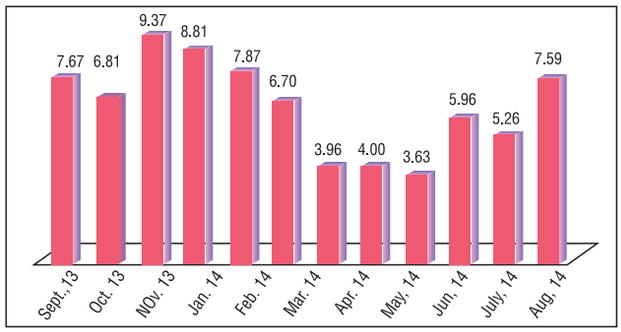


Fig. 49. Culturable fungal colony forming unit cfu X 10^4/ gram soil in the different months of September, 2013- August, 2014

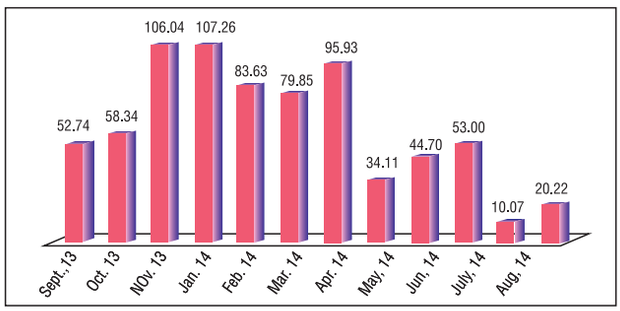


Fig. 50. Bacterial colony forming unit cfu x 10^7/gram soil in the different months of September, 2013- August, 2014

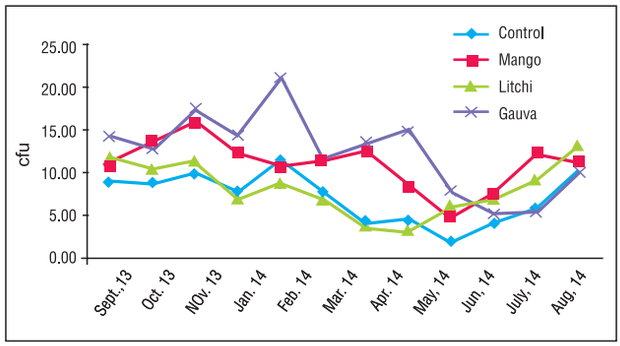


Fig. 51. Culturable fungal colony forming unit (cfu) x 10^4/ gram soil in the different perennial crops

Assessment of Leaf Decomposition Pattern of Different Orchard

The leaf decomposition pattern of different orchard was studied through litter bag technique (Fig. 53). Nylon netting bags measuring 24cm x 37 cm with 1 mm mesh size were used.

Litter decomposition expressed as loss of dry matter (DM) at the end of each month showed

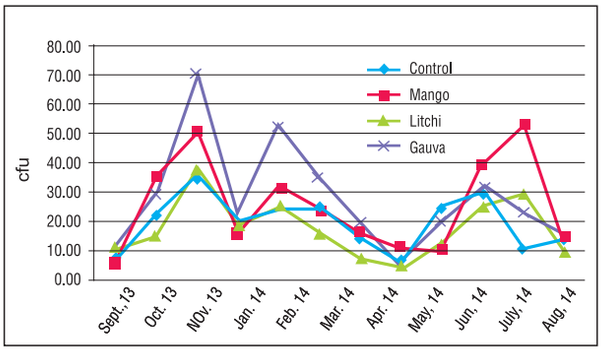


Fig. 52. Culturable bacterial colony forming unit (cfu) x 10^4/gram soil in the different perennial crops

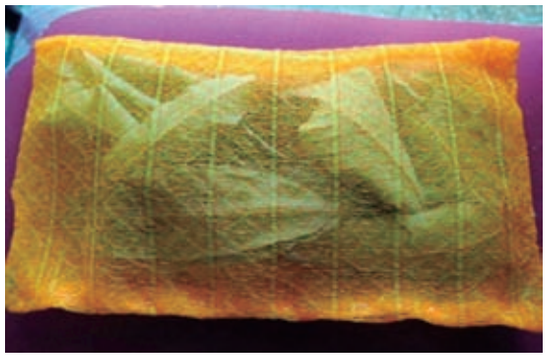


Fig. 53. Preparation of litter bag and placement under the tree canopy

that mango leaf litter completely disappeared in 10 months (Fig. 54) whereas guava leaf disappeared in 12 months (Fig. 55) and litchi leaf decomposed only by 35 % in 12 months period (Fig. 56). In surface placement of mango leaf, only 40 per cent of the DM was lost during the first 5 months (January-May) and the remaining 60 per cent, in the last 5 months (June-October). However, only 15% of guava leaf decomposed in first 5 months (January-May) and the remaining 85 per cent, in the last 7 months (June-December).

Nutrient dynamics in leaf litter decay

Analysis of elemental composition of decomposing litter of mango, litchi and guava revealed an initial rapid loss of N for the first five months, followed by an increase in the concentration in subsequent months (Fig. 57). The initial decline might

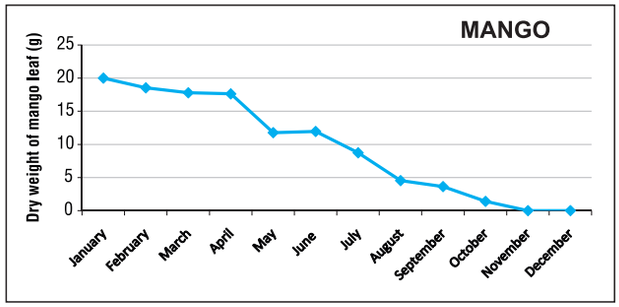


Fig. 54. Litter decomposition expressed as loss of dry matter in mango leaf

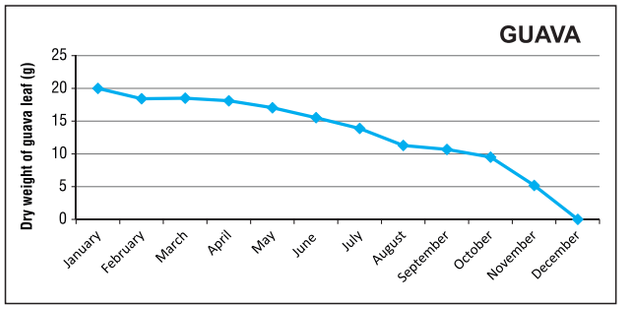


Fig. 55. Litter decomposition expressed as loss of dry matter in guava leaf

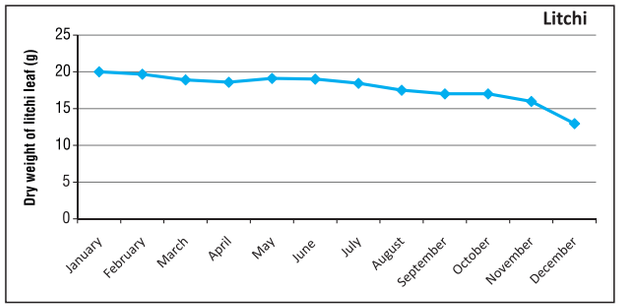


Fig. 56. Litter decomposition expressed as loss of dry matter in litchi leaf

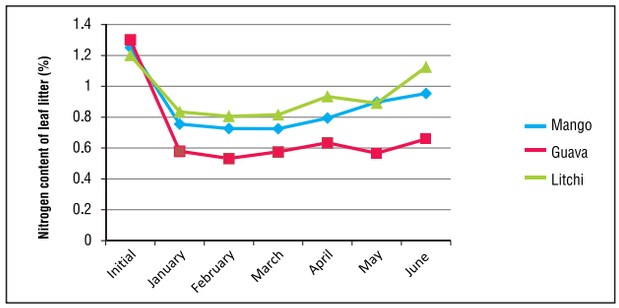


Fig. 57. Concentrations of nitrogen in leaf litter retrieved at monthly intervals on decomposition

be due to the leaching of soluble forms of nitrogen. Second phase of increase may be attributed to immobilization of N by microbial population infesting the litter. After 6 months of decay about 76, 50 and 93 % of initial N content was remaining in mango, guava and litchi leaf litters, respectively.

The phosphorus content in all the leaf litters decreased for the 1st month of decomposition followed by an increase in 2nd month and thereafter P-concentration gradually decreased in subsequent months (Fig. 58). After 5 months of decay about 26, 21 and 23 % of initial P content was remaining in mango, guava and litchi leaf litters, respectively.

The initial potassium content of all the leaf litter decreased in 1st month of decomposition followed by an increase in 2nd and 3rd month and thereafter K-concentration gradually decreased in subsequent months (Fig. 59). After 5 months of

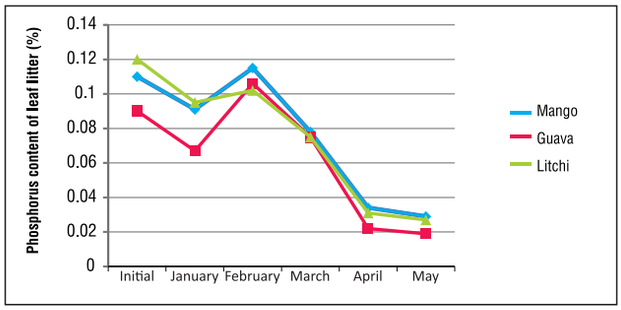


Fig. 58. Concentrations of phosphorus in leaf litter retrieved at monthly intervals on decomposition

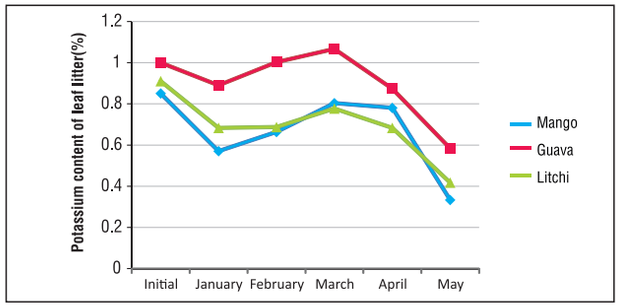


Fig. 59. Concentrations of potassium in leaf litter retrieved at monthly intervals on decomposition

decay about 39, 58 and 46% of initial K content was remaining in mango, guava and litchi leaf litters, respectively.

Nutrient Dynamics in Makhana and Makhana-based Cropping Systems Grown in Inceptisols of Northern Bihar

Soil fertility status under different 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-berseem cropping system appreciably increased the nutrient status of soil over other makhana-based cropping systems. Soil organic carbon also increased in makhana-chestnut-berseem cropping system. The highest amount of available nitrogen (305 kg/ha) and phosphorus (30 kg/ha) was also recorded with makhana-chestnut-berseem cropping system followed by makhana-berseem cropping system (Table 35). Makhana-chestnut cropping system recorded the highest potassium content (240 kg/ha) in soil. The lowest quantity of available nitrogen (206 kg/ha), phosphorus (15 kg/ha) and potassium (210 kg/ha) was recorded with makhana-rice-wheat, makhana-rice and makhana-rice-berseem cropping system, respectively.

The status of micronutrient content of soil due to makhana-based cropping systems

It was observed that soils under makhana-chestnut-berseem cropping system recorded highest content of iron (43 mg/kg) and manganese (15.15 mg/kg) while the lowest content of Fe (25 mg/kg) and Mn (8.13 mg/kg) was found with rice-wheat and makhana-rice-wheat cropping system, respectively. The soils under rice-wheat cropping system contained highest concentration of Zn (0.36 mg/kg) while the highest Cu content (1.82 mg/kg) was registered with makhana-rice-berseem cropping system (Table 36).

Table 36. The status of available micronutrient content of soil under different cropping system (Mean data)

Cropping systems	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Makhana–makhana	38	14.00	0.85	0.24
Makhana–wheat	28	11.00	0.87	0.26
Makhana–rice	34	14.50	0.80	0.13
Makhana–berseem	34	11.30	1.65	0.26
Makhana–chestnut	41	14.00	1.16	0.28
Makhana–rice–wheat	31	8.13	1.55	0.24
Makhana–rice–berseem	33	9.27	1.82	0.35
Makhana–chestnut–berseem	43	15.15	1.66	0.30
Makhana+ fish–rice + fish	38	13.45	1.68	0.20
Rice-wheat	25	12.00	1.66	0.36

Table 35. The physico-chemical properties of soil under different cropping system (Mean data)

Cropping systems	pH	EC (dS $^{m-1}$)	Org. C. (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)
Makhana-makhana	7.25	0.15	0.60	260	22	219
Makhana-wheat	7.50	0.16	0.71	269	18	214
Makhana-rice	6.50	0.20	0.65	210	15	220
Makhana-berseem	6.73	0.20	0.70	281	23	215
Makhana-chestnut	7.25	0.21	0.73	268	20	240
Makhana-rice-wheat	7.51	0.18	0.70	206	19	213
Rice-wheat	7.48	0.24	0.48	248	20	215
Makhana-rice-berseem	7.20	0.18	0.72	238	18	210
Makhana-chestnut-berseem	7.43	0.25	0.80	305	30	235
Makhana+Fish-rice+fish	6.77	0.26	0.65	221	16	210

12 Conservation Agriculture

Productivity, Resource Use Efficiency and Soil Properties in Long-term Rice-based Cropping Systems

Long-term field experiments were initiated in 2009 under Cereal Systems Initiative for South Asia (CSISA) in four scenario (Table 37). Results revealed that grain yield of wheat (5.1 t/ha), rice (7.5 t/ha), and system productivity in terms of rice equivalent yield (19.1 t/ha) increased significantly in complete CA- based (zero-till) rice-wheat-mungbean system (S_3) over conventional rice-wheat system (4.1, 6.0 and 10.4 t/ha, respectively). However, CA-based rice–mustard–maize system (S_4) required less irrigation water as compared to other systems (Table 38). Complete CA based cropping system (S_3) also improved the soil hydraulic conductivity (Table 39), soil aggregation parameters and aggregate associated organic carbon (Table 40).

Table 37. Long-term effect of different cropping systems on productivity (t/ha)

Scenario	*Rabi* (wheat)	Summer/ spring (mung-bean)	*Kharif* (rice)	System productivity (Rice equiv.)
S_1 : Conventional rice-wheat system	4.1b	0	6.0	10.4
S_2: Rice-wheat-mung-bean (partial CA)	4.4b	1.5	6.6	16.6
S_3: Rice-wheat-mung bean (CA-based)	5.1b	2.0	7.5	19.8
S_4: Rice-mustard-maize (CA based)	4.2a*	1.9**	6.2	17.2

*Wheat equivalent mustard yield; **Mungbean equivalent maize fodder yield

Rice-legumes cropping system

In rice-legume cropping system under rainfed upland situation in *kharif* season, the upland rice (Anjali) and legumes like soybean (Swarna Vasundhara), groundnut (Birsa Bold), black gram (Uttara), green gram (CN 9-5), cowpea (line EC 452), rice bean (line HARB-1) and horse gram (GKP-7C) were grown both as sole crops (each of 12 rows) and in combination of (6 row rice + 6 row of each legume). The sole crop of groundnut recorded the maximum Rice Equivalent Yield (REY) of 9.46 t/ha followed by that of soybean 9.15 t/ha. Among vari-

Table 38. Irrigation water used under different cropping systems

Scenario	Irrigation water used (mm/ha)			
	Rabi	Summer	*Kharif*	System
S_1	275a	0d	1406a	1681a
S_2	223b	149b	1257b	1629ab
S_3	176c	134c	1387ab	1697a
S_4	144d	345a	1043c	1532b

[1]Within column, means followed by same letter are not statistically different at 5% level of significance

Table 39. Hydraulic conductivity of soil (after 5 years) as influenced by cropping systems

Scenario	Soil layer (cm)		
	0 - 10	10 - 20	20 - 30
S_1	1.14	1.52	3.75
S_2	1.96	1.80	4.06
S_3	2.46	4.93	3.99
S_4	2.56	2.14	3.94

Table 40. Aggregate associated carbon as influenced by long-term CA practices in rice-based cropping systems

Scenario	8-2 mm	2-0.25 mm	0.25–0.053 mm	<0.053 mm	average
	0-10 cm depth				
S_1	0.69	0.57	0.49	0.39	0.53
S_2	0.90	0.74	0.67	0.42	0.68
S_3	0.94	0.71	0.63	0.70	0.75
S_4	0.74	0.71	0.80	0.89	0.78
	10-20 cm depth				
S_1	0.77	0.53	0.48	0.42	0.55
S_2	0.71	0.47	0.50	0.42	0.53
S_3	0.81	0.42	0.46	0.36	0.51
S_4	0.55	0.46	0.44	0.46	0.48

ous combinations, 6 row rice + 6 row groundnut resulted into REY of (7.18 t/ha) followed by 6 row rice + 6 row rice bean (6.43 t/ha) (Table 41).

Table 41. Rice equivalent yield in rice-legume cropping system

Treatments	Rice equivalent yield (t/ha)
T_1 (12 row rice)	3.67
T_2 (12 row blackgram)	6.17
T_3 (12 row greengram)	4.24
T_4 (12 row soybean)	9.15
T_5 (12 row cowpea)	4.72
T_6 (12 row rice bean)	8.65
T_7 (12 row horsegram)	3.75
T_8 (12 row groundnut)	9.46
T_9 (6 row rice + 6 row blackgram)	4.75
T_{10} (6 row rice + 6 row greengram)	3.81
T_{11} (6 row rice + 6 row soybean)	6.02
T_{12} (6 row rice + 6 row cowpea)	3.24
T_{13} (6 row rice + 6 row rice bean)	6.43
T_{14} (6 row rice + 6 row horsegram)	4.09
T_{15} (6 row rice + 6 row groundnut)	7.18

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

Three planting methods *viz.* flat bed, broad bed and ridge and furrow; and two mulch systems *viz.* plastic mulch and no mulch, based on drip irrigation were evaluated in cauliflower-brinjal-tomato cropping system in acid soils of eastern hill and plateau region. The 75 % of recommended manures and fertilizers were applied as basal in first crop and 50% in subsequent 2nd & 3rd crops through fertigation. The minimum tillage was practiced in mulched treatment by uprooting of crop and planting seedlings of subsequent crop directly. Results revealed that different methods of planting and mulching did not influence the growth attributes of vegetable crops. However, the weed biomass, yield attributes, water use efficiency and water productivity was significantly affected by different treatments.

In cauliflower, curd yield/plant was significantly affected by the planting methods and mulching. Flat bed planting with mulch recorded the highest curd yield/plant (1.03 kg) and was at par with ridge and furrow planting method with mulch (0.92 kg).The planting methods and mulch showed significant effect on cauliflower curd yield and the highest yield/plot (63.56 kg) was recorded in ridge & furrow method. The mulched treatment showed higher yield, irrespective of planting methods.

The ridge and furrow method also resulted in the highest water use efficiency (12.25 kg/m^3) and water productivity (122.61 ₹/m^3). On average the water requirement was recorded to be 81.0-83.0 litres for producing one kg of couliflower.

Nutrient use efficiency in different resource conservation technologies for vegetable cultivation

The mulched treatment showed better nutrient use efficiency of nitrogen, phosphorus and potassium in cauliflower and brinjal. In cauliflower, the highest nitrogen use efficiency (39.86%) was recorded in broad bed with mulch, followed by ridge furrow method, In brinjal, broad bed with mulch showed the highest N-use efficiency followed by broad bed without mulch. The highest phosphorus use efficiency in cauliflower was recorded in flat bed with mulch (15.21%) followed by broad bed without mulch (12.17 %). In brinjal, the highest P- use efficiency (15.95 %) was recorded in R&F (ridge & furrow with mulch), followed by ridge & furrow without mulch.The highest potassium use efficiency in cauliflower was recorded in flat bed with mulch (21.27 %). In brinjal, the highest P- use efficiency (21.41 %) was recorded in (flat bed with mulch) followed by R&F (21.18 %)

Standardization of Basin Enrichment in High Density Orchards of Bael, Sapota and Guava

The trial is being conducted to standardize basin enrichment in high density orchards of bael, sapota and guava under rainfed conditions of eastern plateau and hill region. Four biomass yielding crops *viz.* vegetable soybean (*Glycine max*), ricebean (*Vigna umbellata*),Tephrosia (*Tephrosia candida*) and subabul (*Leucaena leucocephala*) were grown in the alley areas of the newly planted high density orchards as biomass enriching plants (Fig. 60). In the control plot no crop was grown in the alley area. During the first year of experimentation, significant differences in biomass yield of the alley crops were recorded. The highest biomass was obtained in Tephrosia (Table 42). In the control plot, the total biomass of weeds was found to be 11.09 ± 1.99 t/ha which was significantly higher than that of vegetable soybean. The highest nitrogen and

Tephrosia Rice bean Vegetable soyabean

Fig. 60. Growth of different biomass yielding crops in alley areas of high density bael orchard

phosphorus content in the biomass was recored in case of Tephrosia. The highest potassium content was found in rice bean (Table 43). Among the different crops, pod yield of 21.28 t/ha and 7.40 t/ha was obtained in vegetable soybean and ricebean, respectively. The establishment rate and plant growth of Subabul was not satisfactory during the first year. The treatments on basin enrichment through mulching and soil incorporation of harvested biomass have been imposed in the basin of the fruit crops.

Table 42. Biomass production (t/ha) of different crops

Treatment	Leaf biomass	Stem biomass	Total biomass
Vegetable soybean	2.18 ± 0.68	5.08 ± 1.58	7.2 6± 2.26
Ricebean	3.63 ± 0.27	15.87 ± 1.68	19.50 ± 1.95
Taphrosia	9.08 ± 0.85	13.62 ± 1.27	22.7 ± 2.12
Control (weeds)	11.09 ± 1.99		

Table 43. Average N, P and K cocentration (%) in different biomass yielding crops

Treatment	Leaves			Stem		
	N	P	K	N	P	K
Vegetable Soybean	2.13	0.12	0.91	1.21	0.21	0.75
Rice bean	1.63	0.11	1.13	1.31	0.08	1.11
Taphrosia	2.24	0.12	0.95	1.87	0.11	1.02
Control plot (weeds)	2.17	0.22	0.98	2.04	0.20	0.83

Studies on Decomposition Rate of Different Substrates and their Nutrient Release Pattern

Experiments were conducted to study the decomposition rate of different organic substrates and their nutrient release pattern. The organic substrates used were paddy and maize straw, and paddy roots. The decomposition rate was studied using litter bag technique. Decomposition for paddy and maize straw was examined by keeping litter bags above soil surface, whereas for paddy roots, litter bags were placed 10-15 cm deep, below soil surface. The initial nutrient status of paddy and maize straw, and paddy roots is given in Table 44.

Table 44. NPK in paddy & maize straw and paddy root

Substrates sused	N%	P%	K%
Paddy straw	0.57	0.19	1.13
Maize straw	0.67	0.30	0.51
Paddy roots stra	0.41	0.05	0.86

The decomposition rate of paddy straw from 1st month to 5th month was 19, 27, 31, 34 and 40 %, respectively while maize straw was 28, 34, 39, 45 and 56 %. The decomposition rate of paddy roots in 1st month was upto 18% while in second month it was 30% (Fig. 61).

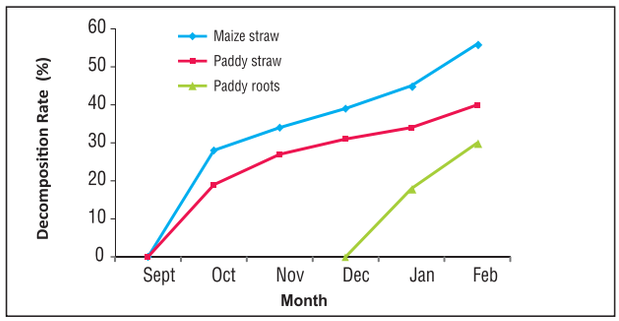


Fig. 61. Month wise decomposition rate of different substrates

13 Livestock and Fisheries

LIVESTOCK

Characterization of Lesser Known Breeds of Farm Animals in Eastern India

Diara buffalo

A field study was undertaken in 47 villages of Barh, Athamalgola, Belchhi, Pandarak and Mokama blocks of Patna district to investigate the production and reproduction traits of Diara buffaloes, and the socio-economic status of farmers' rearing Diara buffaloes. The study on morphometric and body weight traits of Diara buffaloes indicated that these buffaloes were medium-sized animals with prominent forehead and loosely curved horns. They were smaller than the heavy-sized breeds like Murrah, Jaffarabadi and Nili-Ravi (Fig. 62-63). The height, length and girth of female Diara buffaloes were 94.96 ± 0.58 cm, 92.96 ± 0.49 cm and 115.93 ± 0.81 cm up to 1 year of age and 133.60 ± 0.69 cm, 138.36 ± 0.74 cm and 200.79 ± 0.95 cm above 7 years of age group, respectively. Estimated adult body weights of Diara buffaloes pooled over ages were found to be 494.99 ± 27.15 kg in males and 483.21 ± 3.58 kg in females. Diara buffaloes were good milkers with an average daily milk production of 7.8 litre (peak yield up to 10.5 litre). Diara population remains so far largely untouched and breed improvement programmes, probably involving selective breeding, needs to be undertaken to further enhance the genetic potential of these buffaloes.

Fig. 62. Diara bull

Fig. 63. Female Diara buffalo

Buffalo Improvement

The total herd strength of Murrah buffaloes under various age groups is given in Table 45. The test semen doses from Central Institute for Research on Buffaloes, Hisar, Haryana are being utilized to artificially inseminate the buffaloes, maintained in the institute farm (Fig. 64) as well as in the farmers' field.

Table 45. Herd strength of buffaloes at Livestock Farm

Age groups of buffaloes	Number
Total number of buffaloes	37
Female buffalo calves < 1 year old	3
Male buffalo calves < 1 year old	1
Female buffalo calves aged between 1 and 3 years	10
Male buffalo calves aged between 1 and 3 years	3
Female buffalo > 3 years old	20

Data on different parameters is given below:

S.No.	Parameters	Value
1	Lactation yield (kg)	1875.23 ± 0.78
2	Lactation length (days)	381.4 ± 0.66
3	Fat (per cent)	7.14
4	Wet average (kg)	5.5
5	Herd average (kg)	4.3
6	Calving interval (days)	465.07 ± 1.89
7.	Service period (days)	163.55 ± 1.45
8.	Dry period (days)	84.17 ± 0.59

Fig. 64. Buffaloes in paddock

Buffaloes with silent estrum are regularly detected with the help of teaser bull. Anoestrous buffaloes were treated with hormone as per schedule (Table 46) that mimics the normal oestrous cycle of the animals.

Table 46. Hormone schedule for inducing anoestrous buffaloes

Day	Time	Activity
0	Evening 4 to 5 pm	GnRH analogue 2.5 ml
8	Evening 4 to 5 pm	Dinoprost 5 ml
10	Evening 4 to 5 pm	GnRH analogue 2.5 ml
11	Morning 8 to 9 am	Artificial insemination

In order to rejuvenate the physiological parameters of buffaloes, they were allowed inside the wallowing tank from 09.00 am to 03.00 pm (Fig. 65). No mortality was observed in buffalo farm during 2014-15.

Fig. 65. Buffaloes in wallowing tank

Characterization of Red Purnea Cattle

Apart from 37 registered indigenous breeds of cattle in the country, there are few more cattle populations in certain regions, which confines to particular characteristics and are inhabited in a particular area. Red Purnia, which possesses distinct features, and distributed in Araria, Purnea, Katihar, and Kishanganj districts of Bihar is one of them. In order to study the basic information on its morphometric characteristics, production and reproduction performance in its breeding tract, the network project on Animal Genetic Resources was initiated at Patna by NBAGR, Karnal. The study was conducted in 4 blocks each from Araria, Purnea and Katihar districts.

The study revealed that Red Purnea cattle (Fig. 66) is small in size and reared mostly for the milk purpose. The pooled body biometry including its height at withers, body length, chest girth, ear length, horn length and tail length were found to be 110.25 ± 0.31 cm, 105.11 ± 0.32 cm, 145.74 ± 0.25 cm, 21.14 ± 0.19 cm, 15.18 ± 0.38 cm and 65.10 ± 0.28 cm, respectively. The study further brought to light that the farmers do not generally find any reproductive problems with Red Purnea cattle as their age at 1st estrum, age at 1st calving, calving interval and number of services per conception were observed to be 32.15 ± 1.23 months, 41.18 ± 1.27 months, 14.22 ± 0.48 months, 1.08 ± 0.15, respectively.

Fig. 66. Red Purnea cattle

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

Performance of heifer calves fed different levels of concentrate feed in total mixed ration

Feeding experiment for the period of 213 days was conducted in crossbred heifers to study the effect of different levels of concentrate feed in total mixed ration (TMR) on their growth performance and nutrient digestibility. A total six crossbred heifers were selected from dairy herd for the study and distributed into two groups (Fig. 67). The heifers of group T1 were offered concentrate feed @ 1% of body weight whereas, heifers of group T2 were provided concentrate feed @ 1.5% of body weight. The roughages were provided in *ad-libitum* to each animal by mixing wheat straw 40% and available green forage (Sudan in summer and rainy and Berseem in winter season) @ 60% on DM basis and fed to animals after mixing with concentrate feed and water. Digestibility trial was also conducted to study the nutrient digestibility when berseem forage was provided in total mixed ration.

Fig. 67. Feeding trial in heifers

The feeding of concentrate feed @ 1.5 per cent of body weight significantly (P<0.05) improved the dry matter intake (DMI), average daily gain (ADG) and digestible crude protein (DCP) values of TMR than heifers fed concentrate feed @ 1% of body weight (Table 47). However, digestibility of dry matter, crude protein and feeding cost per kg body weight gain were not affected. Thus, it is concluded that feeding of concentrate feed @ 1.5% of body weight in TMR is beneficial and economical for higher growth rate.

Table 47. Performance of heifers fed different levels of concentrate feed

Particulars	Treatment Means ± SE	
	T1	T2
Initial body weight (kg)	138 ± 24.58	154 ± 31.02
Final body weight (kg)	236 ± 35.41	280 ± 34.40
ADG (g/d)	458 ± 50.97	588 ± 45.89
DMI (kg/100kg body weight)	2.32 ± 0.13	2.55 ± 0.12
Intake of concentrate feed in TMR (%)	33.09 ± 1.13	49.43 ± 0.92
Feeding cost (₹ per kg body weight gain)	114.89 ± 13.46	129.23 ± 17.56
DMD (%)	62.44 ± 1.83	65.73 ± 3.76
CPD (%)	68.98 ± 2.46	72.01 ± 1.92
DCP of TMR (%)	12.35 ± 0.45	13.37 ± 0.35

Means bearing different superscripts vary significantly at 5% level.

Productivity of various fodder crops

Different cultivars of promising fodders *viz.* Oat (var. Kent and JHO-822), Maize (var. Hybrid), Annual Rye (*Lolium multiflorum*), multicut wheat (var. VL-829), Berseem (var. Hybrid and Wardan) and Aankathi (*Vicia hirsuta*) were grown during *Rabi* season and Multi cut Sudan (var. MP Chari) during *Kharif* season to study the productivity and nutritive value of forages (Fig. 68).

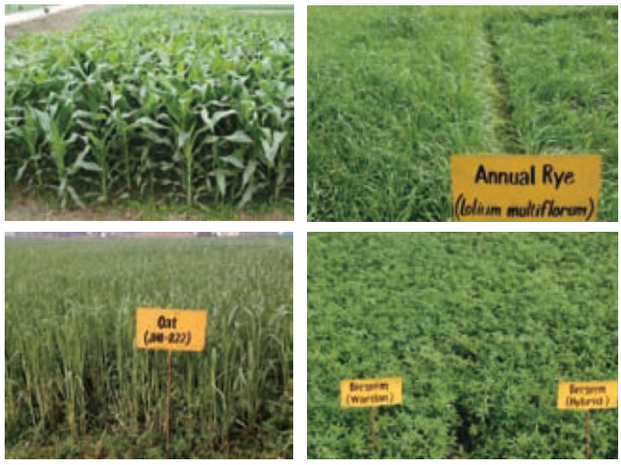


Fig. 68. Promising *rabi* forage crops

The forage productivity along with dry matter (DM) and crude protein (CP) contents of different forage crops are given in Table 48. There were no significant differences in fodder and protein yields in different varieties of oat and berseem. However, maximum cumulative forage and protein yields were recorded in annual Rye grass.

Dual purpose wheat (VL 829) was cultivated to study the fodder and grain yield. The wheat forage was harvested on 70th day after sowing at the base height of 10 cm. Irrigation was provided immediately after forage harvesting and urea

Table 48. Forage productivity with protein content

Fodder crops	Forage yield (t/ha)	DM (%)	Av. CP (g/100g DM	CP Yield (t/ha)
Multicut Sudan (2 cuts at 55, 115d)	96.00 ± 2.08	17.75	8.75	1.49
Berseem (4 cuts at 50, 80, 110, 140d)				
Hybrid	56.63 ± 0.21	12.36	19.27	1.35
Wardan	56.86 ± 0.64	12.51	19.31	1.35
Oat (2 cuts at 60,105d)	27.27 ± 0.92	16.05	11.00	0.48
Kent JHO-822	28.33 ± 0.55	14.77	11.49	0.48
Maize hybrid (at 100d)	58.67 ± 1.33	12.94	8.65	0.66
Annual Rye (4 cuts at 60,80, 100, 120d)	72.82 ± 1.38	13.85	17.12	1.71
Multicut Wheat (VL-829) at 70d	7.20 ± 0.23	15.28	17.46	0.19
Aankathi at 75d	10.33 ± 0.72	20.64	26.85	0.57

was broadcasted @60 kg/ha (Fig. 69). Similarly, multi-cut Sudan gave good forage yield during *kharif* season (96 t/ha). Thus, it is concluded that Berseem and/or Annual Rye grass may be the best option for fodder production during *rabi* season and multi cut Sudan during *kharif* considering the forage yield.

Fig. 69. Multi-cut wheat (var. VL-829) 70, 80, 90 days old crops (L to R)

Nutritive value of various forage crops

Digestibility trials were conducted in crossbred heifers (Fig. 70) to study the nutritive value of berseem, oat, wheat, annual rye, maize and sudan forage crops. The individual forage was provided as sole feed to heifers for 21 days as adaptation

Fig. 70. Digestibility trial in heifer

period and a digestibility trial was conducted for the period of four days. A set of another digestion trial was also conducted in buffalo calves using berseem and oat fodder to study the comparative nutritive values in cow and buffalo calves.

Significantly maximum dry matter intake (DMI) and crude protein digestibility (CPD) were recorded in heifers fed annual rye which was at par with wheat and berseem fodder (Table 49). However, maximum digestible crude protein (DCP) value was obtained in berseem fodder. The nutritive value of maize and sudan forage in terms of DMI, CPD and DCP was recorded the lowest and seems to be poor, hence supplementation of legume fodder is required for balance feeding.

The nutritive value of berseem and oat in cow and buffalo calves indicated that berseem forage had significantly ($P<0.01$) higher DMI, CPD and DCP values than oat forage. Similarly, the DMI, DMD, CPD and DCP intake values were significantly ($P < 0.01$) higher in cow calves than buffalo calves. It is concluded that nutritive value of berseem forage is better than the oat. The oat forage requires supplementation of legume forage to make balance nutrient contents. The forage intake and their nutrients digestibility are better in cattle calves than buffalo calves.

Table 49. Nutritive value of forage crops in cattle heifers

Forage crops	DMI (kg/100kg B. Wt.)	DMD (%)	CPD (%)	DCP (%)
Berseem (Wardan)	$2.71^{cd} \pm 0.09$	$78.36^{bc} \pm 1.77$	$74.01^{bc} \pm 1.19$	$14.29^{d} \pm 0.23$
Oat (JHO-822)	$2.43^{bc} \pm 0.05$	$84.61^{d} \pm 1.25$	$65.87^{b} \pm 1.91$	$7.57^{b} \pm 0.22$
Wheat (VL-829)	$2.61^{cd} \pm 0.03$	$77.99^{b} \pm 0.59$	$72.84^{bc} \pm 0.09$	$12.72^{c} \pm 0.01$
Annual Rye	$2.84^{d} \pm 0.11$	$84.31^{cd} \pm 1.55$	$77.27^{c} \pm 2.25$	$13.23^{c} \pm 0.38$
Maize Hybrid	$2.13^{ab} \pm 0.05$	$66.60^{a} \pm 2.13$	$46.07^{a} \pm 3.68$	$3.99^{a} \pm 0.32$
Multicut Sudan	$2.09^{a} \pm 0.07$	$65.47^{a} \pm 0.51$	$43.83^{a} \pm 0.89$	$3.84^{a} \pm 0.08$

Mean with different superscript under each column differ significantly

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

Preparation of mineral mixture specific for Bihar

The deficiency of zinc, phosphorus, molybdenum and sulphur was detected during examination of soil, feeds & fodder and animal blood samples collected randomly from 14 districts in four agro-climatic zones of Bihar. A specific region based mineral mixture was prepared for Bihar. It was named as "**Swarna Min"** (Fig. 71) for marketing. The chemical composition of the mineral is depicted below:

S.No.	Contents	Value
1.	Calcium	25.46 %
2.	Phosphorus	13.20 %
3.	Iron	0.16 %
4.	Copper	0.12 %
5.	Manganese	0.16 %
6.	Zinc	0.99 %
7.	Cobalt	0.02 %
8.	Iodine	0.04 %
9.	Sulfur	1.04 %

Fig. 71. Swarna meal - an area specific mineral mixture

Multiplication and Production Profiling of Improved Poultry and Pig Germplasm under Backyard Farming System

Poultry

The mean body weights of both male & female of Gramapriya & Vanaraja varieties of backyard poultry are presented in Table 50. Body weight is the direct reflection of growth and it influences the production and reproduction traits of birds. The body weights at different ages (upto 8 weeks of age) were observed significantly higher in Vanaraja variety of birds as compared to Gramapriya, which might be due to exotic broiler inheritance in Vanaraja (Fig. 72). The hatchability percentage in Vanaraja and Gramapriya on total egg set basis were found to be 70.75 and 70.00%, respectively, and on fertile egg set basis were 86.14 and 87.50%, respectively.

Table 50. Body weight of Vanaraja and Gramapriya birds at different ages (g)

Age in weeks	Vanaraja		Gramapriya	
	Male	Female	Male	Female
Day old	37.25±0.80	36.50±1.40	34.57±0.75	32.00±0.62
1st wk	87.75±1.39	79.38±1.92	69.29±1.61	59.86±1.88
2nd wk	150.75±2.64	135.63±1.53	118.71±0.92	92.00±2.53
3rd wk	294.63±6.63	242.00±9.54	152.14±3.65	138.71±1.97
4th wk	466.75±15.69	390.75±6.92	294.29±6.75	246.14±9.37
5th wk	598.25±4.29	499.75±16.38	371.71±9.09	290.71±7.65
6th wk	675.50±16.09	608.00±6.80	405.43±9.07	335.00±7.63
7th wk	863.50±16.73	785.50±21.95	528.86±15.90	464.57±9.52
8th wk	1061.38±64.93	879.00±19.98	699.29±25.88	568.29±11.96

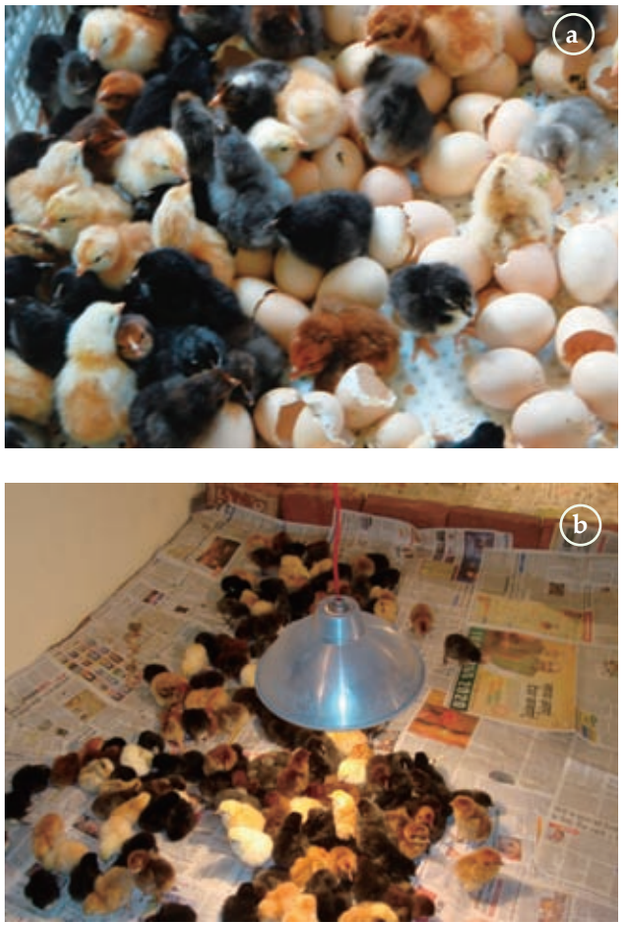


Fig 72. (a) Chicks being hatched out (b) chicks in brooder unit (below)

The mortality percentage was less in Vanaraja (3.5%) as compared to Gramapriya (5.7%) in Deep litter system of rearing.

Pig

A piggery unit was established at Research Centre, Ranchi comprising of 25 numbers of pigs of T & D breed (Fig. 73). The average birth weights of male and female were found to be 1.10 ± 0.08 and 1.07 ± 0.03 kg, respectively. Sex did not influence the birth weight significantly. T&D breeds had significantly ($P<0.05$) heavier birth weights than Desi pigs (0.64 ± 0.04). Average daily gains of male & female pig were found to be 0.65 ± 0.06 and 0.58 ± 0.05 kg, respectively up to 4 months of age.

Fig. 73. T & D breed of pigs at Research Centre, Ranchi

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

Growth performance of grower pigs fed on rice polish and kitchen waste with phytase enzyme

Feeding experiment for the period of 45 days was conducted in 2 groups of 4 crossbred (Hampshire x Desi) male grower pigs of 155 days old) (Fig. 74) having 50% exotic inheritance reared at the farm of Shree Satyendra Kumar Sharma, Khaijuri village of Naubatpur Block of Patna district. The objective of the study was to find the growth performance of crossbred piglets fed on rice polish and kitchen waste based feeding regime supplemented with phytase. The ration was prepared by the farmer after mixing of 20% rice polish in kitchen waste and designated as control (T_1). The phytase was supplemented in control diet @ 20g/100kg feed and designated as T_2. The rations were offered to the respective groups @ 2.5 kg/d/head on DM basis. The half the quantity was fed in forenoon and remaining half in afternoon. The pigs were weighed initially and at 45th day of experiment. The growth rate was calculated and presented in Table 51. The results revealed that the average growth rate was increased by 14.8 per cent in pigs fed on rice polish and kitchen waste based ration supplemented with phytase enzyme. Thus, it is concluded that phytase enzyme supplementation is beneficial for better growth rate even at farmer house who fed their pigs on kitchen waste and other available cereal by-products.

Fig. 74. Feeding of pig at farmer's house

Table 51. Growth rate of crossbred pigs at farmer's house

Particulars	Treatment means ± SE	
	T1	T2
Initial weight (kg)	38.90 ± 2.17	38.92 ± 2.04
Final weight (kg)	57.78 ± 3.45	60.57 ± 1.92
Average growth rate (g/d)	419 ± 29.71	481 ± 12.71

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

A 472 bp fragment (partial intron 2, exon 3 and intron 3 and partial exon 4) of growth hormone gene was amplified (100 samples) by polymerase chain reaction. Primer was designed on the basis of sequence available at NCBI. PCR program followed for amplification of gene fragment was initial denaturation at 95°C for 2 min then 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. Single Strand Conformation Polymorphism (SSCP) technique was used to identify different allelic patterns and genotypes of the animals included in the study at this locus. SSCP revealed that growth hormone

gene is polymorphic in nature and it had five genotypes AA, AB, AC, BB and CC and consequently, only three alleles A, B and C at this locus (Fig. 75). The frequencies of AA, AB, AC, BB and CC genotypes and A, B and C alleles were estimated as 0.12, 0.40, 0.36, 0.07 and 0.05; and 0.50, 0.27 and 0.23, respectively. AB genotype and A allele was predominant in Black Bengal goat.

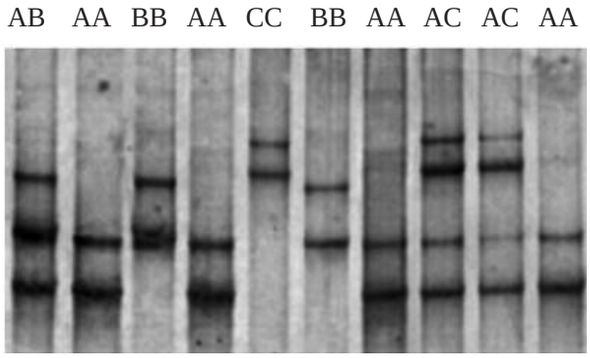


Fig. 75. SSCP typing of 472bp fragment

PCR products were run on 1% low melting agarose gel and the desired product was purified from the gel using gel elution kit. The purified PCR products were cloned by using TA cloning strategy in pGEMT easy vector. Cloned product was identified by blue white screening. Positive clones were sequenced by the automated dye-terminator cycle sequencing method. Sequence of all the alleles detected through sequencing is submitted to NCBI and accession numbers were obtained. Accession no. of various allelic variants were KJ666532 (A allele), KJ666533 (B allele) and KJ666534 (C allele) for 245 bp fragment and KJ782050 (A allele), KJ782051 (B allele) and KJ782052 (C allele) for 472 fragment. Alignment of allelic variants of 472 bp fragment revealed that there were differences at six positions i.e. 70th, 91st, 106th, 167th ,233rd and 240th among the alleles, out of which three, i.e., 70th, 233rd and 240th were found in intronic region where as three i.e 91st, 106th and 167th were found in exonic region. Mutation in exonic region lead to variation in polypeptide sequences of three alleles. Substitution at 91st position (C→T) and 167th position (G→C) leads to substitution of proline in to serine and glycine to alanine, respectively in B allele. Similarly, substitution at 106th position of nucleotide sequence (T→G) leads to substitution of tyrosine to aspartic acid in allele C.

Least squares analysis revealed that genotypes of 472 bp fragment had significant effect (P≤0.05) on body weight at both 6 and 9 months of age (Table 52) in Black Bengal goat. Animals having AC genotype had the highest body weight at both 6 and 9 months of age whereas animals having CC genotype had the lowest body weight at both 6 and 9 months of age. Animals having AC genotype had 65% more weight than the animals having CC genotype at both 6 and 9 months of age. The order of performance for body weight at 6 months of age was CC < AA, AB, BB < AC whereas the order of performance at 9 months of age was CC < BB < AA, AB < AC . One interesting finding in this study was that both the homozygote AA and CC were having the lowest body weight. However, heterozygous condition, i.e., AC genotype is having the highest body weight. This may be due to heterosis where heterozygous performs better than the both homozygote. Therefore, growth hormone can be used as a marker to improve growth performance in Black Bengal goat.

Table 52. Genotype wise (472bp fragment) least-square means of body weight (kg) at different age in Black Bengal goat

Age	Genotype				
	AA	AB	AC	**BB**	**CC**
6 month	6.13±0.72^{b}	6.80±1.15^{b}	7.97±1.39^{c}	5.65±0.64^{b}	4.83±1.04^{a}
9 month	8.98±1.74^{c}	8.88±1.41^{c}	9.90±1.40^{d}	6.82±0.52^{b}	5.95±0.35^{a}

Different superscripts indicate significant difference at 5% level.

Bihar contributes about 9% of India's total goat population.Village goat is mostly of Bengal breed. However, crosses with other breeds like Jamunapari, Barbari, Sirohi and Jakharana are also available. This breed is prolific and has high twinning percentage. In the present study, the crosses available in villages of Bihar were analyzed for genetic basis for prolificacy. In the present study village goats were studied for the BMPR1B (FecB) gene polymorphism. Screening of polymorphism was done by methodology described by Polley *et al.* (2009). The study revealed two allelic variants (A=0.48 and G= 0.52) and three genotypes (AA= 0.16, AG= 0.62 and GG= 0.22). It indicated the abundance of mutant type (G) nucleotide in village goats. The study revealed sign of introgression of mutant allele (G) into Jamunapari, Barbari, and Sirohi goats at village level. The variation in litter size among the genotypes revealed the benefits of introgression of FecB mutation in the crosses. The litter size showed variation among the three genotypes. Percentage single, twin and triplet births were 69, 29 and 2 in AA genotype, 42, 52 and 6 in AG genotype and 14, 66 and 20 in GG genotype. The study shows that the genetic up gradation for prolificacy in goats is taking place at village level.

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 x Desi crossbred calves of 4 to 5 months of age were procured. After deworming and vaccination, the calves were maintained for one month for adaptability (Fig. 76). Calves were fed wheat straw, concentrate and green grass *ad libitum*. Body weight and feed conversion efficiency were recorded fortnightly. Feed conversion ratio of calves varied from 4.1 to 6.2 during 8 to 12 months of growth trial. However, growth of male calves varied from 350 to 600 g/d. Skeletal muscle samples from individual animal was taken for analysis. Isolation of total RNA was done. Primers were designed. Construction of cDNA (UCP-2, UCP-3, ANT-3) was completed and expression studies are in progress.

Fig. 76. Feeding of crossbred calves

Evaluation of Nutraceuticals as Supportive Therapy for Subclinical Mastitis in Peri-urban Cattle

During the period, lactating cattle from Ranchi in Jharkhand and Ballia, Varanasi, Azamgarh and Ghazipur districts of Eastern Uttar Pradesh were screened for status of subclinical mastitis. The milk samples (Fig. 77 & 78) were evaluated for SCC, bacterial isolation and antibiotic sensitivity testing (Fig. 79-81). Safety study was carried out for selected nutraceuticals in animal model for aqueous extracts of *Murraya koenigii* (curry plant) leaf and *Trigonella foenum-graecum* (Fenugreek/ Methi) seeds.

Both were found to be safe based on body weight, clinical signs, liver function and histopathology after feeding different doses under consideration for evaluation based on published reports. Clinical trial of same has been initiated by oral supplementation of dried powdered mixture as adjunct therapy in cattle diagnosed for subclinical mastitis.

Fig. 77. Collection of samples from farmer's herd

Fig. 78. On field SCM screening using CMT in Varanasi using CMT in Ballia

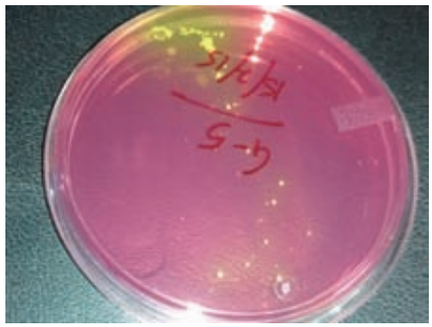


Fig. 79. Colonies of *Staphylococcus aureus* in MSA

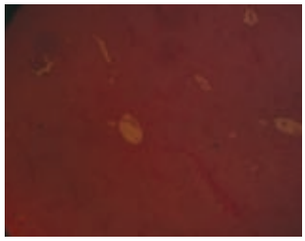


Fig. 80. Spleen of rat showing normal features (post supplement) 10X H&E

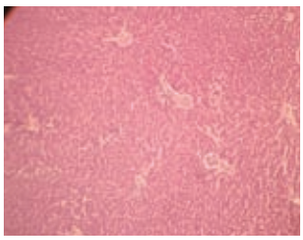


Fig. 81. Liver of rat showing normal features (post supplement) 10X H&E

Serological Epidemiology of Major Viral Pathogen of Caprine in Bihar

Under this project serum samples (for antibody detection) nasal and rectal swabs in PBS collected from clinically affected goats for antibody antigen detection (Fig. 82) were screened for three viral antibodies (PPR, CAE and BT) and one viral antigen (PPR) using ELISA kits procured from IVRI, Izatnagar and VMRD. Following major findings were observed:

- Paramyxoviridae virus resulting in PPR is associated with reproductive problems and visible clinical manifestations.
- Findings indicate significant role of oxidative stress in pathogenesis of paramyxoviridae virus in goats resulting in clinical manifestation.
- Higher level of oxidative stress specifically decrease levels of SOD and GSHPx is significantly correlated with chance of abortion/stillbirth in PPR affected female goats.

Health monitoring and disease surveillance of farm animals

During the reporting period, vaccination of female calf was done against Brucellosis using strain-19 vaccine procured from commercial firm. In addition, routine timely vaccination was provided to all farm animals against major important infectious diseases, i.e., FMD in cattle, buffalo and goats; Hemorrhagic septicemia in buffalo and cattle; Black Quarter in buffalo and cattle; PPR in new borne kids above 4 months age. Deworming was regularly provided to all farm animals at 3-4 monthly interval with broad spectrum anthelmentic. Ecto-parsiticidal spray was conducted at regular interval of 6 months with potent insecticides. Mass Prophylactic vitamin supplementation was provided at regular interval. Mastitis control program was implemented with regular examination and treatment of individual teats and animals. Fecal examination of parasitic load was investigated in all the buffaloes and only (3/36) 8.33% buffalo showed presence of amphistome eggs and (8/36) 22.22% had cyst of *Balantidium coli*. In cattle only 10% animal had eggs of amphistome. In goats 55.0% had eggs of *Heamonchus contortus*, 15% had amphistomes eggs, 15% had mixed infection of *Haemonchus contortus* and *Trichuris* and 10% had eggs of hookworm. Accordingly, goats were treated with effective anthelmentics.

● Each dots indicates 5% ★ 2.5% PPR
● Each dots indicates 5% ★ 2.5% BT

Fig. 82. Dot map indicating sero-prevalence of PPR and BT in districts of Bihar surveyed

Infertility problems in buffaloes were attempted using hormonal therapy and followed by artificial insemination. 13 adult buffaloes were found to be non-cyclic, out of which 12 were treated with hormones. Among the treatment group 9 animals returned to estrus were inseminated and five buffaloes were found pregnant. In cattle during the reported period 6 calves were born which included 3 males and 3 females. In buffalo during the same period 4 calves were born which included 3 females and one male calf. No causality was recorded.

Field Burning of Crop Residues

Aerosol concentration was estimated in the crop field of Buxar district before and after one hour of burning of wheat straw (Fig. 83). Carbon dioxide concentration was recorded 10 times higher after 1 hour of burning of residues as compared to the concentration in air before burning (Table 53). Similarly, concentration of carbon monoxide, methane, sulphur dioxide and particulates was observed higher after one hour of burning. It was also found that use of harvester followed by burning of wheat straw emitted 2500 kg of carbon dioxide per ha of wheat area as compared to 54 kg when harvester followed by bailing was used (Fig. 84).

Fig. 83. Burning of wheat straw

Table 53. Aerosol concentration during residue burning

Parameters	Before burning of crop residues	One hour after burning of crop residues
Carbon dioxide (ppm)	1003.87–1112.95	10670.27–12204.48
Carbon monoxide (ppm)	ND	2495.25–2763.23
Methane (ppm)	ND	352.00–406.79
Nitrogen oxide (ug/m³)	14-17	53-58
Sulphur dioxide (ug/m³)	<5.0	11-13
Total particulate (ug/m³)	66-73	136-141
Fine particulate (ug/m³)	22-26	49-53

Fig. 84. Baling of rice straw

FISHERIES

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

An experiment was conducted for a period of 110 days to assess the impact of varying protein levels on the growth of *L. rohita* fingerling . Five treatments namely control feed T_1, T_2, T_3, T_4 and T_5 corresponding to 16.9, 20, 25, 30 and 35 per cent protein have been prepared. The feed ingredients (sesame meal, maize powder, de-oiled rice bran, wheat bran, mustard oilcake, vitamin & mineral mixture and refined oil) were procured and feed was prepared using standard protocol. Experiment was carried out in 500 L FRP tanks and eight numbers of advanced rohu fingerling (15-20 cm & 35-45 g) were stocked in each tank. Feeding was given @ 2% of body weight. At the end of 110 days, fishes were harvested. Water quality parameters *viz.* temperature (28.04 ± 0.48 ^{0}C), pH (7.86 ± 0.04), dissolved oxygen (5.54 ± 0.41 mgL^{-1}), alkalinity (257.4 ± 3.32 mgL^{-1}) and hardness (239.6 ± 4.66 mgL^{-1}) were regularly monitored throughout the experimental period and were within the expected limit. At the end of the study, it was found that growth increment was the maximum at 30% (T_4) protein level (Fig. 85-87). Percentage growth increment (g) was highest at T_4 followed by T_3 and T_5. Increment was lowest at T_2, which might be due to mortality of fishes from the group. Specific growth rate was also maximum at T_4 (0.14%) followed by T_3 (0.11%). Maximum mortality was recorded at T_1 followed by T_2 and maximum survival rate was recorded in T_4 followed by T_3. Cost of production feed was ₹/kg 21, 20.75, 23.52, 25.68 and 29.34 corresponding to T_1, T_2, T_3, T_4 and T_5, respectively. However, when price per unit of protein was considered then the price became ₹ 1.24, 1.00, 0.92, 0.88 and 0.87 per unit of protein corresponding to T_1, T_2, T_3, T_4 and T_5, respectively.

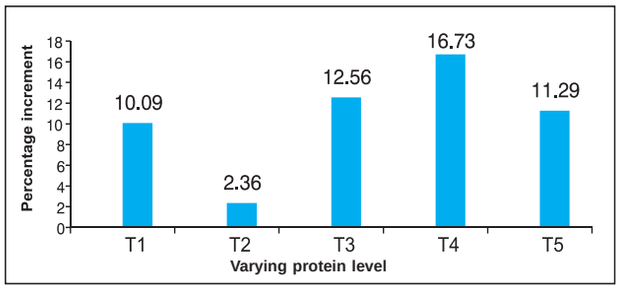


Fig. 85. Percentage growth increment of *L. rohita* after 110 days of culture

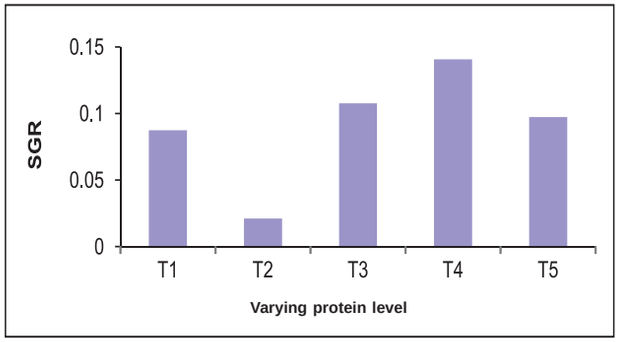


Fig. 86. Specific growth rate (SGR) percentage of *L rohita* under different protein level

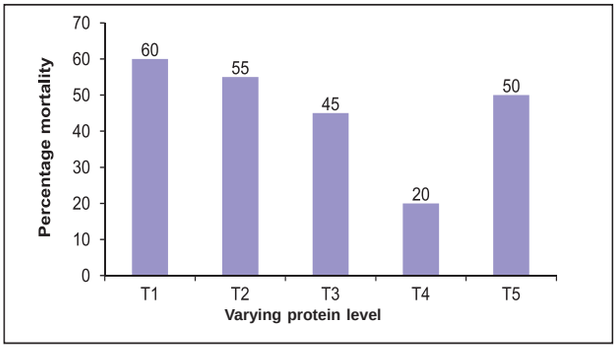


Fig. 87. Percentage mortality of *L. rohita* after 110 days of culture

Fish Culture in Low Lying Areas

During rainy season, it has been observed that, many low lying areas are inundated with water and farmers are unable to cultivate seasonal crops in those areas. Such land mass where the runoff water stagnates and remains for some-times can be utilized through land manipulation to grow vegetables and fodder right in the midst of water-logged areas. In this technology raised beds and furrows are made alternatively in the low lying areas by deepening in one area and depositng the excavated soil to other areas. The raised broad bed areas are used for cultivating seasonal vegetable or fodder crop during monsoon seasons. Okra, amaranthus, coriander, cowpea-groundnut, chillies crossandra, cauliflower, cabbage, brinjal, cucumber, palak (spinach) are the best performed crops on the bed and can be sequenced throughout the year. The depressed portion can be used for rice and fish cultivation. In this concept 9 trenches were made and fishes were grown in those trenches. A total of 200 fishes rohu (130 numbers) (49.7±3.91 g) and catla 70 numbers (47.5 ± 4.36 g) were stocked. At the end of 4 months, 81% recovery was recorded and 29.5 kg production was obtained with an average body weight of rohu : 158.5±8.6 g) and catla 172.2±12.53 g).

Fig. 88. Rice-cum-fish culture in low lying areas

Rice-fish culture, has been practiced in the seasonally waterlogged areas in Walmi campus. Fish refuge (10% area) has been made in the centre of the area and rice seedlings of BPT 5204, i.e., Super Mansuri was transplanted in the peripheral area. A total of 50 numbers of stunted IMCs carp (104.7 ± 2.65 g) and catla species (95.1 ± 3.22 g) were stocked @ 5,000 yearlings / ha of refuge area. Average yield from 5 five trenches were 1.70 t/ha of fish.

Integrated Fish-Farming

Integrated fish farming (cattle-fish, buffalo-fish, goat-fish, poultry-fish, pig- fish and duck-fish) models were studied for their production potential and water quality parameters.

Composite fish culture was adopted involving rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), grass carp (*Ctenopharyngodon idella*), batta (*Labeo batta*) and puthi (*Puntius javanicus*).

The stocking density was maintained @ 10,000 fingerlings per ha for each integration including control. Among various integrations, pig-fish and poultry-fish resulted into maximum fish productivity (2.86-2.37 t/ha) after seven months of growth (Fig. 89).

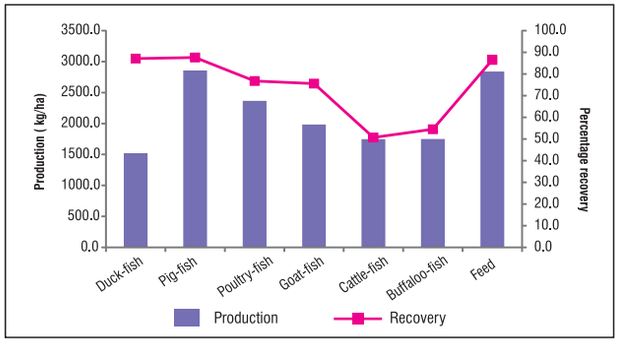


Fig. 89. Production and recovery of different integrated fish farming systems

14 Solar Energy Application

Solar Energy Application in Agriculture

A solar powered aerator was developed using a 1 HP pump with permanent magnetic DC motor of 750 watt. In Eastern India, the global solar radiation on a bright sunshine day, between 9.00 - 14.00 hours (IST), ranges from 600 - 900 W/m^2 in most of the months of the year (Fig. 90).

Therefore, this pump was powered by 900 WP solar arrays with module combinations to get output voltage in the range of 28-33 V (as per the power characteristics of the pump (Fig. 91).The motor was directly connected to the solar array and no power storage system (battery bank) was used.

This is a sprayer type aerator which pumps out water from the same pond and sprays high in the air through perforated pipe. The relatively high jet speed with surrounding air and manifold increase in surface area accelerates the oxygen diffusion at water droplets-air interface. This process breaks the thermal stratifications existents due to temperature gradient in vertical column of pond water. This improves the dissolved oxygen level in lower layers due to mixing up the relatively more oxygenated upper layer with the bottom water layer. This provides more oxygen to bottom dwellers and serves as reserve oxygen for night use.

The installed aerator operates at full capacity over from 9.00 - 14.00 hours (IST) on a bright sunshine day, and beyond this it operates below of its rated power due to reduction in solar irradiance. Since total dynamic head was kept near to 4.0 m, it was observed that aerator spray about 50000-60000 liters of water per day. This aerator is installed in a pond of 50 m x 30 m size with water level of 1.5 m (Fig. 92). The performance testing of this solar aerator is underway, however, the preliminary observations have shown that if the aerator is operated for the whole day, a considerable increase in dissolved oxygen was found in almost all the layers of pond water. Intensive data recording and

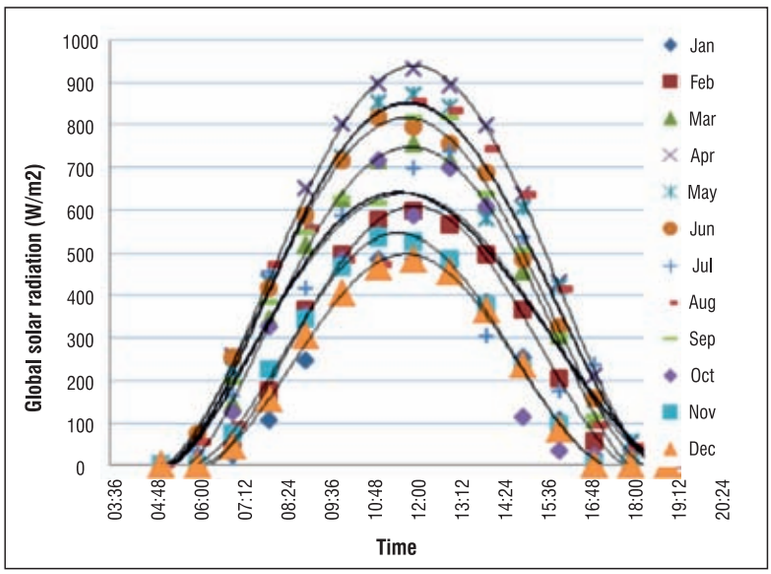


Fig. 90. Mean monthly diurnal variation of solar irradiance received on cloud free day at Patna (25.65° N).

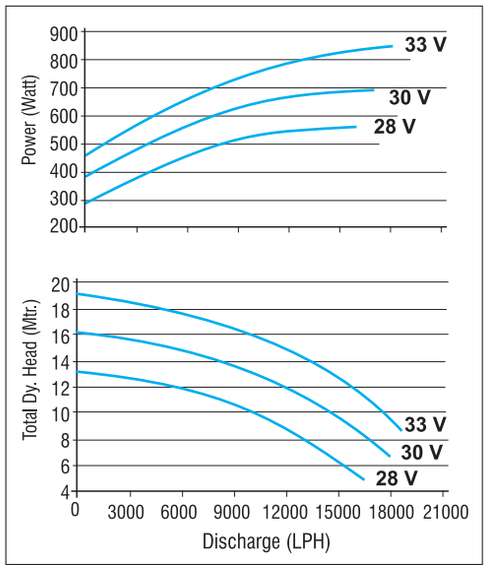


Fig. 91. Power and discharge characteristics of pump used in developing solar aerator for fish pond

Fig. 92. View of solar aerator designed and installed at experimental farm of ICAR Research Complex for Eastern region, Patna

actual performance observation are being carried out for performance assessment of the aerator. It was found that dissolved oxygen level in water was more uniformly distributed throughout the water column in pond where solar operated pump was used compared to control pond. Moreover the dissolved oxygen level was also relatively higher specially in the bottom of the pond compared to control (Fig. 93).

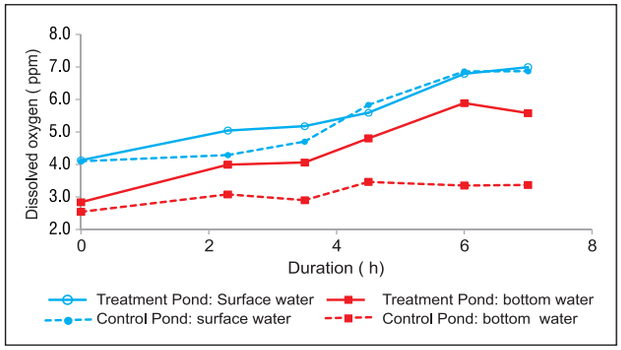


Fig. 93. Variations in dissolved oxygen level in water of solar operated pump

The experiment was also designed for ground water pumping through solar energy application as evidenced from Fig. 94.

Fig. 94. A view of solar unit for ground water pumping

15 Post Harvest Technology

Development of Value Added Products of Makhana

Makhana refers to the white puffs (popped makhana seeds) (Fig. 95). The puffs of makhana are eaten in various forms, like salted snacks and as an ingredient in a number of other food preparations. The handling of raw puffed makhana is not convenient because of high volume. The development of convenient processed products will certainly increase their market demand. The ready to use makhana powder is developed which is more convenient to use in many food preparations (Fig. 96-97). The handling and shelf life is also increased due to compact packaging. Makhana samples were graded based on the popping level, i.e., the extent of volume expansion. It was observed that about 40% of makhana was not fully popped. The good quality popped makhana was used for preparation of powder. As such, the grinding of makhana could not yield a good quality and fine makhana powder. The popped makhana was heated in a microwave oven for about 2-3 min; the heated makhana was kept outside the oven for tempering for about 15-20 min. It was grinded in a rotary grinder for obtaining powder. The adhered seed coat (in residual form) over the popped makhana was simultaneously grinded which affects the white color of the powder. The grounded makhana was sieved using a fine sieve of size 0.2 mm to finally get the fine powder of makhana. The brown seed coat is partially removed during the process and a good coloured with fine textured makhana powder is obtained. The powder is packed in polypropylene envelops in a convenient size and kept for shelf life studies with quality analysis. No qualitative change was observed upto 9 months.

Table 54. Nutritional analysis (g/100g) of fine seed powder of makhana

Nutritional profile	Quantity (g/100g)
Protein	12.20
Fat	7.00
Carbohydrate	80.50
Calcium	0.1526
Sodium	0.1332
Potassium	0.1000
Magnesium	0.0318
Iron	0.0055
Cholesterol	0.02
Trans fatiacids	0.25
Saturated fatiacids	4.33

Design and Performance Evaluation of Zero Energy Cool Chamber for Storage of Fruits and Vegetables in Warm and Humid Climates

Sizeable amount of fruits and vegetables are lost after harvesting due to lack of cold/cool storage facility. In order to overcome this problem, a Zero Energy Cool Chamber (ZECC) has been designed and erected for storing fruits and vegetables (Fig. 98).

Fig. 95 Raw makhana puff

Fig. 96. Course powder

Fig. 97. Fine powder

Fig. 98. View of Zero energy cool chamber

A comparative study was made for the storage of tomato fruits inside the zero energy cool chamber (ZECC) and in ambient condition for their weight loss, changes pH levels, TSS and firmness. The results revealed that inside temperature was about 1.57 - 11.68°C (ΔT = 4.29°C) lower than outside temperature and inside humidity was about 24.08 - 68.73% higher than outside. Physiological loss in weight (PLW) was faster for fruits stored at ambient temperature. Weight loss during the storage at ambient temperature was 6.41% as compared to 4.9% in ZECC. The TSS of tomatoes increased from 4.20 to 5.20% at ambient temperature after 5 days of storage and from 4.10 to 4.90% at ZECC after 9 days of storage inside the ZECC. pH value during 9 days of storage at ZECC slowly increased, ranging from 4.15 to 4.41, but in case of outside the same was 4.19 to 4.34 after 5 days. The ZECC stored tomatoes maintain more uniform colour and firmness than stored in open. The higher firmness of fruits inside the ZECC was likely due to lower temperature and higher humidity maintained inside the environment. In another study with Okra vegetables, it was found that storage of okra in ZECC had significant effect on the quality of okra. This research showed that okra fruits were better preserved for optimum period of 6-8 days with ZECC than in open condition.

Agricultural Tools used by Tribal Farmers in Eastern India

A study was carried out with the objective to document indigenous tools used by tribal farmers of Odisha and West Bengal. A qualitative research approach was adopted for the study and the traditional tools, used by tribal farmers are depicted in Table 55. It is evident from the table that Khurpi (*khurpa)*, Sickle *(kaste/daw)*, *Daw (katuri)*, Axe *(kural/kurali), Bamboo sieve (chalni),*Winnower *(kula), Bamboo* basket *(jhuri/tukri), Bankua, Silnora and Nanda* were found in every household.

Table 55. Traditional tools used in select villages of Odisha and West Bengal

Name of traditional tools	Use of tools in different villages (%)			
	West Bengal	Odisha		
	Uttar Simlabari	Phatepur	Mobarakpur	Bareswar
Plough	60	00	50	32
Khurpa	100	100	100	100
Weed rack	32	00	00	00
Weeder	60	00	48	24
Spade	100	96	72	56
Guity	00	00	48	00
Sickle	100	100	100	100
Daw	100	100	100	100
Axe	100	20	08	64
Sabal	32	08	40	32
Hand stone mill	24	00	00	00
Sil nora	100	100	100	100
Paddy spader	72	00	00	00
Bamboo sieve	80	24	72	52
Kula	100	100	100	100
Silo	48	00	16	24
Jhuri	100	100	100	100
Nanda	72	16	24	28
Bankua	88	00	00	00
Mugura	00	24	00	00
Pola	00	48	00	00
Khalui	32	00	00	00
Paniki	100	100	100	100

16 Transfer of Technology

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

ICAR-ICRISAT collaborative project was implemented in order to understand the dynamics of poverty in Eastern India. Regular high frequency data was collected across various categories of farm. The salient findings observed based on analysis of data collected during 2010-11 to 2013-14 are depicted below:

- Rainfall still plays a key role in determining cropping pattern, gross cropped area and intensity of cropping in Bihar. Rice and wheat constituted more than 85 per cent of gross cropped area, mainly due to consumption consideration and assured market on reasonable price.
- Farm mechanization increased considerably in the study villages of Bihar. But agricultural mechanization is still at lower level in Jharkhand.
- Per hectare productivity of principal crops increased during last 4 years of period in Bihar.
- Role of institutional support in providing modern technology and poor access to formal credit system were observed the main constraints in agricultural development in villages under study in Bihar and Jharkhand.
- Milk production also increased in Bihar during last 4 years but it remained stagnant in Jharkhand.
- Rice fallow management is major area of operation in Jharkhand.

NAIP

The NAIP Component-3 sub-project entitled "Sustainable livelihood improvement through need based IFS models in disadvantaged districts of Bihar" was operational in four selected districts of Bihar namely Vaishali, Samastipur, Munger and Darbhanga during 2008-14. Through this project, an attempt was made to address the agri centric livelihood security of farmers with strengthening the capacity and capability of smallholders in support and collaboration with NGOs, SAUs, CGIAR Centres, civil societies and ICAR institutions. The project was planned, developed and implemented in participatory mode and special attention was paid towards small and marginal, landless/asset less farmers, share croppers, farm women, SHGs and unemployed youth.

The following integrated farming system models/systems were developed in participatory mode:

- Half acre integrated farming system model was developed in Chakramdas village of Vaishali district which included crop, buffalo, duck-cum- fish culture and backyard vegetable production. Vermi-compost was prepared with crop and livestock wastes. The cost-benefit analysis showed six fold increase in net income (₹ 55578/-) over traditional cropping system (₹ 7528/-).
- Similarly, one acre IFS model was developed in the same village with agri-horticrop-goat-poultry as the village is dominated by rice-wheat cropping system followed by fruits and vegetable production. The net return from the system was achieved at ₹ 59428/- and gross return of ₹ 235072/-.
- Two and half acre IFS model was developed in Chakramdas, Vaishali where 1 ha of land was kept for field crop production in which rice-wheat crop sequence was followed. A land of 0.6 ha was allocated for vegetable production, 0.05 ha for orchard, 0.02 ha for poultry rearing (500 Nos) and 0.012

ha for mushroom production. All around the field bund about 2.5 feet raised bunds was constructed where creeper vegetables were cultivated. With system 7-8 cow and buffalo were also integrated (0.03 ha) and dungs were recycled. The net saving from the system was recorded as ₹ 292825/- .

- IFS model by integration of fish and singhara with makhana was developed in farmers' field in Darbhanga district. The net benefit from the system was recorded at ₹ 52435/- as compared to traditional system (makhana production alone) of ₹ 20614/-. The makhana contributed the major share of around 40% followed by fish at 22.5%.
- Integrated makhana + fish + horticulture model was developed in a lowland area in Darbhanga district where cultivation of other crop was not possible due to waterlogging. For effective utilization of land and water resources, a system was developed by converting 20% of makhana pond area to raise embankment of 1.5 m height along the pond sides while the remaining 80% area was kept as such as a pond. The pond was used for makhana-fish cultivation and raised embankment was used to grow the horticultural plants. The gross and net return from the system were estimated as ₹ 1,19,246/- and ₹ 50,439/- per ha, respectively. However, net return on makhana cultivation alone, makhana-fish culture and makhana-water chestnut was obtained as ₹ 25725/-, ₹ 37660/- and ₹ 41745/-, respectively.
- Field based system of makhana cultivation was standardized with fish, rice and water chestnut in cropping system mode. The gross return from makhana-fish, makhana-rice and makhana-water chestnut was obtained as ₹ 282810/-, ₹ 273480/- and ₹ 354340/- per ha, respectively while a gross return of ₹ 1,32,552/- was obtained from makhana cultivation alone. The net return from the above system was recorded at ₹ 1,21,520/-, ₹ 1,16,322/- and ₹ 1,56,436/- per ha, respectively as compared to ₹ 88,368/- per ha in makhana cultivation alone.

Institute Foundation Day Organized

ICAR Research Complex for Eastern Region, Patna celebrated its 15th Foundation Day on 22nd February 2015. Shri Radha Mohan Singh, Union Minister of Agriculture was the Chief Guest of the function. He stressed on the implementation of 'lab to land' programme in large scale for taking technologies to the villages. He urged the scientists to visit at least one village in every month and interact with the farmers. He also desired that extension bulletins and leaflets should reach to the District Agriculture Officers for effective extension. Four publications were also released by the Hon'ble Minister (Fig. 99). Dr. H. S. Gupta, Director General, Borlaug Institute for South Asia and the Special Guest in this function.

Fig. 99. Release of publications by Chief Guest

Online System of Examination

An Online Examination Hall was established at the Institute. The system is equipped with high end infrastructure such as LAN, servers, terminals, power systems, routers and a dedicated Internet connection (Fig. 100). Just after inauguration, ASRB NET 2014(I) online examination was successfully conducted from 26.3.2014 to 4.4.2014 for 55 disciplines of agricultural sciences.

Fig. 100. Online examination hall in the Institute

Activities Under Tribal SubPlan (TSP)

Activities under Tribal Sub Plan (TSP) were implemented by the Institute for holistic development of the tribal population through up scaling of livelihood based interventions to the stakeholders. Cluster based participatory technological intervention were implemented by the institute at tribal dominated areas of Ranchi, Bhadrak, Kamrup and Jalpaiguri districts of Jharkhand, Odisha, Assam and West Bengal states, respectively with collaboration of SAUs, IINRG, Ranchi, R.K.Mission and local Panchayats. Total targeted beneficiary under TSP was around **500 households** that were directly benefited through implementation of the activities.

Livelihood approach was adopted by the institute focusing on capacity building of stakeholders, working with them in participatory mode, analyzing people's existing strength and utilization of available resources. Further, women and youths were involved in capacity building and implementation of livelihood interventions. Based on the available resources and needs of the tribal population following interventions were implemented:

Assam : Rewa Maheshwar (Guwahati)
Jharkhand : Saraitoli and Hundru (Ranchi)
Odisha : Baradeswar, Mobarkpu & Phatepur (Bhadrak)
West Bengal : Uttar Simlabari (Alipurduar)

1. Name of the districts and states : Kamrup (Assam) No. of beneficiaries: (120)

Activities

- Creation of water harvesting/ storage structures for life saving irrigation in 3.4 ha area.
- Pond reshaping and bund strengthening for composite fish culture with stocking density of 10,000 fingerlings/ ha.
- Livelihood improvement of 65 farm families through pig (T x D) with average annual income of ₹ 8, 359/ house hold.
- Livelihood improvement of 23 farm families through poultry farming (Khaki Cambell duck and Vanraja poultry) with average annual income of ₹ 4,090 / house hold.
- Organizing of animal health camp.
- Farmers-scientists' interaction ensuring supply of quality seed and planting materials of agri-horti crops.

Fig. 102. Pig farming at Rewa Maheswar (Guwahati)

Fig. 103. Backyard duck rearing

Fig. 101. Farmers'-scientists interaction at Rewa Maheshwar, Assam

Fig. 104. Water harvesting in farmer's field at Rewa Maheshwar, Assam

2. Name of the districts and states : Ranchi (Jharkhand) No. of beneficiaries: (80)

Activities

- Livelihood improvement of 51 households through backyard goat and poultry farming with total annual income of ₹ 46,359 and average income of ₹ 909/ house hold.
- Scientific lac cultivation by 59 farm families with average annual income of ₹ 6,842/ house hold.
- Vegetable seed production by 11 farm families resulting net annual income of ₹ 3,564/ family and capacity building on Improved package of practices of seasonal vegetables.
- High density orchard in guava and banana.
- Recycling of within farm renewable resources through vermi composting.
- Soil acidity amelioration through agricultural grade lime application.
- Development of Integrated fish farming.
- Micro irrigation and protected cultivation in 6.3 ha area covering 55 farmers.
- Rice fallow management-Micronutrient management in rice fallow, fruit based production system in rice fallow, soil organic carbon management under rice-fallow, performance evaluation of acid soil tolerant rice genotypes under rice fallow.
- Creation of water harvesting/storage structures for life saving irrigation and Installation of water lifting device for assured irrigation in around 10.3 ha area.
- Restoration of degraded lands through agro-forestry interventions, Multi-tier orchard establishment.
- Farmers-scientists interaction.
- Organizing Animal health camp.
- Availability of quality seed and planting materials of agri-horti crops.

For strengthening of water resources, 7 numbers of pucca ring wells were prepared in different farmers' fields with the purpose of sharing of water by surrounding farmers (Fig. 106). A check dam was constructed on the rivulet flowing around the village for facilitating irrigation water availability to the farmers. The enhanced access to irrigation water resulted in 1.1 times, 1.3 times and 1.4 times increase in area under cultivation during *kharif, rabi* and summer, respectively.

Fig. 105. Traditional method of water harvesting small temporary wells prepared by the farmers every year

Fig. 106. Pucca ring wells in farmers' fields and Check dam on the rivulet

A total of 108 tribal farmers were provided exposure to the improved vegetable production techniques at the experimental farm of ICAR RCER, RC, Ranchi. Hands-on training on vegetable nursery raising in pro-trays was provided to the farmers at the centre in which farmers raised their own seedlings to be grown in their respective fields (Fig. 107). Two exposure visit programmes of the villagers to the fields of progressive vegetable and fruit growers were at Ormanjhi, Ranchi were conducted.

Fig. 107. Villagers interacting with progressive vegetable and fruit growers in Ormanjhi, Ranchi

Rice- fallow Management

Vegetable prodution systems have been demonstrated in the famers' field. One of the farmers Mr. Nanka Kachhap, could earn more than ₹ 65000/- by growing cucumber, cowpea (cv Swarna Mukut), sponge gourd (cv Swarna Prabha), bitter gourd and chilli (Swarna Praphulya) during kharif and more than ₹ 15000/- from cabbage and brinjal (Swarna Pratibha) during *rabi* through drip irrigation and plastic mulching. (Fig. 108).

Technology demonstration on drip irrigation was conducted in 20 farmers' fields covering 4 acre area. During the first year, the adoption rate of drip irrigation was 20%.

Fig. 108. Mr. Nanka Kachhap in his field

Fig. 109. Mrs Pratima Kachhap in her field of cowpea and sponge gourd

Fig. 110. Mrs. Sita Kachhap with her cucumber crop

Livelihood sustainability through lac cultivation

The lac cultivation was initially started by few farmers but non availability of brood lac and non availability of scientific know how of lac cultivation restricted the expansion of lac cultivation in Saraitoli in spite of available natural resources of kusum, ber, palas trees in abundance. The capacity building of stake holders of 55 households were done for scientific cultivation of lac and initially provided brood lac of 400 kg (Fig. 111).

The brood lac was inoculated by the farmers in total of 98 trees of Kusum in the month of Feb-March, 2013. After inoculation of 4.0 q brood lac in the Feb-March, 2013, 29.06 q of lac was obtained in July-August, 2013 out of which 26.31 q of brood lac was re-inoculated by the farmers in 226 of Kusum and 140 in Ber tree in the month of July- August, 2013. In Feb.-March, 2014 total of 64.72 q of lac was produced and 20.57 q brood lac was again re inoculated in February- March, 2014.

In the month of July-August, 2014, lac production of 82.28 q and recorded out of which 26.29 q was again reinoculated in July-August, 2014. The average income after harvest in July, 2014 of lac resulted ₹ 18,353/household/ season. The initial average income from lac before start of the project was only ₹ 4,653/yr/ household.

Fig. 111. Lac production and inoculation by stake holders at Saraitoli village

3. Name of the districts and states: Bhadrak (Odisha) No. of beneficiaries: (100)

Activities

- Livelihood improvement of 60 farm families through backyard goat, pig poultry farming and mushroom cultivation.
- Pond reshaping and bund strengthening for composite fish culture.
- Creation of water harvesting/ storage structure for life saving irrigation in 9.80 ha area.
- Capacity building on Improved package of practices of seasonal vegetables.
- Organizing Animal health camp and farmers-scientists interaction and ensure supply of quality seed and planting materials of agri-horti crops.

Fig. 112. Distribution of goats to the beneficiaries at Phatepur Village, Odisha

4. Name of the districts and states : Jalpaiguri (W.Bengal) No. of beneficiaries: (200)

Activities

- Livelihood improvement through backyard goat, poultry farming by 175 farm families with annual average income of ₹ 1,243/ house hold.
- Mushroom cultivation by 6 farm families with average income of ₹ 34 / kg.
- Improved package of practices of seasonal vegetables by 10 families with annual average income of ₹ 78,616/ ha.

Fig. 113. Happy women farmer with goat rearing

Fig. 114. Water harvesting in farmer's field at Mubarakpur village, Bhadrak, Odisha

Fig. 115. Farmers' scientist' interaction at Uttar Simlabari (Alipurduar)

- Creation of water harvesting/ storage structure for life saving irrigation for 7.3 ha area.
- Use of micro irrigation for vegetable cultivation.
- Organizing Animal health camp and farmers-scientists interaction and ensure supply of quality seed and planting materials of agri-horti crops.
- Restoration of degraded lands through agro-forestry interventions.

Fig. 116. Teak Plantation (above) and Bottle gouard (below) cultivation at Uttar Simlabari (Alipurduar)

Participatory Evaluation of Acid Soil Tolerant Rice

Twelve acid soil tolerant rice germplasm *viz.*, Tsamu fiirii, Motodhan, RCPL1-13, SKAU-390, COL-4, UPR-2992-17-3-1, UPR-2919-14-1-1, Sanri fiirii, VL-31331, VL-31329, IR-1552, Khougjai Phou were procured from ICAR RCNEH, Umiam, Meghalaya. They were evaluated under direct sown rainfed condition at farmer's field, Hundru, Ranchi (Soil pH 4.9) and Farm-I, ICAR RCER Research Centre, Ranchi (soil pH 5.1) along with two local checks Anjali and Lalat (Fig. 117-123). The highest yield was recorded in Sanri fiirii (8.65t/ha) followed by Khougjai Phou (8.15 t/ha) (purple colour foliage), COL-4 (6.9t/ha) and SKAU-390 (6.2t/ha) (Table 56). Among the genotypes, Motodhan was

Fig. 117. Evaluation acid soil tolerant rice germplasm at Farm-I, ICAR RCER RC, Ranchi

Fig. 118. Sanri fiirii

Table 56. Performance of acid soil tolerant germplasm along with the checks

Name of the trait	Range	Mean	Ftest significance	CV%	CD at 5%	SEM
Grain yield (kg)	1.08-0.11	0.59	Highly significant	40.84	0.34	0.12
Days to 50% flowering	104.25-68.0	87.86	Highly significant	2.02	2.52	0.89
Days to harvest	148-107	132.68	Highly significant	0.21	0.38	0.13
No. of tillers/hill	39.25-23.25	31.16	Non significant	22.19	-	3.46
Plant height (cm)	131.85-63.4	101.43	Highly significant	6.93	10.01	3.51
Panicle length (cm)	31.65-23.3	27.82	Highly significant	4.40	1.75	0.61
No.of grains /panicle	377.55-128.5	208.81	Highly significant	15.38	45.77	16.06

long duration (104.25 days to 50%flowering) and local check Anjali was short duration (68 days to 50%flowering). UPR-2919-14-1-1 (4.9t/ha) is recommended under dwarf category (96.3cm) to avoid lodging problems.

Fig. 119. Khougjai Phou

Fig. 122. COL-4

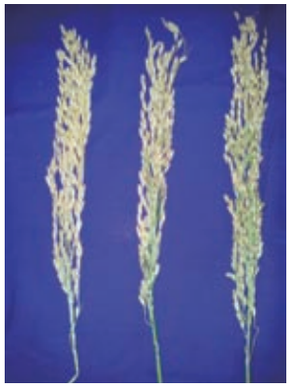


Fig. 121. SKAU 390

Fig. 122. UPR-2919-14-1-1

Fig. 123. Participatory evaluation of acid soil tolerant rice germplasm at farmer's field, Hundru, Ranchi

Dumka District

Demonstration of production of oyster mushroom by tribal farm women

The production of oyster mushroom was demonstrated in households of 21 tribal women in Sagbehri village under Dumka block and 20 tribal women in Karela village under Jama block in Dumka district of Jharkhand. In Sagbehri village, the harvest of mushroom was ≥1.0 kg per kg of paddy straw in 16 households. The mushroom was sold @ ₹ 120-130/- per kg. The maximum harvest of 1.27 kg mushroom/kg of paddy straw was obtained by Smt. Bale Hansda. The maximum income of ₹ 4833/- was obtained by Smt. Bahamuni Hansda who produced 38.5 kg mushroom from 34.9 kg paddy straw.

In Karela village, the harvest of mushroom was 0.69-0.79 kg per kg of paddy straw in 20 households. The mushroom was sold @ ₹ 150-180/- per kg. The maximum harvest of 0.79 kg mushroom/kg of paddy straw was obtained by Smt. Sarita Soren. The maximum income of ₹ 1035/- was obtained by Smt. Deathmai Soren who produced 6.3 kg mushroom from 8.0 kg paddy straw.

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

- Three day Training Programme on KOHA Library management software during 20-22 February, 2014 at ICAR-RCER, Patna.
- One day demonstration programme on IFS for the Researchers, NGOs on 26 February, 2014 at ICAR-RCER, Patna.
- Three day farmers' Exposure visit to ICAR-RCER Research Centre, Plandu, Ranchi during 24-26, March, 2014 under NAIP- 3 Project.
- Three day Workshop on "Integrated Farming System" under AICRP-IFS at ICAR-RCER, Patna during 09-11 June, 2014.
- Farmers-scientist interaction at Uttar-Simlabari village, Alipurduar, West Bengal under TSP on 10 December, 2014.
- Farmers-scientist interaction at Uttar-Simlabari village, Alipurduar, West Bengal under TSP on 13-14 February, 2014.
- Farmers-scientist interaction at Rewa Maheswari village, Kamrup, Assam under TSP on 11 January, 2014.

- Farmers-scientist interaction at Fatepur village, Bhadrak, Odisha under TSP on 26-27 February, 2014.
- Farmers-scientist interaction at Rewa Maheswari village, Kamrup, Assam under TSP on 4 March, 2014.
- Farmers-scientist interaction at Uttar-Simlabari village, Alipurduar, West Bengal under TSP on 10 December, 2014.
- Integrated fish farming from 26 Feb-7 March 2014 at ICAR-RCER, Patna.
- Integrated fish farming from 21-22 March 2014 at ICAR-RCER, Patna.
- Livestock production in watershed" from 26-27 March 2014 at ICAR-RCER, Patna.
- Livestock production in watershed" from 26-27 March 2014 at ICAR-RCER, Patna.
- 'Earth Day' ceelbrated on 22nd April, 2014 Kukurha village under NICRA Project where 41 farmers participated.
- 'World Environment Day' was celebrated on 5th June, 2014 in Kukurha village under NICRA Project where 50 farmers participated.

World Environment Day Celebrated at KVK, Buxar

World environment day was celebrated on 5th June 2014 under NICRA Project at KVK, Buxar. Smt Meena Singh, Chair person of Nagar Parishad, Buxar was the chief guest on this occassion. Subject matter specialists interacted with fifty farmer participants on climate resilient technologies to reduce green house gas (GHG) emission, enhance sequestration of carbon, within the farming system, increasing soil fertility, use of renewable resource in locally organized production system and minimize all forms of pollution.

Workshop on Real Time Mango Pest Surveillance

The two days workshop on Real Time Pest Surveillance (RTPs) of Mango was organized at ICAR RCER, Research Centre, Ranchi during 25-26 February, 2014 (Fig. 124). Thirty four participants including Director, NBAII, Bangalore, Project Coordinator, AICRP on Fruits, Bangalore, PI, Co-PIs, RAs, SRFs, Pest Scouts and Data Entry Operators from all Centres of NICRA project on "Mango pest" (ICAR RCER, RC, Ranchi, IIHR, Bangalore,

Fig. 124. Participants of workshop on RTPS in Mango

CISH, Lucknow, FRS, Sagareddy, AES, Paria, RFRS, Vengurla, NCIPM, New Delhi and CRIDA, Hyderabad) participated. During the programme, review of project activities at different centres was undertaken.

Demonstration on Mat Method Nursery of Paddy

Delayed monsoon is now a common phenomenon in Buxar district. To combat the situation one intervention of staggered mat method nursery of paddy crop was demonstrated in 500 m^2 area of Paddy Var MTU7029 and Sahbhagi . The total mechanical paddy transplantation has been promoted in 1.0 ha area with three beneficiaries.

Demonstration of Bajra as Contingent Crop in Rice Fallow

Rice bowl, Buxar district of Bihar was faced severe drought situation in 2014 in adopted village Kukurah with very low precipitation (533.4 mm) against normal rainfall 975 mm. Late onset of monsoon leads to thousands of ha area as rice fallow in the area. As a result, farmers are not able to sow/transplant the rice crop in the field. KVK Buxar has introduced two pearl millet var. HHB 67 and VBH 380 in 6 ha (beneficiaries 15 farmers) and 24 ha (beneficiaries 100 farmers) area, respectively. HHB 67 is an extra early maturing hybrid which matures in 60-65 days. Plants are medium tall with profuse tillering and have thin stem with thin leaves. Ear heads are dense with medium bold grains. This variety is very well suited for inter and multiple cropping system and highly resistant to downy mildew and lodging. Its yield was 3.0 t/ha against local var. yields 2.6 t/ha with BC ratio

1.91. Secondly, VBH 380 yields 3.3 t/haa with BC ratio 2.11 against local check. The percent increase in yield was 11.84 and 23.12 in HHB 67 and VBH, 380 respectively.

NAAS Regional Chapter Meet Organised

NAAS Eastern Rgional Chapter Meet was organised at RC, Ranchi during 27-28 February, 2014 to discuss the issue of IPR in Agiculture. Dignitaries namely Dr. S. Kumar (Ex-Head ICAR RCER, RC, Ranchi), Dr. R. P. Singh Ratan (Director Extension Education, Birsa Agricultural University), Dr. R. Ramani (Director IINRG), Dr. B. P. Bhatt (Director ICAR RCER, Patna), Dr. A. K. Singh (Head ICAR RCER,RC, Ranchi) and scientist of centre participated in the meeting (Fig. 125).

Fig. 125. Dignitaries Inaugurating the Eastern Regional Chapter Meet on IPR,

Foundation Stone of KVK, Ramgarh

The foundation stone of KVK Ramgarh was laid out on 27th August, 2014 at Mandu by Sri Radha Mohan Singh, Hon'ble Union Minister of Agriculture, Govt. of India (Fig. 126).

Dr S. Ayyappan, Secretary, DARE and Director General, ICAR presided over the function. A Farmers' Fair cum Kisan Gosthi was also organized during the occasion in which exhibition stalls by different stakeholders were set up and more than 2000 farmers participated. Twelve progressive farmers were felicitated in the function by the Hon'ble Union Minister of Agriculture (Fig. 127).

Fig. 126. Laying out of foundation stone of KVK, Ramgarh by Shri Radhamohan Singh, Hon'ble Minister of Agriculture, Govt. of India

Fig. 127. Felicitation of progressive farmers by Shri Radhamohan Singh, Hon'ble Minister of Agriculture, Govt. of India

Farmers Training/Field Day

Farmers Training / Field Day / OFT, etc. organised by the Institute are depicted in Table 57-64.

Table 57. Training programme conducted by Regional Research Centre, Ranchi

Topic	Sponsored by	No of participants
Seasonal vegetable cultivation	CCL, Ranchi	26
Mushroom cultivation	ATMA, Latehar	25
Off seasonal vegetable cultivation	ATMA, Latehar	25
Hybrid vegetable seed production	ATMA, Latehar	25
Seasonal vegetable cultivation	ATMA, Patna	26
Seasonal vegetable cultivation	ATMA, Latehar	25
Off seasonal vegetable cultivation	ATMA, Chaibasa	22
Seasonal vegetable cultivation	ATMA, Chaibasa	19
Seasonal vegetable cultivation	CCL, Ranchi	25
Mushroom cultivation	JSPL, Patratu Ranchi	25
Dendrobium cultivation	NHM, Ranchi	25

Topic	Sponsored by	No of partici-pants
Dendrobium Mushroom & protected vegetable cultivation	NHM, Ranchi	21
Dendrobium Mushroom & protected vegetable cultivation	NHM Ranchi	18
Hybrid vegetable seed prodcution	Araya Shambhu Krishak Club, Kharda, Odissa	25
Seasonal & off-seasonal vegetable cultivation	CCL, Ranchi	25
Seasonal & off-seasonal vegetable cultivation	CCL, Ranchi	25
Seasonal & off-seasonal vegetable cultivation	CCL, Ranchi	25
Seasonal & off-seasonal vegetable cultivation	CCL, Ranchi	25
Dendrobium mushroom & protected vegetable cultivation	NHM, Ranchi	25
Dendrobium mushroom & protected vegetable cultivation	NHM, Ranchi	24
Commercial vegetable cultivation through drip irrigation system	NABARD	23
Commercial vegetable cultivation through drip irrigation system	NABARD	22
Seasonal & off-seasonal vegetable cultivation	SIRD, Ranchi	30

Table 58. Training Programmes for Rural Youth at KVK, Buxar

Topic	Total
Mushroom production: A source of income generation	10
Bakri Palan at Bhimrao Ambedkar Dalit Vikas Sansthan, Joyti Library, Buxar	50
Goat rearing	16
Quality seed production techniques of *kharif* cereal crops.	20
Seed production technique of lentil and chickpea	20
Bee keeping: A source of income generation	10
Mushroom production: A source of income generation	10
Livestock production	11
Poultry production	13
Establishment and management of vegetable and fruit nursery	20
Construction of poly tunnel for nursery raising	20
Seed production technology of wheat & chickpea	15
Seed production of rabi cereal crops	20
Total	**235**

Table 59. On-campus training programmes conducted at KVK, Buxar

Topic	Total
Integrated insect pest management in summer veg-etable	25
IPM in rice and rice based cropping system	21
Quality seed production on pigeon	23
Quality seed production of QPM maize	20
Quality seed production of wheat	20
Total	**109**

Table 60. Off-campus PF training programmes conducted at KVK, Buxar

Topic	Total
Training programme on soil testing – "How to collect soil sample" at Kukudha village.	30
Dryland farming at Bhimrao Ambedkar Dalit Vikas Sansthan, Joyti Library, Buxar.	50
Collective farming at Bhimrao Ambedkar Dalit Vikas Sansthan, Joyti Library, Buxar.	50
Water management in summer vegetables	22
Management of diseases and insects through soil solarization	20
Nursery raising of vegetables	21
Management of insect pest by cultivar practices in summer season	20
Deep summer ploughing and its importance	21
Integrated pest management in rice nursery	20
Integrated nutrient management of okra	20
Nursery management of paddy	22
Layout and management of orchard	20
Termite damage and their control measures	31
Year round fodder production	25
Layout and management of orchard	20
Integrated crop production technology for pigeonpea	20
Crop residue management for maintaining soil health	20
Improved management techniques for rice nursery production	20
Method of binding and its importance	20
Storage pest of cereals and their control measures	22
Reproductive problem in cattle	21
Methods of soil samples collection	20
Quality seed production techniques of pigeonpea	22
Pruning & training of young orchard	20
Production of low volume & high volume crop	20
Insect pest and disease management in jowar & bajra	20
Quality seed production of wheat	20
Quantity seed production of paddy	22
Seed production of okra	25
Production technology of low volume crop	50
Production technology of capsicum and tomato	20
Insect and disease management in Mentha	20
Integrated disease management of false smut in rice	25
Crop production technique for pearl millet and sorghum	20
Abiotic and biotic stress management in rice	20
Integrated nutrient management on paddy	20
Integrated Farming System	20
Insect and disease management in oil seed crop	27
Pod borer and milt management in chickpea and lentil	24
Storage Pest and pulses and their control measures	26
Pod borer and pod fly damage in Arhar and their control measures.	20
Early and late blight disease of Tomato and Potato and their management	23
Conservation of Natural enemies in rice eco system (02 days)	21
INM in rice	23
INM management in paddy	25

Topic	Total
INM in potato	23
Soil and water sample collection	21
Crop management in Integrated Farming system	20
Mud management in Rice-Wheat cropping system	20
A biotic and biotic stress management in pigeon pea	20
Integrated Farming System	20
Production technology for quality planting material of vegetable crops	20
Method of rizobium culture inoculation and suphor in rabi pulses (chick pea, lentil and field pea)	20
Management of roots and leafy vegetable	20
Production technology of garden pea	20
Integrated Crop Management for chickpea production	20
Integrated crop management for rapseed and mustard production	20
Method of INM in cauliflower	24
Production technology of mustard	20
Application of balance fertilizer in oil seed crop	20
Bio security	21
Management of young orchard	20
Method of INM in wheat	20
Quality seed production of mustard	20
Quality seed production of onion	20
Seed production technique of potato	20
Seed production techniques of rabi oil seed crop	20
Seed production of garden pea	20
Identification and utilization of bio control agent in rabi season	23
Seed born disease of cereals and pulses and their management	20
Pod borer and wilt management in chick pea and lentil	20
Pod fly damage I arhar and their control measures	20
Insect and disease management in mango	20
Storage pest of pulses and their control measure	22
IPM in mango leaf hopper & mealy bug	21
Neem seed in plant protection	20
Year round fodder production	23
Fish cum Duck farmingss	20
Swine production	22
Small scale silage making	24
INM in cowpea & lentil	23
INM in wheat	23
Application of sulphur in oil seed crop	23
Water management in rabi pulses (chickpea & lentil)	43
Weed management in wheat	20
Weed management in rabi season crops	20
Quality planting materials production technology of vegetables	20
Scientific management & planting of cole crops	20
Production technique of drought tolerant variety of wheat	21
Seed production technique of potato	22

Topic	Total
Quality seed production of onion	22
Feeding of animal during scarcity	22
Bio security	26
Mastitis in dairy cow	22
Proper disposal of dead carcasse	24
Urea mineral molasses brix feeding in cattle	21
Year round health protection practices for sheep and goat	22
Degnalla diseases in cattle	22
Feeding of sheep and goat	25
Manure & fertilizer management in sugarcane	20
Water management in Japani podina	20
Production of Vermi compost	22
Foliar application of micronutrient in mango	22
Manure & fertilizer management in Japani podina	26
Manure and fertilizer management on cucumber	31
Water management in japani podina	20
Scientific plants & management of cole crop	20
Production technology of onion	21
Transplanting and management of onion crop	22
Scientific cultivation of okra in zayad season	20
Integrated nutrient management in onion	20
Integrated crop management in maize	20
Management of cuscuta	20
Resource conservation technology in wheat	20
Aboitic and biotic stress management in lentil and chickpea	20
Quality seed production of rapseed & mustard	20
Quality seed production of chickpea	20
Quality seed production technology for wheat	20
Integrated crop management in mentha	20
Nutrient management in onion	20
Management of cuscuta	20
Seed production of *rabi* pulses seed crops (lentil & field pea)	20
Quality seed production of green gram	20
Total	**2737**

Table 61. Training programmes for extension functionaries conducted at KVK, Buxar

Topic	**Total**
Quality seed production on paddy	20
Seed production technique of *rabi* cereal crops	20
IPM in rice and rice based cropping system	20
Biological control and its component	20
Rice and their insect pest in rice ecosystem and eco friendly management	21
Advance cultivation of vegetable crop	20
Resource conservation technology in rice wheat cropping system	10
Organic farming	10
Seed production of wheat	20
Total	**161**

Table 62. FLDs conducted at KVK, Buxar

Topic	Area (ha.)/ no.	No. of beneficiaries	Village Covered
FLD on mustard	5.0	20	Pawani, Boxa, Kamarpur, Nai Bazar, Dafa Dehri, Turkpurva
To introduced high yielding variety of Pigeon pea Var. ND Arhar -1	5.0 ha	24	Baruna, Kulharia, Raghunathpur, Baijnathpur, Manikpur, Manjharia, Ora, Sauri, Pavani, Badka, Dhakaich, Baijnathpur
To introduced high yielding medium duration scented variety	20.0 ha	62	Mungasi, Dhakaich, Harpur, Ukarwalia, Patnapura, Nathpur, Jalhara, Pokharha, Kukurha, Govimdpur, Dalsagar, Sohanipati, Gurudas-Mathia, Turkpurwa, Nandan, Arjunpur, Boxa, Bharkhar, Hakimpur, Noniapur, Nadaon, KamarpurDhobahi
FLD on sorghum (MP Chari)	1.7 ha	15	Rasen, Nidhuan, Dalsagar, Varuna, Raghunathpur, Vaijnathpur, Naya Bhojpur, Sauri, Paliya, Katharkhurd, Pavani
FLD on Berseem (Var. Wardan)	0.9 ha	11	Amsari, Ndaon, Boxa, Pavani
Bajra	50 ha	114	Pawani, Nidhuan, Dullahpur, Chanda, Phulimishra Ked Era, Kukurha
Finger millets	1.0 ha	04	Kukurah
Performance of okra (var. Kashi Pragati)	1.0 ha	10	Kukurah
Demonstration of wheat var. HD 2967	2.0 ha	8	Pawani, Boxa, Churamanpur. Turkpurwa, Chakrahansi, Lalganj, Mathia
Demonstration of vegetable pea (var. Kashi Udai)	2.0 ha	20	Kukurah, Dalsagar
Demonstration of onion (var. Pusa Red)	1.0 ha	13	Churamanpur, Dalsagar, Pavani
Demonstartion of moongbean (varsamrat)	1.5 ha	6	Kukurah
Mulching effect on okra	0.25 ha	10	Kukurah
Mulching effect on mentha on growth and weed management	0.50 ha	10	kukurah
Role of *Rhizobium* culture in Lentil production (var. K-75 and Narmada Masoor)	3.0	19	Chunni, pavanikukurah
Under NIFTD			
FLD on berseem (NIFTD) var. Warden	0.66 ha	09	Darahpur, Manjharia, Kanpura, Sohanipatti, Parsia, Dulahpur, Nagarpura, Bharchakia
FLD on MP chari	0.4 ha	06	Kathar, Kukurah, Kulharia, Katharkhurd
FLD on Oats (NIFTD) var. JH0822	0.44 ha	07	Manjharia, pavani, Sohanipati, Boxa.
FLD on maize (African tall)	0.25 ha	03	Dalsagar, JagdishpurChausa
FLD on cowpea (UPC 628)	0.4 ha	07	Dalsagar, Kulharia, Kukurah
Under NICRA			
FLD on MP chari	2.0 ha	16	Kukurah, Gheuria, Bijhaura
FLD on Subabool NICRA (Community Land)	0.4	02	Kukurah
Demonstration of Happy seeder in under NICRA project	1.5	04	Kukurha
Zero tillage in wheat under NICRA project	15.0	35	Kukurha
Drought tolerance paddy var. Naveen	2.5 ha	05	Kukurha
Drought tolerance paddy var. Sushak Smarat	2.0 ha	07	Kukurha
Drought tolerance var. Sahbhagi	2.0 ha	02	Kukurha
DSR of BPT-5204	0.8 ha	03	Kukurha
Green manuaring of susbania	2.0 ha	04	Kukurha
Under IARI-Post office linkage Programme			
Demonstration on Wheat under IARI-Post office linkage programme	1.0	08	Pawani, Chunni, Kukurah, Vish-Rampur, ,
Demonstration on Wheat under IARI-Outreach Programme	3.5	20	Pavani, Hukaha, Churamanpur, Nidhua, Bharchakia, Turkpurva, Mathila, Nayabazar, Lalganj, Dafadehri, Barki Basauli, DKB Gaon, Ismilepur, Chunni.

Table 63. OFTs conducted at KVK, Buxar

OFT Topic	Area (ha.)/ no.	No. of beneficiaries	Place
Thrips management in onion	1.0	06	Jagdishpur
Assessment and refinement of IPN Module on okra crop	3.0 ha	12	Gajadharganj
To access the SRI methods for transplanting of rice for higher yield	0.6 ha	10	Pawani
Evaluation of submergence-tolerant cultivars under different rice production technology	0.5 ha	05	Kukurah, Bishrampur
Submergence/Drought-prone environment Partner's sites	0.5 ha	05	Jagdishpur, Boxa, Pawvani
Varietal performance of okra (var. A. Anamika, Asha Pragati)	0.5 ha	10	Pawani, Kathrkhurd, Boxa, Churamanpur
Varietal performance of high yielding varieties of bottle gourd	0.50 ha	10	Pavai, DalsagarNayabhojpur
Varietal performance of high yielding varieties of cow pea (var. Pusa Komal and Kashi Kanchan)	1.0 ha	10	Kamarpurchhotka, Dhakaich, Dulahpur
Assessment and refinement of different doses of sulphur on onion crop (var. Pusa Red)	0.5	10	Dalsagar, Pavai, Nidhua
Effect of Boron in yield of onion (var. Pusa Red)	0.5	10	Dalsagar, Pavai, Nidhua
To assess the yield performance of garden pea variety	0.6	10	Kukurah
Assessment of chemical fungicide for the management of false smut in rice	1.5	04	Jagdishpur
Weed management in chickpea	1.0	08	Pawani, Boxa, Bisrampur
INM in chickpea	0.5	08	Chunni, Jagdishpur
Weed management in wheat	0.8	08	Pawani, Baruna
Micro nutrient management in lentil	1.10	10	Pawani
Assesment of new strain of Tricoderma against wilt disease in lentil.	1.0	04	Kukurah
Nutrient expert recommendation on wheat yield by the IPNI	1.0	05	Bharchakia, Bishrampur
INM in Japani podina (Mentha)	1.2 ha	12	Bharchakia, Bishrampur
Under IRRAS Projects			
On farm testing of trichoderma strains for increasing lentil productivity	0.5 ha	05	Kukurah, Pawani, Manjharia, Chkki
Evaluation of performance of wheat varieties under zero and conventional method of sowing	1.0	05	Chunni, Pawani, Kukurah

Table 64. Other extension activities/ lecture delivered/ Kisan Mela

Topic	Total
Methods for soil sample collection in soil testing training programme organized by ATMA Buxar	155
Training programme on Soil testing at Kukurha sponsored by IFFCO, Buxar	30
Training on Dry land farming at Jyoti Library sponsored by Dr. Bhim Rao Ambedker Dalit Vikas Sansthan Buxar	50
Training on IPM on Paddy under ATMA, Buxar	150
Training on LCC (Nitrogen management through leaf color chart) in Paddy under ATMA, Buxar.	130
Crop residue management through farm implements under ATMA, Buxar.	210
Delivered a lecture on Kisan Pathsala on toipic "IPM in Rice through SRI method" .	25
Training on IFM at Devariya under ATMA, Buxar	250
Training on IFM at Dhansoi under ATMA, Buxar.	250
Participated in Krishi Yantrikaran Mela organised by Agriculture department, Buxar.	500
Nutrient Management in rabi pulses organised by ATMA, Buxar	130
Rabi workshop on district level and training programme	150
Early sowing of Wheat by zerotillage conducted by CSISA, Buxar.	50
Field day on Bajra production	43
Scientists-farmers introduction on RCT sponsored by CSISA.	200
Participation in Rabi Mahotsav in different blocks as well as district headquarter in the month of November, 2014.	1000
Participation in Krishi Yantrikaran Mela at Kila Maidan, Buxar	200
Participation in Kisan club opening ceremony at Kamarpur, Buxar.	150
Total	**3673**

Consultancy, Patents and Commercialization of Technology

Trademark "SWARNA" was filed with below given logo, TM Application No. 2833351 dated 28.10.2014 (Fig. 128).

Fig. 128. Trademark "Swarna" filed by ICAR RCER, Patna

PPV & FRA and Farmers Variety Application are filed depicted in Table 65-67.

Table 65. PPV&FRA applications filed

Name of variety	Registration number	Date
Swarna Mukti (Garden Pea)	Awaiting	08.09.14
Swarna Anmol (Tomato)	REG/2014/1475	11.07.14
Swarna Vijaya (Tomato)	REG/2013/1094	18.11.13

Table 66. Farmer's Variety Application filed

Crop	Farmer's name and address	Date
Cucumber	Robert Ekka Chhota Ghagra (Village), P.S-Doranda, Ranchi-834002	17.01.2015
Paddy	Vinod Prakash Ekka & Group Bada Ghagra Village, Maga Bagaicha, Ranchi	31.01.2015
Paddy	Sanchariya Kachap & Group Bada Ghagra Village, Maga Bagaicha, Ranchi	31.01.2015
Paddy	Anil Kachap Chota Ghagra Village, P.O-Hinoo , P.S-Doranda, Ranchi	31.01.2015

Table 67. Distribution of makhana seed (Swarna Vaidehi) in the year 2014-15.

Address of beneficiaries	Date	Amount of seed (kg)
Assistant Director, Horticulture, Purnea	17.12.2014	05.00
Farmer (Satyadeo) of Laxmi Nagar, Delhi	09.12.2014	01.00
Farmer (Bhola Mahaldar) of Rangpura, Distt.- Purnea	26.11.2014	05.00
Rajeshwari Sahu, SMS, KVK, Dhamtari (C.G)	13.11.2014	10.00
Farmer (Hemant Jha) of Village-Jhajha, Distt-Darbhanga	01.12.201	20.00
Farmer (Shatrughan Sahani), Village-Chak Bhawani, Distt.- Darbhanga	01.12.2014	30.00
Farmer (Prakash Ram), Vill.-Ranipur, Distt.- Darbhanga	12.01.2014	8.00

Animal Health Camp Organized

Table 68. Animal health camps organized at different villages

Particulars of Animal Health Camp	Date
Animal health and fish farming camp at village of Sheohar district, Bihar	30.01.2014
Animal health and fish farming camp at village of Muzaffarpur district, Bihar	11.03.2014
Fatepur, Mubarakpur and Baradeswar village of Bhadrak district, Odisha	02.05.2014
Uttar Simlabari village of Alipurduar district of West Bengal	05.05.2014

Awards & Recognitions

- Bikash Das, B. P. Bhatt, A. K. Singh and R.S. Pan received prestigious Fakhrudddin Ali Ahmed Award 2013 for Outstanding Research in Tribal Farming System (Fig.129).
- Arun Kumar Singh was conferred Fellowship by Confederation of Horticulturists Association of India, New Delhi

Fig. 129. Dr. Bikas Das receiving Fakhrudddin Ali Ahmed Award 2013 Award from Hon'ble Union Minister of Agriculture, Govt. of India

- Santosh Kumar received "Young Scientist Award" by the Society for Scientific Development in Agriculture and Technology (SSDAT), Meerut (U.P) for his outstanding contribution in the field of plant breeding on the occasion of "National Conference on emerging challenges and opportunities in biotic and abiotic stress management (ECOBASM 2014) during 13-14 December, 2014 at DRR, Hyderabad.
- Santosh Kumar was recognized as Associate Editor of "Journal of AgriSearch" for the period of 01.01.2015 to 31.12.2015.
- A.K. Singh was awarded "ISA Associateship-2012" by Indian Society of Agronomy on 18th November, 2014 during 20th National Conference held at PAU, Ludhiana.
- Ajay Kumar received the best paper award in oral presentation in "6th International Conference on Bioscience Research for Nutritional Security, Environmental Conservation & Human Health in Rural India" held at Indian Institute of Natural Resin and Gum, Ranchi from 22-24 December, 2014.
- Shanker Dayal acted as Editor of "*American Journal of Medical and Biological Research*" and "*Journal of Animal Health and Production*"
- Shanker Dayal acted as reviewer for *Indian Journal of Animal Science, Journal of Applied Animal Research, Indian Journal of Experimental Biology* etc.
- Pankaj Kumar acted as editor: *Research & Reviews: Journal of Veterinary Science and Technology*
- Pankaj Kumar acted as editor: *International Journal of Livestock Research.*
- Pankaj Kumar acted as editorial Board member: *Advances in Animal and Veterinary Sciences.*

- Pankaj Kumar acted as Secretary, Indian Society for Veterinary Medicine (Bihar Chapter)
- Rajni Kumari received Best Oral Presentation award at National Conference of Indian Association of Women Veterinarians and National Seminar on"Livestock Breeding Strategies for Productivity Enhancement towards Rural Prosperity" held on August 26-28, 2014 at Anand, Gujarat.
- U.R. Sangle received the best Poster Presentation award for poster presented on "Management of gram pod borer Helicoverpa armigera (Hubner) in chickpea through biopesticides" at International Symposium on " Role of fungi and microbes in the 21st Century- a Global Scenario" organized by Indian Mycological Society, Kolkata held from February 20-22,2014.
- A.K. Choudhary received "Distinguished Scientist Award" during the National Conference organized jointly by Society for Scientific Development in Agriculture and Technology (SSDAT), Meerut, Astha Foundation, Meerut and Directorate of Rice research (DRR), Hyderabad during December 13-14, 2014.
- A.K. Choudhary contributed to SABRAO Journal of Breeding and Genetics as its Associate Editor.
- A.K. Choudhary acted as the reviewer for Indian Journal of Agricultural Sciences.

Education and Training of Staff Undertaken in India/ Abroad

- Sanjeev Kumar attended International training Programme on 'Basic Experimental Design and Data analysis' at IRRI, Philippines w.e.f. 02-07 February, 2014.
- Sridhar Gutam visited Bioversity International, Rome, Italy. To work on a proposal "Securing Food and Nutritional Security through Subtropical Fruits in India" with grants from under CGIAR International Science and Partnership Council (ISPC) w.e.f. 3-19 September, 2014.
- Sridhar Gutam participated in OpenCon 2014 - the student and early career researcher conference on Open Access, Open Education, and Open Data. Washington, DC., United States of America w.e.f. 15-17 November, 2014.
- Snatashree Mohanty attended Professional Attachment Training at CIFA, Bhubaneswar, w.e.f. 12th May to 18th August, 2014.
- Tarakeshwar Kumar attended Professional Attachment training at CIFA, Bhubaneswar, w.e.f. 17th November, 2014 to 16th February, 2015.
- Tshering Lhamu Bhutia attended Professional Attachment Training at NBPGR, New Delhi w.e.f. 19th November, 2014 to 18th February, 2015.

Linkages and Collaborations in India/ Abroad

- AAU, Khanapara, Assam
- Animal and Fishery Resource Department, Govt. of Bihar
- BAIF, Bihar
- Bihar Veterinary College, Patna
- Birsa Agricultural University, Ranchi
- Cereal Systems Initiative for South Asia (CSISA)
- CIRB, Hisar
- CIPHET, Ludhiana
- COMFED, Patna
- Department of Biotechnology, Govt. of India
- Establishment of Piggery unit with Birsa Agricultural University, Ranchi
- IGFRI, Jhansi
- Integrated Farming System with IIFSR, Modipuram, Meerut (U.P.).
- Improved Rice-Based Rainfed Agricultural System IRRAS
- IVRI, Izatnagar and Kolkata
- Ministry of Water Resources, Govt. of India
- NRC on Pig, Guwahati
- R.K.Sevashram, Bhadrak, Odisha
- Rajendra Agricultural University, Pusa.
- Stress Tolerance Rice for Africa and South Asia (STRASA–Phase II) with IRRI, Philippines.
- Submergence and drought stress tolerance in rice with DRR, Hyderabad and CRRI, Cuttack.
- NABARD
- Testing of basic slag for amendment of acid soil with Tata Steel, Jamshedpur
- UBKV, Coochbehar, West Bengal
- Water Resources Department, Govt. of Jharkhand
- KVK, Supaul

- KVK, Saharsa
- KVK, Purnea
- KVK, Katihar
- KVK, Darbhanga
- Rajendra Agricultural University, Pusa, Samastipur, Bihar
- Bihar Agriculture Management Extension and Training Institute (BAMETI), Patna
- NGO, Dhamthari, Chhatisgarh
- ATMA, Buxar
- IFFCO, Buxar

Participation in Conference/Seminar/ workshops/Symposia/Meetings

Bharati, R.C. participated in 3rd National Knowledge Network Annual Workshop held at Indian Institute of Technology, Guwahati from 15th to 17th December, 2014.

Chandran, P.C. attended Launching and Planning Workshop of CCAFS Flagship Projects on "Climate Smart Agriculture: Practices Portfolios, Institutions and Policies" jointly organized by CIMMYT, IFPRI and CCAFS held at NASC Complex, New Delhi during 24-25th February, 2015.

Chandran, P.C. attended NAAS Silver Jubilee Symposium "Technology – Policy Integration for Pushing Livestock Sector Growth and Productivity" held at Assam Agricultural University, Jorhat, Assam during 12-13th January, 2015.

Chandran, P.C. participated in ICAR-NAVS Expert Consultation Meet on "Strategies for Enhancing Milk Productivity of Indigenous Cattle" held at NASC Complex, New Delhi on 20th October, 2014.

Choudhary, A.K. participated in National Conference on "Emerging Challenges and Opportunities in Biotic and Abiotic Stress Management" at Directorate of Rice Research, Rajendranagar, Hyderabad during 13-14 December, 2015.

Choudhary, Jaipal Singh participated in International Conference on "Changing Scenario of pest problems in agri-horti ecosystem and their management" held at MPUAT, Udaipur during 27-29th November, 2014.

Das, Bikash attended Annual Review Workshop of NICRA, held at New Delhi during 3-5th June, 2014.

Das, Bikash attended the Expert Committee Meeting of "Horticulture and Pest Dynamics, NICRA" at IIHR, Bangalore on 6th April, 2014.

Dayal, Shanker attended International Symposium on "Sustainable Management Of Animal Genetic Resources for Livelihood Security in Developing Countries" held at TANUVAS, Chennai during 13-14th February, 2015.

Dey, A. and Gupta, J. J. participated in meeting on "Cerebration on Fodder Production" held at IGFRI, Jhansi on 17th November, 2014.

Dey, A. participated in meeting on "Research Prioritization and reconciliation in Eastern Region held at ICAR Research Complex for Eastern Region, Patna on 28th May, 2014.

Jha, B.K. participated in "6th Indian Horticulture Congrss-2014" organized by Indian Horticulture Society of India, New Delhi held at Coimbatore, Tamil Naidu during 6-9th November, 2014.

Kumar, Abhay attended NAAS – IFPRI Brainstorming meeting on Developing PME indicators and mechanisms in NARS held at NASC Complex, New Delhi on 12th August 2014.

Kumar, Abhay attended Policy Consultation Workshop on "A Food Secure Bihar: Challenges and Way Forward" jointly organized by A. N. Sinha Institute of Social Sciences (ANSISS), Patna and International Food Policy Research Institute, New Delhi at ANSISS, Patna, Bihar on August 06th, 2014.

Kumar, Abhay attended Stakeholder Workshop on "Small-holder Dairy Value Chain Transformation in Bihar – Challenges, Opportunities and the Way Forward" organized by International Livestock Research Institute, New Delhi at Hotel Maurya, Patna during August 01-02, 2014.

Kumar, Abhay attended Symposium on "Transformation in Rural Economy and Employment Opportunities in Eastern India" organized by ICRISAT, Hyderabad in collaboration with Institute for Human Development, New Delhi on 17th December 2014 at BIT, Mesra, Ranchi (Jharkhand).

Kumar, Abhay participated in 8th Asian Society of Agricultural Economists (ASAE) International Conference and Review Meeting of VDSA Project organized at Dhaka, Bangladesh from 13-18th October, 2014.

Kumar, Abhay participated in the Annual Review Meeting of VDS Projects organized at ICRISAT, Hyderabad on Dec. 13th, 2014.

Kumar, Ajay attended International Seminar on "Integrating Agriculture & Allied Research: Prioritizing Future Potentials for Secure Livelihoods" held at BCKV, Mohanpur, West Bengal during 6-9th November, 2014.

Kumar, Ajay; Singh, I.S.; Bhavana, P. and Mondal, S. attended International Conference on "Bioscience Research for Nutritional Security, Environmental conservation and Human health in rural India" organized by MEST-ICCB, Ranchi and IINRG, Ranchi during 22- 24th December, 2014.

Kumar, Pankaj attended and acted as Rapporteur in "XXXIII Annual Convention of Indian Society for Veterinary Medicine (ISVM)" held at Pookode, Kerela during 22-24 January, 2015.

Kumari, Rajni participated in National Seminar on "Livestock Breeding Strategies for Productivity Enhancement towards Rural Prosperity" held at Anand, Gujarat during 26-28th August, 2014.

Maurya, Sudarshan participated in "Training on Plant Genetic Resource Management in Mango and Guava" at CISH, Lucknow, UP during 6-7th March, 2014.

Maurya, Sudarshan participated in Annual workshop on "All India coordinated workshop on Mushroom" at Rajendra Agricultural University, Pusa, Samastipur, Bihar during 20-21st March, 2014.

Mishra, J. S. and Chandran, P. C. participated in the launching and planning workshop of CCAFS flagship project on Climate Smart Agricultural Practices, Priorities and Policies at NASC Complex, New Delhi during 24-25th February, 2015.

Mondal, S. attended winter school on "Soil-Plant-Water Relations under Conservation Tillage Practices for Sustainable Agriculture" at IARI, New Delhi during 4-25th November, 2014.

Mondal, S. participated in "CSISA's Objective 2 Review and Planning Meeting" held at New Delhi during 9-10th October, 2014.

Sarma, Kamal attended in "10th Indian Fisheries and Aquaculture Forum" held at NBFGRI, Lucknow during 12-15th November, 2014.

Singh, A. K. participated in "20th National Conference" organized by Indian Society of Agronomy held at PAU, Ludhiana during 18-20th November, 2014.

Singh, A.K. attended "Annual Zonal Meeting of ZTMC, East Zone" at NIRJAFT, Kolkata on 12th September, 2014.

Singh, A.K. attended "Global Conference on Technological Challenges and Human Resources for Climate Smart Horticulture- Issues and strategies" and Annual General Council Meeting of CHAI at NAU, Navsari, Gujrat on 29th May, 2014.

Singh, A.K. attended National Conference on "Pre/Post harvest losses and Value addition in vegetables" at IIVR, Varanasi on 12th July, 2014.

Singh, I.S. participated in XII Agricultural Science Congress on "Sustainable Livelihood Security for Smallholder Farmers" at ICAR-NDRI, Karnal, Haryana during 03–06th February, 2015.

Singh, S.K. attended national conference on " System of Rice intensification Research issues, priorities and prospects" organized by Livolink Foundation, Bhubaneswar and supported by Sir Dorabji Tata Trust and Allied Trusts, Mumbai, held in Bhubaneswar during 12-13th August, 2014.

Singh, S.K. attended Workshop on "Agriculture based occupation in Madhepura, Bihar" organized by Jan Utthan Sangh, New Delhi during 16-17th February, 2014.

Thakur, A.K. participated in 49th Annual Convention of ISAE and Symposium on Engineering Solutions for Sustainanble Agriculture and Food Processing, College of Agricultural Engineering Technology, Punjab Agricultural University, Ludhiana, Punjab during 23-25 February, 2015.

Upadhyaya, A. participated in discussion with officials of NRSC at Regional office, Kolkata and Head office, Hyderabad during 6-9th August, 2014.

Upadhyaya, A. participated in Koshi Basin Programme (KBP) Partners Forum Meeting at ICIMOD, Kathmandu, Nepal during 12-13th June, 2014.

Upadhyaya, A. participated in Workshop for the project entitled "Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains" in Kathmandu, Nepal during 17-19th September, 2014.

New Entrants, Selection, Promotion, Transfer and Retirements

Joining

Mr. Ved Prakash, Scientist w.e.f. 09.04.2014

Ms. Snatashree Mohanty, Scientist (Fish Health) w.e.f. 09.04.2014

Dr. A.K. Choudhary, Principal Scientist (Genetics and Plant Breeding) joined at ICAR RCER Research Centre for Makhana, Darbhanga w.e.f. 10.05.2014
Dr. Sridhar Gutam, Sr. Scientist w.e.f. 03.06.2014
Sh. Pradip Kumar Sarkar, Scientist w.e.f. 16.08.2014
Sh. Mahesh Kumar Dhakar, Scientist w.e.f. 25.08.2014
Miss Anuradha Srivastava, Scientist w.e.f. 25.08.2014
Dr. Tarakeshwar Kumar, Scientist (Aquaculture) w.e.f. 12.10. 2014.
Ms. Tshering Lhamu Bhutia, Scientist w.e.f. 13.10.2014
Dr. S. K. Gupta, Scientist (Vet. Microbiology) w.e.f. 10.11.2014 on transfer from IVRI, Izatnagar
Dr. Rajvir Sharma, Principal Scientist (Agronomy) joined as Head, ICAR RCER Research Centre for Makhana, Darbhanga w.e.f. 10.11.2014
Dr. J.S. Mishra, Principal Scientist (Agronomy) joined as Head, Division of Crop Research w.e.f. 27.11.2014.

Joining from study leave

Dr. S. J. Pandian, Scientist, w.e.f. 05.06.2014
Er. Santosh S. Mali, Scientist w.e.f. 01.08.2014

Promotions

Scientists

Dr. A. K. Thakur from RGP Rs.9000 to 10000 w.e.f. 11.02.2010
Dr. B.K. Chaudhary from RGP Rs. 6000 to 7000, w.e.f. 08.01.2011
Dr. Bikash Das from RGP Rs.8000 to 9000 w.e.f. 22.06.2012
Dr. (Mrs.) P. Bhavana from RGP Rs.6000 to 7000 w.e.f. 21.04.2013
Dr. Santosh Kumar from RGP Rs. 6000 to 7000 , w.e.f. 23.06.2013
Dr. S.K. Nayak from RGP Rs. 8000 to 9000, w.e.f. 31.03.2014
Dr. Shankar Dayal from RGP Rs. 8000 to 9000, w.e.f. 15.04.2014
Dr. Sridhar Gutam from RGP Rs.8000 to 9000 w.e.f. 09.05.2014
Dr. A.K. Singh from Pr. Scientist to Head w.e.f. 05.11.2014

Technical

Er. M. L. Swarnkar, ACTO to CTO, w.e.f. 06.09.2011
Sh. Madi Lakra T-2 to T-3 (Driver) w.e.f.29.06.2011
Sh. H.P. Kashi, T-2 to T-3 (Pump House Operator) w.e.f. 29.06.2011
Dr. G.P. Singh, ACTO to CTO w.e.f. 16.07.2012
Sh. Om Prakash, T.O to Sr. T.O. w.e.f. 26.09.2012
Sh. Kishan Singh ACTO to CTO, w.e.f. 01.07.2013
Sh. Dilip Kumar STO to ACTO, w.e.f. 11.04.2014
Sh. Suresh Kumar, TO to STO, w.e.f. 30.07.2014

Administration

Sh. Kamal Kumar Lal, PA to JAO, w.e.f. 09.02.2015
Sh. Firoz Akhtar, UDC to Asst., w.e.f. 16.03.2015
Sh. Bharat Ram, UDC to Asst., w.e.f. 21.03.2015

Transferred

Internal

Dr. B.R. Jana, Scientist transferred to RCM, Darbhanga w.e.f. 27.05.2014
Dr. A.K. Thakur, Pr. Scientist transferred to RCM, Darbhanga w.e.f. 27.05.2014
Dr. Asit Chakrabarti, Sr. Scientist transferred to RC, Ranchi w.e.f. 02.01.2015
Sh. Murari Maharaj, T-3 (Jeep Driver) transferred to RCM, Darbhanga w.e.f. 02.06.2014.

Outside

Sh. V.K. Rai, JAO transferred to NBPGR, New Delhi w.e.f. 16.06.2014
Dr. B. K. Chaudhary, Scientist (Fish & Fishery Science) w.e.f. 15.11.2014
Dr. A. Haris, Principal Scientist (Agronomy) w.e.f. 18.12.2014

Retirement

Scientific

Dr. Alok Kumar Jain, Sr. Scientist w.e.f. 31.08. 2014
Dr. R.D. Singh, Principal Scientist (Agronomy) w.e.f. 30.09.2014

Technical

Sh. M.N. Choudhary, w.e.f. 31.10.2014
Sh. Kishore Kumar, T.O. (Driver) w.e.f. 28.02.2015

Administration

Sh. Matlu Hussain, LDC w.e.f. 30.09.2014
Smt. N.D. Barla, Private Secretary w.e.f. 28.02.2015

Supporting

Sh. Atma Ram, SSS (Messenger) w.e.f. 31.05.2014
Sh. Suresh Ram, SSS (Safaiwala) w.e.f. 31.01.2015

VRS

Sh. Chandan Hembrom, Sr. Technician (Farm) w.e.f. 11.06.2014
Sh. Mahadeo Toppo w.e.f. 05.12.2014
Sh. Bandhu Mahli w.e.f. 01.01.2015
Sh. Siril Oraon w.e.f. 01.01.2015

17 Publications

Research Papers

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Chandran, P. C.; Dey, A.; Barari, S. K.; Kamal, Reena; Bhatt, B. P. and Prasad, R. E. (2014). Characteristics and performance of Bachaur cattle in the Gangetic plains of North Bihar. *Indian Journal of Animal Sciences*, **84**(8): 872-875.

Chandran, P. C.; Dey, A.; Barari, S. K.; Kamal, Reena; Dayal, S. and Chakrabarti, A. (2014). Socio-economic status of farmers rearing Bachaur cattle in its habitat under middle Gangetic plains. *Indian Journal of Animal Sciences*, **84**(12): 1300-1303.

Chandran, P.C.; Verma, S.B.; Dey, A.; Kamal, Reena and Chakrabarti, A. (2015). Non-genetic factors affecting the body weight of Shahabadi lambs. *The Indian Journal of Small Ruminants*, **21**: 17-19.

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Choudhary, A. K. and Singh, I. P. (2015). A study on comparative fertility restoration in A2 and A4 cytoplasms and its implication in breeding hybrid pigeonpea [(*Cajanus cajan* (L.) Millsp.]. *American Journal of Plant Sciences*, **6**(2): 385-391. (http://dx.doi.org/10.4236/ajps.2015.62044)

Choudhary, J.S.; Naaz, N.; Mukherjee, D.; Prabhaker, C.S.; Sudarshan, Maurya Das, B. and Kumar, S. (2015). Biodiversity and seasonality of predacious coccinelids (Coleoptera: Coccinellids) in mango agro-ecosystem of Jharkhand. *The Ecoscan*, **8**: 53-57.

Choudhary, J.S.; Srivastava, C. and Walia, S. (2014). Screening for antifeedant activity of gymnema sylvestre leaf extracts against *Spodoptera litura* f. (Lepidoptera: Noctuidae). *The Bioscan*, **9**(2): 633-638.

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Extension folder

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18 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 Extd.Mar. 2015	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 Extd. June 2016	ICAR RCER
1.3	ICAR-RCER/ RC Ranchi/ 2011/ **25(iii)**	Development of location specific Integrated Farming System models for rainfed ecosystem of Eastern Plateau Hill region	B. K. Jha A. K. Singh Reshma Shinde	June 2011	May 2014	ICAR RCER
1.4	ICAR-RCER/ R.C Makhana/ 2011/ **117**	Dynamics of nutrients under makhana and makhana based cropping system grown in inceptisols of Bihar	I. S. Singh V. K. Gupta L. Kumar	April 2012	Mar. 2015	ICAR RCER
1.5	ICAR-RCER/ RC Ranchi/ 2014/**145**	Farmers Participatory Evaluation of Basic slag in Acidic soils of Jharkhand under different cropping systems	S. K. Naik Reshma Shinde A. K. Singh	July 2014	June 2017	Tata Steel
1.6		Introduction of sweet flag and tuber vegetable crop under wetland ecosystem with makhana crop for north Bihar	V.K. Gupta L. Kumar	July 2014	June 2017	ICAR RCER
1.7	ICAR-RCER/ DLFM/ 2014/**155**	Optimization of production efficiency of fish-livestock integrated farming system	Kamal Sarma A. Dey Snatashree Mohanty S. Mondal Tarkeshwar Kumar	Aug. 2014	July 2017	ICAR RCER
1.8	ICAR-RCER/ DLFM/ 2014/**143**	Multiplication and production profiling of improved pig and poultry germplasm under Backyard farming system	Reena Kumari Kamal	July 2014	June 2019	ICAR RCER
1.9	ICAR RCER/RC Ranchi/2014/147	Development of multi-tier cropping system for rainfed uplands of eastern plateau and hills	M.K. Dhakar Bikash Das Reshma Shinde	September 2014	September 2019	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 Extd. May 2015	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
3	**Climate Resilient Agriculture**					
3.1	ICAR-RCER/ RC Ranchi/ 2011/**29**	Understanding the changes in host-pest interactions and dynamics in mango under climate change scenario (NICRA) (2011 -2013)	Bikash Das J.S. Choudhary S. Maurya A. Abdul Haris	Jan. 2011	Jan. 2014	NICRA (Externally funded)
3.2	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
3.3	ICAR-RCER/DCR/ 2014/**144**	Impact of elevated CO_2 and temperature on growth and yield of rice-wheat cropping system under predicted climate change scenario.	S.K. Dwivedi	July 2014	June 2017	ICAR RCER
4.4	**New**	Sustainable and Resilient Farming System Intensification (SRFSI) in Eastern Gangatic Plains	Ujjwal Kumar Rajvir Sharma S.K. Singh A.K. Choudhary Bikash Sarkar S. Mondal Ved Prakash	October 2014	June 2018	ACIAR (Externally funded)
Theme- 2. Genetic Resource Management and Improvement of Field, Horticultural and Aquatic crops						
4	**Varietal Development**					
4.1	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 Extd. June 2015	ICAR RCER
4.2	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 Extd. March 2019	IRRI (Externally funded)
4.3	ICAR-RCER/ EF/ IRRI/2012/**33**	Improved Rice based rainfed Agricultural System (IRRAS) in Bihar State, India	A. Abdul Haris Santosh Kumar A. K. Singh U. R. Sangle	July 2012	June 2015	(Externally funded by IRRI)
4.4	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
4.5	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
4.6	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 Extd. 2017	ICAR RCER
4.7	ICAR-RCER/ RCR/2012/**132**	Collection, characterization and evaluation of potentials wild edibles including tuber crops	R.S. Pan Bikash Das Reshma Shinde	Apr. 2013	Mar. 2018	ICAR RCER
4.8	ICAR-RCER/ DCR/ 2013/ **136**	Characterization of wheat (*Triticum aestivum L.)* genotypes for terminal heat stress tolerance	S.K. Dwivedi Santosh Kumar Sanjeev Kumar	July 2013	June 2016	ICAR RCER
4.9	ICAR-RCER/DCR/ 2014/**142**	Evaluation and identification of rice genotypes for tolerance to drought stress at different growth stages.	Santosh Kumar	July 2014	June 2018	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
4.10	**New**	Development of high yielding rice genotypes with submerge tolerance for rainfed lowlands	N. Bhakta	July 2014	June 2018	ICAR RCER
4.11	ICAR-RCER/ RC Ranchi/ 2014/ **153**	Phenotyping abiotic stress tolerant traits in solanaceous crops	Sridhar Gautam P. Bhavana Reshma Shinde	Aug. 2014	July 2017	ICAR RCER
Theme- 3. Improved Production and Protection Technologies for Agri-Horti Crops						
5	**Production Technologies**					
5.1	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 Extd. 2015	ICAR RCER
5.2	ICAR-RCER/ DC/ 2011/ **104**	Evaluation of different production system for Carbon sequestration potential	A. Haris A. S. Mondal S.K. Naik S. Maurya	July 2011	June 2015	ICAR RCER
5.3	ICAR-RCER/ DLWM/ 2012/**130**	Evaluation of vegetable varieties under different irrigation methods	Shivani A.K. Singh R.D. Singh M. Idris	Sept. 2012/ Initia-ted in 2014	Aug. 2017	ICAR RCER
5.4	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
5.5	ICAR-RCER/ DLWM/ 2013/ **137**	Design and performance evaluation of low cost green house suitable for vegetable production in Bihar and Jharkhand	Bikash Sarkar A. Upadhyaya P.K. Sundaram N. Chandra	2013	2014	ICAR RCER
5.6	ICAR RCER/ RCR/2013/ **139**	Evaluation of spike production of Dendrobium hybrid under protected conditions in Jharkhand	S.K. Naik S. Maurya J.S. Choudhary	Nov. 2013	Oct. 2014 Extd. 2016	ICAR RCER
5.7	**New**	Sustainable crop intensification through the development of suitable plant type in cool season pulses under rice-fallow and makhana - fallow cropping system in Eastern India	A.K. Choudhary I.S. Singh	July 2014	June 2017	ICAR RCER
5.8	**New**	Development of value-added product of makhana.	A.K. Thakur	July 2014	June 2017	ICAR RCER
5.9	ICAR-RCER/ RC Makhana/ 2014/156	Response of some macro and micronutrients on the production potential of makhana crop growing under field condition in northern Bihar.	I.S. Singh L. Kumar	July 2014	June 2017	ICAR RCER
5.10	ICAR-RCER/ RC Ranchi/ 2014/151	Standardization of basin enrichment in high density orchards of bael, sapota and guava under eastern plateau and hill region	Bikash Das P. K. Sarkar	Aug. 2014	July 2017	ICAR RCER
5.11	**New**	Evaluation of decomposition rate of different organic mulch and nutrient availability in Rice-tomato cropping system	Reshma Shinde	July 2014	June 2017	ICAR RCER
5.12	ICAR-RCER/ RC Ranchi/ 2014/152	Nutritional characterization and value addition of potential under utilized leafy vegetables of Jharkhand	Anuradha Srivastava	September 2014	September 2017	ICAR RCER
5.13	ICAR-RCER/ RC Ranchi/ 2014/154	Study on decomposition rate of different organic substrate and their nutrient release pattern	Reshma Shinde	July 2014	July 2015	ICAR RCER
6	**Protection Technologies**					
6.1	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

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
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/ 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 Extd. Dec. 2015	ICAR RCER
Theme- 4. Integrated Land & Water Management						
7.	**Land & Water Management**					
7.1	ICAR-RCER / DLWM/ 2011/ **102**	Refinement of LEWA for its better performance	Ajay Kumar A. Upadhyaya	July 2011	Dec. 2013 Ext. Sept 2014	ICAR RCER
7.2	ICAR-RCER / DLFM / 2010/ **118**	Diversification of fish farming system to maximize the water productivity	Binod Kumar Choudhary	April 2012	March 2015	ICAR RCER
7.3	ICAR-RCER/ DLWM/ 2013/ **138**	Rice - fallow management	S.K. Singh Abdul Haris A. S. Mondal Manibhushan Ajay Kumar S.K. Naik A. Upadhyaya	2013	2016	ICAR RCER
7.4	New	Development of bio-drainage in participatory mode under waterlogged area	S.K. Singh S.K. Dwivedi Ajay Kumar	July 2014	June 2022	ICAR RCER
7.5	ICAR-RCER/ RC Ranchi/ 2014/149	Participatory management of rice-fallow in eastern plateau and hill region	A. K. Singh B.K. Jha Bikash Das R S Pan Reshma Shinde P. Bhavana	July 2014	June 2017	ICAR RCER
7.6	New	Application of optimization techniques in planning and management of land, water and other resources	A. Upadhyaya Manibhushan A. Rahman	July 2014	June 2017	ICAR RCER
7.7	New	Flood and drought mapping in Eastern region	Manibhushan A. Upadhyaya	Sept 2014	Aug. 2017	ICAR RCER
7.8	New	Optimization of water productivity of aerobic rice based cropping system	S.K. Singh Ajay Kumar	July 2014	June 2017	ICAR RCER
7.9	New	Solar energy utilization in drip irrigation system, aerator for fish pond, humidifier and washing system for dairy management.	A. Rahman A. Dey Kamal Sarma Ajay Kumar Bikash Das B. Sarkar	Aug. 2014	July, 2017	ICAR RCER
7.10	ICAR-RCER/ RC Ranchi/ 2014/148	Evaluation of hydrological response of micro water sheds in eastern plateau and hill region	S.S. Mali S.K. Naik P.K. Sarkar	January 2015	June 2018	ICAR RCER
7.11	ICAR-RCER/ RC Ranchi/ 2014/150	Rehabilitation of coal mine affected area of Jharkhand through agroforestry interventions	P.K. Sarkar Reshma Shinde	September 2014	September 2017	ICAR RCER
Theme 5. Livestock & Fisheries Management						
8.	**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 K.M. Singh Rajni Kumari S. Bandopadhyay	Apr. 2011	Mar. 2015	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
8.2	ICAR-RCER / DLFM / 2011/ **91**	Network project: Growth performance of poultry and pig as influenced by phytase supplementation in eastern region	J.J. Gupta A. Dey K. Burman A. Chakrabarti	July 2011	June 2014	ICAR RCER
8.3	ICARRCER /DLFM / 2011/ **95**	Exploring Growth Hormone and prolificacy gene for improvement of growth performance traits in Black Bengal goat	S. Dayal S.P. Sahu Rajni Kumari	Aug. 2011	July 2014 Extd. July 2015	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	ICAR-RCER/ EF/DBT/ 2012/**34**	DBT Twining Programme on Elucidating the mechanisms involved in higher feed conversion efficiency of bovine species by expression of the genes regulating mitochondrial proton leak kinetics	A. Dey S. Dayal Rajni Kumari	Jan. 2013	Dec. 2015	DBT (Externally funded)
8.6	ICARRCER/DLFM/ EF/2011/ **31**	Buffalo improvement	P.C. Chandran A. Dey A. Chakrabarti Pankaj Kumar	June 2012	Dec. 2016	ICAR RCER
8.7	ICAR-RCER / DLFM / 2010/**103**	Adaptability and management study for poultry species in Bihar (Turkey, Quail and Vanaraja) in Bihar	A. Chakrabarti J.J. Gupta	April 2012	Mar. 2015	ICAR RCER
8.8	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, BVC S. Kumar, BVC P. Kumar, BVC	Feb. 2013	Jan. 2016	ICAR RCER
8.9	ICAR-RCER/ DLFM/ 2012/ **123**	Serological epidemiology of major viral pathogen of caprine in Bihar	Pankaj Kumar P.C. Chandaran R.K. Roy, KVK, Buxar K.K. Rajak, IVRI Manoj Kumar, BVC P. Shekhar, BVC	Mar. 2013	Mar. 2016	ICAR RCER
8.10	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
8.11	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
8.12	ICAR RCER/ DLFM/2014/141	Management of heat stress in buffalo	S. Dayal A. Dey S.J. Pandian	Jan. 2015	Jan. 2018	ICAR RCER
8.13	ICAR RCER/ DLFM/2014/140	Assessing stocking density of livestock under different land use system of fodder production.	J.J. Gupta A. Dey Reshma Shinde A. Chatterjee, NDRI, Kalyani centre	April 2015	Mar. 2019	Network project linkage NDRI Regional Station, Kalyani
8.14	New	Management strategies for optimum performance of improved and deshi breed of ducks	A. Chakrabarti	Jan. 2015	Dec 2017	ICAR RCER
8.15	ICAR RCER/ DLFM/2014/146	Development of herb-based calf care mix for production of disease free calf.	S.J. Pandian	Oct. 2014	Sept. 2017	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
8.16	ICAR RCER/DLFM/ EF/2014/35	Characterization of Red Purnea cattle.	P.C.Chandran Pankaj Kumar S.J. Pandian Reena Kumari Kamal	July 2014	June, 2016	NBAGR, Karnal
9.	**Fisheries Management**					
9.1	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
9.2	New	Optimization of production efficiency of fish-livestock integrated farming system	Kamal Sarma	Aug. 2014	July 2017	ICAR RCER
Theme 6. Socio-Economics, Extension and Policy Research						
10.	**Socio-economic Research**					
10.1	ICAR-RCER/ SEET/ 2011/ **111**	Risk proneness of major crops of eastern India	R.C. Bharati K.M. Singh N. Chandra	July 2011	June 2014 Extd. June 2015	ICAR RCER
10.2	ICAR-RCER/ E.F/2010/ **23**	Tracking change in rural poverty in village and household economics in south Asia.	Abhay Kumar R. C. Bharati A.K. Jha R.K.P. Singh	Jan. 2010	April 2014 Extd. April 2015	Bill & Melinda Gates foundation (Externally funded)
10.3	ICAR-RCER/ DSEE/ 2012/ **127**	Technology out-scaling for sustainable food production and livelihood improvement	Ujjwal Kumar Kamal Sarma A. Haris A. A. Dey B.K. Choudhary	Sept. 2013	Aug. 2015	ICAR RCER
10.4	ICAR-RCER/ DSEE/ 2012/ **134**	Tribal farming system in Eastern India	Ujjwal Kumar B.P. Bhatt R.S. Pan Bikash Das Bikash Sarkar A. Dey Kamal Sarma	Jan. 2013	Dec. 2015	ICAR RCER
10.5	New	Impact assessment of agricultural technologies in Eastern India	N. Chandra	Aug. 2014	July 2017	ICAR RCER
10.6	New	Growth and instability in production of principal crops in Bihar	Abhay Kumar	July 2014	June 2017	ICAR RCER

19 Contributors

Division of Land and Water Management

Scientists

Dr. A. Upadhyaya Pr. Scientist (SWCE) & Head
Dr. S. K. Singh, Pr. Scientist (Agron.)
Dr. A. Rahman, Pr. Scientist (Phy.)
Dr. Anil. Kr. Singh, Pr Scientist (Agron.)
Dr. Bikash Sarkar, Sr. Scientist (FMPE)
Dr. Ajay Kumar, Sr. Scientist (SWCE)
Sh. Manibhushan, Scientist(SS) (Comp. App.)
Mr. Surjit Mondal, Scientist (Soil Science)
Er. P.K. Sundaram, Scientist (FMPE) (Study leave)
Sh. M. K.Meena, Scientist (Soil Chem.)

Division of Crop Research

Scientists

Dr. J.S. Mishra, Pr. Scientist (Agronomy) & Head
Dr. Md. Idris, Pr. Scientist (Entomology)
Dr. Sanjeev Kumar, Pr. Scientist (Agronomy)
Dr. Narayan Bhakta, Sr. Scientist (Gen. & Plant Breeding)
Dr. U.R. Sangle, Sr. Scientist (Plant Pathology)
Dr. Santosh Kumar, Scientist (Plant Breeding)
Dr. S.K. Dwivedi, Scientist (Plant Physiology)
Sh. Ved Prakash, Scientist (Agril.Meteorology)
Dr. Tshering Lhamu Bhutia, Scientist (Veg. Science)

Technical Officer

Sh. Anil Kumar, Technical Officer (T-5)

Division of Livestock and Fishery Management

Scientists

Dr. A. Dey, Pr. Scientist (Animal Nutrition) & Head
Dr. J.J. Gupta, Pr. Scientist. (Animal Nutrition)
Dr. Kamal Sharma, Pr. Scientist (Fishery)
Dr. S. Dayal, Sr. Scientist (Animal Gen. & Breeding)
Dr. P. K. Ray, Scientist (Veterinary Pathology) (Study leave)
Dr. P.C. Chandran, Scientist (Animal Genetics and Breeding)
Dr. S. J. Pandian, Scientist. (Veterinary Medicine)
Mrs. Rajni Kumari, Scientist (Animal Biotechnology) (Study leave)
Dr. Pankaj Kumar, Scientist (Vet. Medicine)
Dr. Reena Kumari Kamal, Scientist (LPM)
Ms. Snatashree Mohanty, Scientist (Fish Health)
Dr. Tarkeshwar Kumar, Scientist (Aquaculture)
Dr. Santosh Kumar Gupta, Scientist (Vet. Microbiology)

Technical Officers

Dr. S. K. Barari, Chief Technical Officer (T-9)

Division of Socio-Economics and Extension

Scientists

Dr. Abhay Kumar, Pr. Scientist (Agril. Stat.) & Head
Dr. Ujjwal Kumar, Pr. Scientist (Agril. Extn.)
Dr. R.C. Bharti, Pr. Scientist (Agril. Stat.)
Dr. N. Chandra, Sr. Scientist (Agril. Econ..)
Dr. V. Dwivedi

Technical Officers

Sh. V.K.Tiwari, Technical Officer (T-5)
Sh. Sanjay Rajput, Technical Officer (T-5)

Performance Monitoring & Evaluation Cell

Dr. (Mrs) Shivani, Pr. Scientist (Agron.)

Technical Officer

Sh. Kishan Singh, Chief Technical Officer (T-9)
Sh. Sarfaraj Ahmad, Sr. Technical Assistant (Computer/T-4)

Farm Section

Sh. A. K. Khan, Farm Manager (T-9)
Sh. Hari Shankar, Asstt. Chief Technical Officer (T-7-8)
Sh. R.K. Tiwari, Technical Officer (T-5)
Sh. P.K. Singh, Technical Officer (T-5)

Workshop and Estate Section

Sh. M.L.Swarnkar, Workshop Engineer (T-9)

ICAR RCER, Research Centre, Ranchi

Scientists

Dr. A.K. Singh, Pr. Scientist (Horticulture) & Head
Dr. R.S. Pan, Pr. Scientist (Horticulture)
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. Sridhar Gutam, Sr. Scientist (Plant Physiology)
Dr. Asit Chakrabarti, Sr. Scientist (LPM)
Dr. (Mrs.) P. Bhavana, Scientist (Plant Breeding)
Dr. Jaipal Singh Choudhary, Scientist (Entomology)
Er. S.S. Mali, Scientist (CWC)
Ms. Reshma Shinde, Scientist (Soil Science)
Mr. Mahesh Kumar Dhakar, Sceintist (Fruit Science)
Ms. Anuradha Srivastava, Scientist (Food Technology)
Mr. P.K. Sarkar, Scientist (Agroforestry)

Technical Officers

Sh. G.P. Singh, Asstt. Chief Technical Officer (T-7-8)
Sh. Y.N. Pathak, Sr. Technical Officer (T-6)
Sh. D.K. Sah, Sr. Technical Officer (T-6)
Sh. Paul Sanjay Sircar, Sr. 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. Kushal Kesariar, Technical Officer (T-5)
Sh. Dhananjay Kumar, Technical Officer (T-5)
Sh. Chandra Shekher Prasad, Technical Officer (T-5)
Sh. Birendra Prasad Srivastava, Technical Officer (T-5)
Sh. Pradeep Kumar Singh, Technical Officer (T-5)
Sh. Suresh Kumar, Technical Officer (T-5)

ICAR RCER, Research Centre for Makhana, Darbhanga

Dr. Rajvir Sharma, Pr. Scientist & Head
Dr. V.K.Gupta, Pr. Scientist (Plant Breeding)
Dr. A.K. Choudhary, Pr. Scientist (Plant Breeding)
Dr. A.K. Thakur, Pr. Scientist (AS & PE)
Dr. I.S. Singh, Scientist (Soil Science)
Dr. B.R. Jana, Scientist (Horticulture)

ICAR RCER, Krishi Vigyan Kendra, Buxar

Subject Matter Specialist

Dr. R.C. Verma, SMS (Horticulture) & I/c PC
Dr. Deokaran, SMS (Soil Science)
Dr. Ramakrishna Roy, SMS (Animal Science)
Mr. Ramkewal, SMS (Plant Protection)
Dr. Mandhata Singh, SMS (Agronomy)
Dr. Hari Govind Jaiswal, SMS (Plant Breeding)

Technical

Sh. Arif Parwez, Farm Manager
Sh. Afroz Sultan, Programme Assistant (Lab. Tech.)
Sh. Vikash Kumar, Programme Assistant (Computer)

ANNEXURE - I

Results-Framework Document (RFD) for ICAR Research Complex for Eastern Region (2013 - 2014)

RFD for
ICAR Research Complex for Eastern Region
(2013 - 2014)

Section 1: Vision, Mission, Objectives and Functions

Vision

A broad based institutional framework to address diverse issues relating to land and water resources management, crop husbandry, horticulture, fishery, livestock and poultry, agro-processing, and socio-economic aspects in a holistic manner for enhancing research capability and providing a backstopping for improvement in agricultural productivity and sustainability in the eastern region.

Mission

Transform "Low Productivity – High Potential" eastern region into High Productivity region for food, nutritional and livelihood security in a manner that is environmentally sustainable and socially acceptable.

Poverty alleviation, livelihood improvement and women empowerment through income generation through on-farm and off-farm job opportunities and promote network and consortia research in the eastern region

Objectives

- To undertake strategic and adaptive research for efficient and integrated management of natural resources to enhance agricultural production, productivity and profitability in different agro-ecological zones of eastern region.
- Human resource development and capacity building

Functions

- 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 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 in the eastern region.
- 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 in promoting agriculture, horticulture, and livestock in the eastern region.
- Socio-economic evaluation and impact assessment of agricultural technologies.

Section 2: Inter se Priorities among Key Objectives, Success Indicators and Targets

S. No.	Objectives	Weight	Action	Success indicators	Unit	Weight	Target /Criteria Value				
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%
1	To undertake strategic and adaptive research for efficient and integrated management of natural resources to enhance agricultural production, productivity and profitability in different agro-ecological zones of eastern region"	64	Integrated farming system including wetland rehabilitation	IFS models developed/tested/ refined	No.	20	5	4	3	2	1
			Collection, conservation and evaluation of germplasm of agri-horti crops including livestock & fish	Germplasm of agri-horti crops, animal breed and fish species collected, conserved and evaluated	No.	24	6	5	4	3	2
			Development of production technologies for different components of IFS	Technologies developed for enhancing input use efficiencies and improving livestock & fish production	No.	20	5	4	3	2	1
2	Human resource development and capacity building	25	Transfer of technology	FLDs/OFTs conducted	No.	10	25	22	20	17	15
			Creation of awareness and knowledge	Training programmes organized	No.	15	60	54	48	42	36
	*Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	May 15 2013	May 16 2013	May 17 2013	May 20 2013	May 21 2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	May 1 2013	May 2 2012	May 5 2013	May 6, 2013	May 7, 2013
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for Innovation	On-time submission	Date	2	July 30, 2013	Aug. 10, 2013	Aug. 20, 2013	Aug. 30, 2013	Sep. 10, 2013
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3: Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 11/12	Actual Value for FY 12/13	Target Value for FY 13/14	Projected Value for FY 14/15	Projected Value for FY 15/16
1	To undertake strategic and adaptive research for efficient and integrated management of natural resources to enhance agri-cultural production, pro-ductivity and profitability in different agro-ecological zones of eastern region"	Integrated farming system including wetland rehabilita-tion	IFS models developed/ tested/ refined	No.	4	3	4	4	3
		Collection, conservation and evaluation of germplasm of agri-horti crops including livestock & fish	Germplasm of agri-horti crops, animal breed and fish species collected, conserved and evaluated	No.	10	9	5	6	6
		Development of production technologies for different components of IFS	Technologies developed for enhancing input use efficien-cies and improving livestock & fish production	No.	8	8	4	5	5
2	Human resource develop-ment and capacity building	Transfer of technology	FLDs/OFTs conducted	No.	26	23	22	25	30
		Creation of awareness and knowledge	Training programmes orga-nized	No.	28	57	54	60	70
	*Efficient Functioning of the RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	May 16 2013	-	-
		Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	May 2 2013	-	-
	Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	-	-	95	-	-
		Prepare an action plan for Innovation	On-time submission	Date	-	-	Aug. 10, 2013	-	-
	Improving internal ef-ficiency / responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Imple-mentation of Citizen's Charter	%	-	-	95	-	-
			Independent Audit of imple-mentation of public grievance redressal system	%	-	-	95	-	-

Section 4: Description and definition of success indicators and proposed measurement methodology

Success Indicator	Description	Definition	Measurement methodology	General Comments
IFS models developed/ tested/ refined.	Keeping in view the small scattered and fragmented landholdings in irrigated ecosystem, IFS mode of food production system has been developed in order to achieve food and nutritional security at household and even at individual level. Decision Support Tool (DST) has been used for testing different component of IFS model involving crop, livestock, poultry, beekeeping and fisheries. Wetland rehabilitation will be achieved through harnessing the complementarity of crop, livestock and fish through various technological interventions.	IFS refer to integrate different components of faming systems in such a manner that by product of one component becomes input of other component.	The input and output of different component of IFS will be recorded in structural schedule. The output of different components will be converted in yield equivalence of major component for calculation of production and profit of farming system model under irrigated, rainfed and plateau region.	IFS is the need of the hour as it may improve the food security, soil health and livelihood of small and marginal farmers.
Germplasm of agri-horti crops, animal breed and fish species collected, conserved and evaluated	The germplasm of various agri-horti and aquatic crops besides animal and fish will be collected, screened and evaluated / tested for their yield ability under different eco-systems of eastern region. The germplasm will be evaluated as on-station trial and subsequently the on-station trial will be disseminated to the farmers through front line demonstrations.	It refers to collection, conservation and evaluation of different varieties/species of agricultural crops, animal and fish.	The germplasm of various agri-horti and aquatic crops besides animal and fish will be collected from different part of eastern region. All the germplasm will be conserved & evaluated as on-station trial and finally screened to develop varieties suitable for eastern region.	Biodiversity can be maintained and problem of seed shortage can be minimized.
Technologies developed for enhancing input use efficiencies and improving livestock & fish production	Development of production technologies for crops, livestock and fish will be achieved through different interventions on soil, water, nutrient and resource conservation measures. It will lead to efficiently utilize the critical inputs like seed, fertilizer and irrigation requirements. Non-conventional energy sources like solar radiation shall be used for irrigation keeping in view the constraints of electricity supply in agriculture sector.	It refers to input use efficiency for increasing productivity of agricultural production system	Expansion of area, productivity and profitability of different interventions will be measured through impact assess before and after interventions.	Input use efficiency of different agri-horti crops and livestock can be enhanced through developed technology packages.
FLDs/OFTs conducted	Adoption and demonstration of the technologies developed by the institute through structural schedule. as well as training to the farmers, different stakeholders	It refers to front line demonstration, on- farm trial	Survey of constraints, knowledge gap dissemination and impact analysis of technologies through structural schedule	FLD in participatory mode helps in quick adoption of technology by the farming community.
Training programmes organized	Up scaling of knowledge of farmers through improved technical knowhow	Knowledge sharing and dissemination	Number	Exchange of ideas and information among different stakeholders on recent advances

Acronym : DST = Decision Support Tool ; FLD = Front Line Demonstration; ICAR = Indian Council of Agricultural Research; IFS = Integrated Farming System; NGOs = Non-Government Organizations; OFT = On-Farm Trial; SAU = State Agricultural University; SHM = State Horticulture Mission

Section 5 : Specific performance requirements from other Departments

Location Type	State	Organization Type	Organization Name	Relevant Success Indicator	What is your requirement from this organization	Justification for this requirement	Please quantify your requirement from this organization	What happens if your requirement is not met
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Section 6: Outcome / Impact of activities of organisation/ministry

S. No	Outcome / Impact of organisation	Jointly responsible for influencing this outcome / impact with the following organisation (s) / departments/ ministry(ies)	Success Indicator (s)	Unit	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
1	Increased crop productivity and profitability of farmers of eastern region.	State Agriculture Deptt./ Livestock and Fisheries Deptt./ SAUs/ NGOs/ SHM and farmers	Increased in productivity	%	4	3	5	6	7
			Enhanced profitability of farmers	%	3	4	5	6	6