ICAR-RCER, PATNA

ANNUAL REPORT

2015-16

भाकृअनुप
ICAR

ICAR Research Complex for Eastern Region
ICAR Parisar, P.O. : Bihar Veterinary College,
Patna-800 014 (Bihar)

ICAR-RCER, PATNA

ANNUAL REPORT

2015-16

ICAR Research Complex for Eastern Region
ICAR Parisar, P.O. : Bihar Veterinary College
Patna-800 014

Correct Citation

Annual Report
2015-16

Guidance
B.P. Bhatt
Director

Editors
Janki Sharan Mishra
Bikas Das
Sivani
Naresh Chandra
Santosh Kumar
Santosh Kumar Gupta
Snatashree Mohanty
Tshering Lhamu Bhutia
Sameer Kumar Barari

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

Printed at
The Composers Press
2151/9A/2, New Patel Nagar, New Delhi-110 008
Tel.: +91-11-25707869, +91-9810771160

Preface

I have great pleasure in bringing out the 15th 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 available natural resources in diverse agro-climatic zones of eastern states.

During the period under report, research, extension and agricultural development activities continued to gain momentum. For achieving the goal of food, nutritional and livelihood security, emphasis was given on conservation agriculture, water productivity enhancement, rain water harvesting, weed management, varietal development for stress condition, management of fallow land, rehabilitation of water logged areas, restoration of degraded lands, solar energy application in agriculture and diversification in cropping systems. Keeping in view the small and marginal farmers of the region, 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. However, large scale adoption of these models is the need of the hour as the technology may be one of the most important steps towards second green revolution which is to be expected from the eastern region. Development of climate resilient farming system model is yet another priority of the institute to address the adverse effect of climate change. Studies on host-pest interaction and its dynamics in mango have been studied under climate change scenario in different states *viz*. Jharkhand, Uttar Pradesh, Karnataka, Gujarat, Maharashtra and Telangana.

To strengthen the plant genetic resource management, promising genotypes of different fruits like, mango, litchi, bael, sapota and improved lines of makhana, water chestnut, solanaceous vegetable and cucurbits have been identified and maintained. In the field of agro-diversity conservation, several germplasm of wild edibles including tuber crops have been collected from Chhattisgarh, Jharkhand,, Odisha and West Bengal.

Sahiwal breed of cow and Murrah buffalo have been introduced to study their production potential and heat tolerance ability. Characterization of indigenous duck is being done in all the eastern states. Integrated fish farming models developed by the institute are gaining popularity among the fish farmers in order to improve upon the fish productivity. Cattle-fish integration has been found most suitable for improving fish productivity in non-tribal areas. Likewise, pig-fish integration has been found suitable for tribal dominated areas. The fish productivity was 3-4 fold higher in these integrations than the fisheries alone.

A total of 83 training programmes, 26 Front Line Demonstrations, 10 On Farm Trials have been conducted for the farmers and the state government officials. During the period under report, the institute published 95 nos. of research papers in the journal of national and international repute, 05 books, 13 book chapter, 7 technical bulletins, 20 extension bulletins and 20 popular articles. On the occasion of Word Soil Health Day on 5th Dec., 2015 Soil Heath cards were distributed to the farmers of Patna, Ranchi and Buxar by the institute and its centre/KVK.

I acknowledge the consistent support, keen interest and guidance received from Dr. S. Ayyapan, Secy. DARE and Director-General, ICAR in order to plan and implement various research and extension activities. The encouragement, valuable guidance and support rendered by Dr. A.K.Sikka, DDG (NRM) is duly acknowledged. All Heads of the Divisions/Research Centres deserve appreciation for submitting their research findings in time. The editorial assistance rendered by Dr(s). J. S. Mishra and his team in bringing out the report is duly appreciated.

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

Contents

1. *Executive Summary*

- Sixteen promising rice varieties have been evaluated for their performance in transplanted conditions. Irrespective of varieties, early duration genotypes exhibited the average productivity of 3.75 t/ha (3.29-4.26 t/ha), followed by medium duration varieties (4.54 t/ha). Highest productivity was, however, recorded in long duration rice varieties (6.22 t/ha).
- Seven rice genotypes (IR 84899-B-179-16-1-1-1, IR83929-B-B-291-2-1-1-2, IR84899-B-183-CRA-19-1, IR 83387-B-B-27-4, IR83929-B-B-291-3-1-1, IR84894-143-CRA-17-1 and IR88964-24-2-1-4) have been found promising for multiple drought tolerance with productivity range of 0.82-1.83 t/ha compared to check (0.45 t/ha).
- For dry direct seeded rice, IR84899-B-179-16-1-1-1, IR84898-B-168-24-1-1-1, IR77298-14-1-2-130-2, IR84898-B-165-9-1-1, IR88867-9-1-1-4, IR84899-B-185-8-1-1-2, IR84899-B-183-20-1-1-1, IR84899-B-179-13-1-1-1, IR 84899 -B-182-3-1-1-2, IR83929-B-B-291-2-1-1-2, IR88964-24-2-1-4 and IR83929-B-B-291-3-1-1 were found promising with grain yield of 1.68-3.43 t/ha.
- Nineteen elite rice genotypes including Swarna *sub-1* as tolerant and Swarna as susceptible checks were evaluated for submergence tolerance at vegetative stage. The genotypes IR09L204 (5.62 t/ha), IR09L337 (5.66 t/ha), IR 10L182 (5.95 t/ha) and IR09L311 (5.73 t/ha) were found promising for medium maturity duration (130 days).
- Wheat genotypes NW 1014, Kundan, GW 273, Raj 3765, HD 3093 and HD 2987 performed better with average productivity of 3.91- 4.19 t/ha as compared to checks (HD 2733 and HD 2967- productivity range of 3.57-3.63 t/ha) under late sown heat stress condition.
- Wheat genotype HD 2967 (4.18 t/ha) followed by HD 2733 (4.17 t/ha) showed more positive response towards elevated CO_2 as compared to DBW 17 (3.61 t/ha) and Halna (2.74 t/ha).
- Zero tillage in wheat and inclusion of mungbean during summer increased the yields of wheat and succeeding rice crop by 16.7 and 7.7%, respectively, as compared to current farmer's practice consisting of puddling in rice (5.82 t/ha)and intensive tillage in wheat (3.33 t/ha).
- Adoption of complete CA in rice-wheat system exhibited 6.1% reduction in energy use (total energy requirement- 74722 MJ/ha/yr) as compared to conventional system (79568 MJ/ha/yr). CA system reduced soil bulk density from 1.61 to 1.55 g/cm^3 and increased the organic carbon content from 0.53 to 0.71%, besides improving the hydraulic conductivity, infiltration rate and soil aggregation.
- Inclusion of higher cropping intensity and diversification (rice-potato or mustard-maize rotation) with CA, 141% higher rice-equivalent system productivity was attained as compared to conventional system (9.3 t/ha).
- Drip irrigation with plastic mulch produced significantly higher yield of tomato (42.2 t/ha), brinjal (35.7 t/ha), cucumber (27.9 t/ha) and ridge gourd (15.3 t/ha) over surface irrigation without mulch.
- Mixed Para pheromone based fruit fly trap was developed to manage fruit flies in vegetables and fruit crops with a single trap. Incidence of 'Blossom blight' disease in mango was directly correlated with temperature and rainfall.
- The complete mitochondrial genome of the fruit fly, *Bactrocerazonata* (Saunders) (Diptera: Tephritidae), (15,935 bp in length, circular in nature) was sequenced using next generation DNA sequencing, whichwill be further used for determination of stress resilience traits in fruit fly species.
- Among the 201 genotypes of different tuber crops evaluated, the best performer in terms of productivity include: Sweet potato accession ACC-173 (17.1 t/ha), Colocasia accession ACC-37 (52.16 t/ha), Cassava accession ACC-152 (35.17 t/ha), Greater yam accession ACC-34 (42.24 t/ha), Lesser yam genotype Lotni (30.76 t/ha), Elephant foot yam accession ACC-85 (36.17 t/ha) for cultivation in Eastern Plateau and Hill region.
- DRIS analysis of mango orchard soils indicated that Ca and Mg were the most limiting nutrients when soils were having below critical pH of 5.5 whereas Zn, B and N were the most limiting nutrients for mango orchards grown in soils having pH > 5.5.

- Studies on carbon sequestration potential of different fruit orchards indicated the highest carbon build-up rate (1.53 Mg C/ha soil/yr) in mango orchard as against lowest of 0.98 Mg C /ha soil/yr in litchi orchard in 0-60 cm soil depth.
- Litchi genotypes 'Rose scented' and 'Deshi' were found most promising for Hill and Plateau region based on fruit quality and yield.The harvesting period of litchi 'Shahi' can be extended upto 11 days with the use of 30 and 50% light transmission shade net. Application of GA_3 at 40 mg resulted in increased fruit weight and quality.
- In order to diversify the aquatic ecosystem, 22 local cultivars of thornless water chestnut (*Trapa bispinosa*) were collected for evaluation from Madhya Pradesh and Odisha. Initial screening indicated better performance in terms of survival and yield in the cultivars from Madhya Pradesh than those collected from Odisha.
- Three advance breeding lines (derived from 'KWR 108 × ICC 4958', 'Pusa 256 × WR 315' and BGD 103 × TL-II 109) in chickpea, 3 promising lines in lentil (selected from germplasm), 3 thermo tolerant lines with low ODAP content (selected from breeding materials received from ICARDA) in grass pea and 5 'cleisto' lines (zero per cent natural outcrossing) in pigeonpea were selected for further evaluation in station trials.
- In the agro-climatic conditions of Bihar, average milk yield of Murrah buffalo was recorded at 10.28 kg/day and the individual peak yield was observed to be 20.2 kg/day. However, provision of wallowing tank for buffalo during summer months improved conception rate to the tune of 54.6% compared to previous year's record of 34.2%.
- Characterization of Purnea Red cattle and indigenous ducks was done in Purnea, Katihar and Kishanganj districts of Bihar and Odisha state, respectively.
- Sahiwal breed of cow was introduced at the institute to study the production potential and heat tolerance ability of Sahiwal in Eastern Indo Gangetic Plains.
- Supplementation of Bihar specific mineral mixture 'Swarna Min' improved milk yield of cows from 8.52 to 9.75 kg/day indicating the increase in yield by 14.1% with the use of Swarna Min. Even cattle supplemented with commercially available mineral mixture had the milk yield of 8.90 kg/day indicating the superiority of Swarna Min.
- Fodder productivity of QPM, hybrid and baby corn was assessed. It was observed that hybrid maize resulted into highest green fodder yield (58.7 t/ha) compared to QPM (24.7 t/ha) and baby corn (19.2 t/ha).
- Heat stress in Murrah buffalo exhibited higher percentage of Cortisol, T3 and T4 level at 5.34±0.24, 1.92±0.14 and 32.25±2.3 ng/ml, respectively, as compared to winter season. However, supplementation of sodium bicarbonate in feed improved milk yield of heat stressed buffalo from 6.85 to 7.33 l/day, i.e., net increase in milk yield by 7.0%.
- Analysis of real time PCR data revealed that UCP 2 gene is down regulated and UCP 3 gene is Up-regulated in feed efficient crossbred calves of Holistein Friesian.
- Hatchability of Vanaraja and Grampriya strain of backyard poultry was recorded at 86 and 87%, respectively. Body weight of day old chicks was recorded higher in Vanaraja strain (36.5 g) as compared to Grampriya (32.0 g).
- The prevalence of subclinical mastitis was recorded at 27.27% in the peri-urban lactating cattle of Eastern U.P. However, prevalence was recorded highest in Varanasi (37.5%), followed by Gajipur (35.29%), Ballia (27.78%) and Azamgarh (8.33%).
- During the period under report, Gaya and Jehanbad districts of Bihar have been surveyed to find out the prevalence of PPR, BT and CAE. It was observed that the incidence of PPR was more severe in both the districts (31.0-38.0%), followed by BT (15.5-16.7%).
- Various integrated fish farming models, developed by the institute, showed the highest fish productivity in case of cattle-fish integration (4.50 t/ha), followed by poultry-fish (4.14 t/ha), goat-fish (3.60 t/ha), pig-fish (3.40 t/ha) and duck-fish integration (2.85 t/ha).
- Plankton density in different fish-livestock integrated farming systems ranged between 6-10 mg/litre of water (Dry wt. basis). Gross primary productivity (GPP) and Net primary productivity (NPP) was highest in cattle-fish integration (0.34 g $C/m^3/hr$),followed by poultry-fish (0.32g $C/m^3/hr$) and goat-fish integration (0.28 $C/m^3/hr$).
- The breeding techniques have been standardized in case of Punticus (*Puntius japonicas*) and Bata (*Labeo bata*).
- During the year under report, the Institute published 95 nos. of research papers in the journal of national and international repute, 05 books, 13 book chapters, 07 technical bulletins, 20 extension bulletins, and 20 popular articles.
- Further, total of 83 training programmes, 26 Front Line Demonstration and 10 On Farm Trails 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 human and 31% of bovine population. Though the region is endowed with rich natural resources to support higher agricultural production including livestock and fisheries, the production levels have remained low due mainly to lack of location-specific production technologies, dissemination of scientific knowledge to farmers, fragmented land holdings, low seed replacement rate, large population of non-descript type of livestock, poverty, lack of infrastructure facilities, natural calamities e.g. frequent floods and droughts, water logging and social conflicts. Nevertheless, the region has vast untapped potential to enhance the production. Keeping this fact in view, planning priorities has also been set up to achieve the food self sufficiency at national level from eastern region under Act 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:

- Strategic and adaptive research for efficient integrated management of natural resources to enhance productivity of agricultural production systems in eastern region.
- Transform low productivity-high potential eastern region into high productivity region for food, nutritional and livelihood security.
- Utilization of seasonally waterlogged and perennial water bodies for multiple uses of water.
- Promote network and consortia research in the eastern region.

The modalities to achieve the mandate include:

- 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, livestock and fishery 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 2015-2016 of the complex is presented below (Table 1).

Table 1. Financial allocation and expenditure during the year 2015-16 (Rs. in Lakhs)

Head of accounts	Budget allocation		Actual expenditure	
	Plan	Non-plan	Plan	Non-plan
Establishment charges	-	1750.00	-	1670.25
T.A.	18.54	11.00	18.54	11.00
HRD	2.27	-	2.27	-
Works	153.35	15.03	153.35	15.03
Other charges	258.84	917.63	258.84	807.20
Total	433.00	2693.66	433.00	2503.48

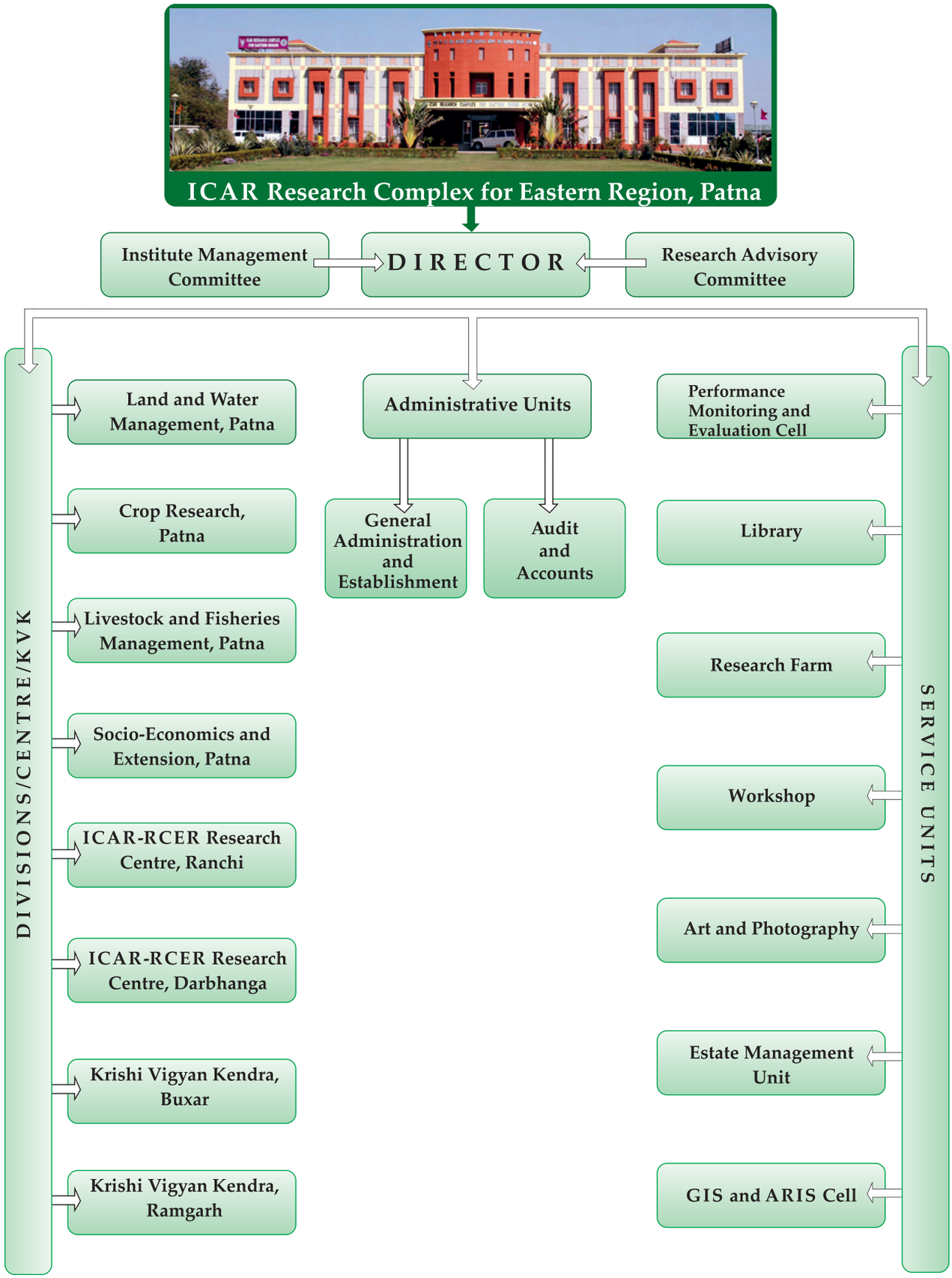


Fig. 1. Organogram of ICAR Research Complex for Eastern Region, Patna

3. Weather

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

At Patna, the total annual precipitation received in 2015 was 703.7 mm which was 37.6% deficient than that of normal rainfall. The distribution of rainfall over time and intensity in the rainy season was very erratic. The monsoon rainfall (June-September) was very low (649.2 mm) as compared to normal (951.9 mm). The mean maximum temperature varied from 37.9°C in May to 19.1°C in January while the mean minimum temperature varied between 27.8°C in June to 10.5°C in January. The average relative humidity and sunshine hours were 69.24% and 4.91 hrs, respectively. Summary of the monthly meteorological data for the year 2015 is presented in Table 2. Trend in monthly variation of temperature and rainfall is presented as Fig. 2.

At Ranchi, a total rainfall of 1092 mm was received during 2015, which is 21.8% less than the long-term average annual rainfall. The rainfall deficit during monsoon months of July, August, September and October was about 10.2, 40.7, 81.8 and 26.8% of the normal rainfall (Fig 3). However, the non-monsoon months recorded slightly higher rainfall than the respective monthly normal. Compared to seasonal normal, the monsoon rainfall (592 mm) of the year 2015 was about 39.5% deficient. January was the coldest month with one day minimum temperature reaching down to 6°C. The month of May recorded the one day maximum temperature of 42.0°C. The mean monthly minimum temperature of the year varied from 9.4°C

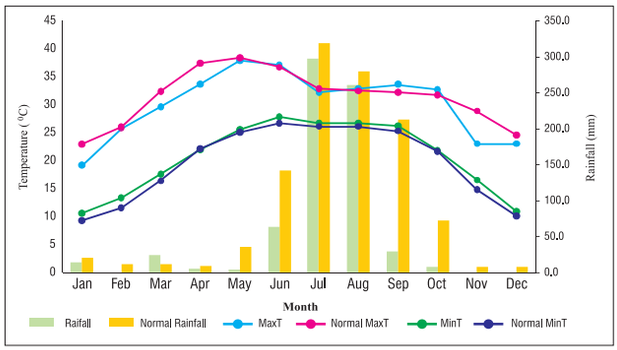


Fig. 2. Monthly variation of temperature and rainfall during 2015 at Patna

Table 2. Monthly meteorological data of 2015 at Patna

Month	Temperature (°C)				Avg. RH (%)	Average sunshine (hrs/day)	Total rainfall (mm)		Rainy days	Pan. Evaporation (mm)
	Max.	Normal	Min.	Normal			Observed	Normal		
January	19.1	23.0	10.5	9.3	79.66	2.36	14.3	20.4	2	45.20
February	25.7	26.1	13.3	11.6	70.61	4.95	0.0	11.1	0	82.00
March	29.6	32.4	17.6	16.4	62.45	7.34	24.5	11.4	2	151.50
April	33.6	37.4	21.9	22.1	57.50	6.57	5.0	9.0	1	195.90
May	37.9	38.4	25.5	25.1	56.39	7.06	3.3	35.6	1	268.40
June	37.0	36.7	27.8	26.7	63.23	6.02	62.7	141.0	4	232.40
July	32.2	32.9	26.7	26.1	79.90	4.41	296.6	319.0	13	144.20
August	32.8	32.5	26.7	26.1	80.69	3.36	260.9	279.3	12	144.60
September	33.6	32.2	26.2	25.3	71.78	6.42	29.0	212.6	3	146.90
October	32.7	31.7	21.8	21.6	68.34	6.44	7.4	72.3	1	110.00
November	23.0	28.9	16.5	14.8	68.72	2.95	0.0	8.2	0	80.30
December	23.1	24.6	10.8	10.1	71.66	0.96	0.0	7.4	0	45.20
Annual	30.5	31.4	20.4	19.6	69.24	4.91	703.7	1127.3	39	1646.6

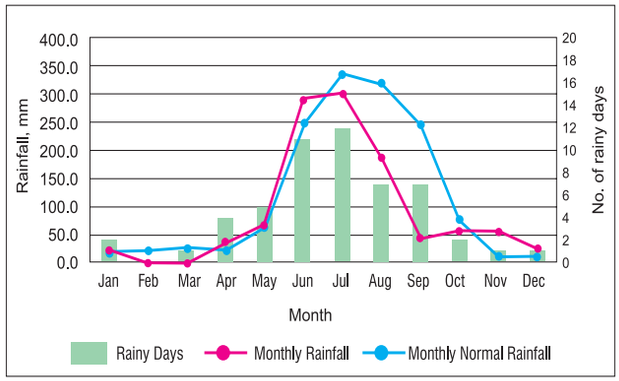


Fig. 3. Monthly rainfall compared with monthly normal rainfall at Ranchi

in January to 25.8°C in June while the mean maximum temperature varied from 23.4°C in January to 37.3°C in the month of May (Table 3). The relative humidity was above 60% with mean monthly relative humidity varying from 83.5% (December) to 92.2% (June). The average annual humidity of the year was 88.3%. The year also witnessed a heavy hail storm (size 2-6 cm) (Fig.4). The highest and the lowest values of the daily weather parameters observed during 2015 are presented in Table 4.

Table 3. Mean monthly weather parameters recorded at Ranchi

Month	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean relative humidity (%)	Monthly Rainfall (mm)
January	9.4	23.4	87.9	23.0
February	11.9	27.8	86.8	0.0
March	15.1	30.7	86.4	0.0
April	20.6	32.8	87.8	38.0
May	24.0	37.3	89.0	67.0
June	25.8	33.8	90.0	291.0
July	25.1	30.0	92.2	302.0
August	24.9	29.9	90.4	189.0
September	23.2	31.4	88.2	45.0
October	18.8	30.3	88.6	56.0
November	14.6	27.9	89.2	56.0
December	10.8	24.8	83.5	25.0
Total rainfall (mm)				1092.0

Table 4. Important observations during 2015

Weather Parameter	Value	Date
Highest maximum temperature	42.0 °C	26 May 2015
Lowest minimum temperature	6.1 °C	13 Jan 2015 and 26 Dec 2015
Maximum one day rainfall	95 mm	16 Jun 2015
Highest relative Humidity	95 %	22 Jul 2015
Lowest Relative Humidly	59 %	28 Dec 2015
Hail storm	Size: 2-6 cm Depth: 7 mm Coverage: 300 ha	29 Nov 2015

Fig. 4. Damage caused due to the hailstorm to vegetables and fruit trees at the experiemental farm, Ranchi

4. *Climate Change*

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

Four wheat genotypes (HD 2967, HD 2733, DBW 17 and Halna) were evaluated in open top chambers (OTCs) in *Rabi* season 2014-15 to assess the impact of elevated CO_2 (25% higher than ambient) and temperature (2°C ambient) on morpho-physiological traits and yield (Fig. 5). The treatment condition in each OTC was OTC1 (ambient CO_2; 400 ppm), OTC2 (25% higher CO_2; 500ppm), OTC3 (500 ppm + 2°C > ambient temperature) and OTC4 (2°C > ambient temperature).

Elevated CO_2 has resulted in improvement of Relative Water Content (RWC %), Membrane Stability Index (MSI %), Photosynthetic rate (Fig. 6), Chlorophyll and TSS content. Genotype 'Halna' followed by 'DBW 17' was the least affected due to elevated temperature as compared to other genotypes. Genotypes HD 2967 (4.48 t/ha) and HD 2733 (4.17 t/ha) showed more positive response to elevated CO_2 as compared to other genotypes (Table 5).

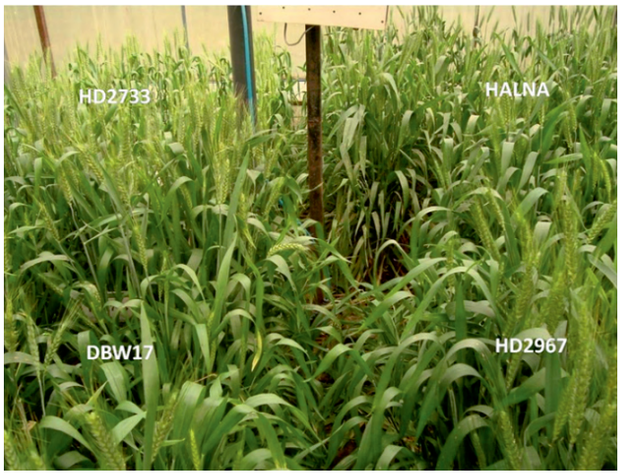


Fig. 5. Effect of elevated CO_2 on growth of wheat genotypes (Halna, HD 2733, HD 2967 and DBW 17) in open top chambers

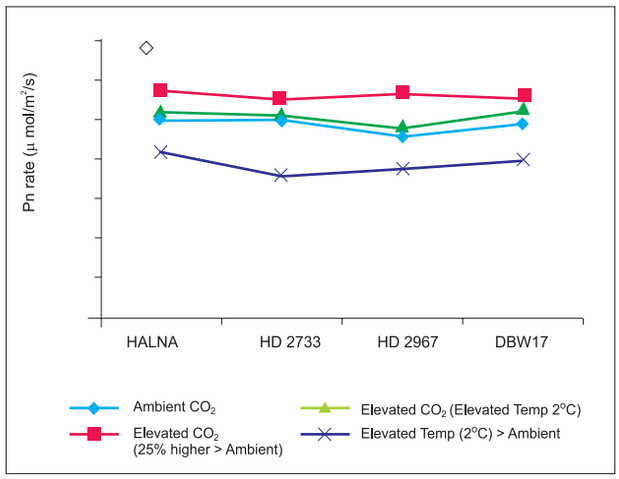


Fig. 6. Photosynthetic rate (μ mol/m^2/s) of different wheat genotypes in different open top chamber (OTCs) at anthesis stage

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

Studies on phenological behaviour of mango genotypes indicated marked reduction in intensity of flowering during 2015 than that recorded during 2014 (Fig. 7). A two weeks hastening in the first flower opening stage was recorded during 2014-15 which can be attributed to the sudden increase in the average temperature during last four weeks of December, 2014. This altered phenology contributed towards early incidence of thrips and hopper at the time of panicle initiation to fruit setting during 2015 (Fig. 8).

Among the different diseases, the incidence of *Blossom blight* was found to be most severe during the year and was directly correlated with temperature and rainfall. Rainfall in 9th Standard Meteorological week (SMW) induced the conidial dispersal of *Colletotrichum gloeosporoides* and then after PDI increased sharply (Fig. 9). The temperature range of 25-30°C was found conducive for spore germination of *C. gloeosporioides*.

Table 5. Yield contributing traits and yield of wheat genotypes under different climatic conditions

Cultivars	Treatment	Height (cm)	Ear length (cm)	Grains/ ear	1000- grain weight (g)	Grain yield (t/ha)
HALNA	Ambient CO_2	77.56	08.61	40.0	28.46	2.38
	Elevated CO_2 (25% higher >Ambient	79.39	09.39	50.5	34.94	3.02
	Elevated CO_2 + Elevated Temp (2°C)	84.12	08.62	47.5	32.81	2.74
	Elevated Temp (2°C) >Ambient	77.92	07.59	37.5	25.11	2.10
HD 2733	Ambient CO_2	91.36	09.76	32.0	37.31	3.50
	Elevated CO_2 (25% higher >Ambient	97.61	10.44	43.5	43.06	4.17
	Elevated CO_2 + Elevated Temp (2°C)	84.15	10.28	41.0	41.69	3.86
	Elevated Temp (2°C) >Ambient	83.89	08.52	32.0	31.86	3.04
HD 2967	Ambient CO_2	92.14	11.68	50.0	40.71	3.72
	Elevated CO_2 (25% higher >Ambient	99.45	13.19	76.5	43.12	4.48
	Elevated CO_2 + Elevated Temp (2°C)	93.07	10.61	72.0	39.90	4.12
	Elevated Temp (2°C) >Ambient	94.24	10.05	48.0	28.76	3.01
DBW 17	Ambient CO_2	85.45	10.64	50.5	38.86	3.04
	Elevated CO_2 (25% higher >Ambient	86.76	12.88	57.0	43.09	3.90
	Elevated CO_2 + Elevated Temp (2°C)	87.72	11.94	52.5	40.30	3.61
	Elevated Temp (2°C) >Ambient	86.26	10.18	48.5	35.44	2.80
CV (%)		3.68	4.52	9.23	4.85	3.78
SEm±		1.61	0.23	2.24	0.88	0.06

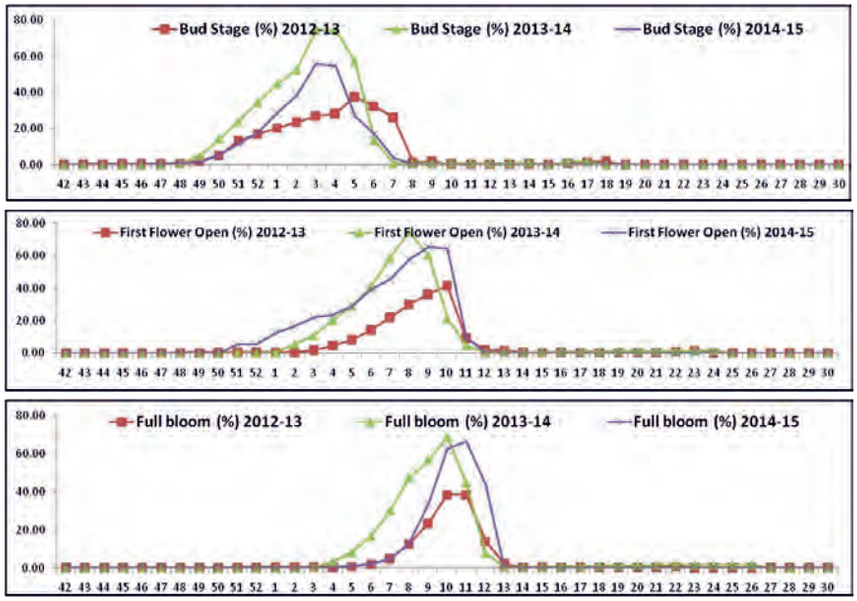


Fig. 7. Floral phenology of mango under Jharkhand conditions

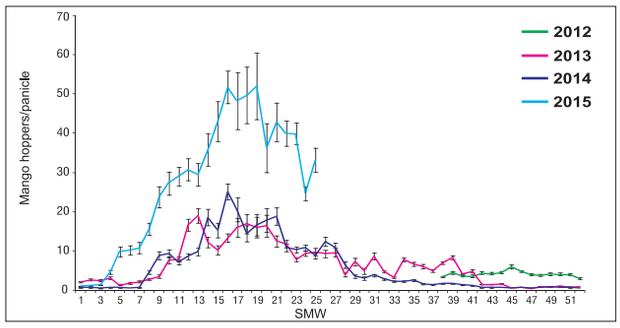


Fig. 8. Population dynamics of mango hopper incidence in Jharkhand over the years

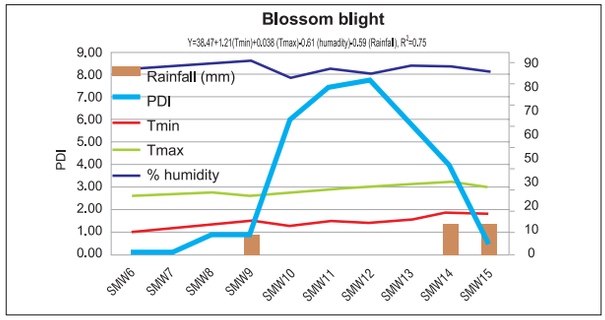


Fig. 9. Influence of weather parameters on blossom blight of mango in 2015

Based on data received from different centre's, significant correlations have been recorded between incidence of different mango hoppers, thrips and mealy bugs and weather parameters which indicated their suitability for developing pest forecasting models (Table 6). The incidence of mango hoppers and thrips was found to be influenced positively within the temperature range of 15-35°C.

Table 6. Relationship between mango pest behaviour and weather parameters

Weather	Parameters	T_{Max}	T_{Min}	RH	Rain-fall	Wind speed
Hopper	Ranchi	0.46*	0.71*	-	-	-
	Paria	0.33*	-0.45*	-0.48*	-0.31*	-0.43*
	Bangalore	0.32*	0.68*	-	-	-
	Lucknow	0.76*	0.42*	-0.70*	-	0.53*
	Sangareddy	0.36*	0.63*	-	-0.41*	-
Thrips	Ranchi	0.39*	-0.46*	-	-0.71*	-0.41*
	Paria	0.43*	-0.49*	-0.46*	-0.28	-0.27
	Bangalore	-	-	-	-	-
	Lucknow	0.43*	-0.71*	-	-	-
	Sangareddy	-	-0.68*	-	-	-
Mealy bug	Ranchi	-	0.38*	-	-	-
	Paria	-	-	0.44*	-	-
	Bangalore	-	-	-	-	-
	Lucknow	-0.30*	-0.36*	-	-	-
	Sangareddy	0.38*	0.41*	-	-	-

* Significant at $P \leq 0.05$

Data on species composition of mango hoppers and thrips at different time scales have been generated and it indicated variation in dominant species along the time series RTPD data (Fig. 10 & 11). This indicated differential climatic suitability of different species of mango hoppers and thrips.

Incidence of different fruit fly species was found to be positively correlated with rainfall and phenological stages of mango (Fig. 12). Emergence of adult fruit flies from pupae was directly correlated with soil moisture and availability of host for egg laying.

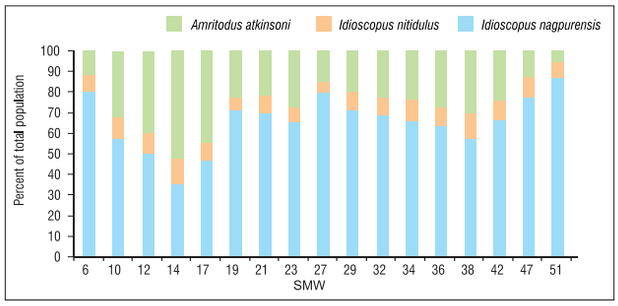


Fig. 10. Mango hopper species composition at different time interval in Jharkhand conditions

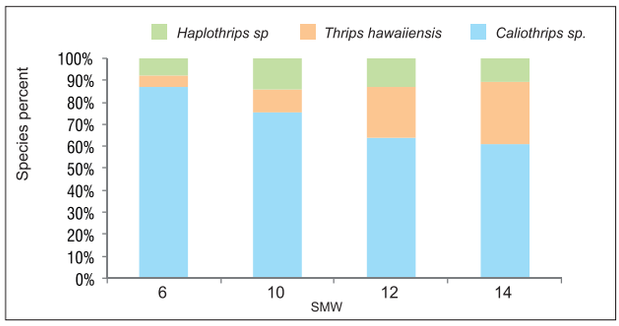


Fig. 11. Thrips species composition on mango inflorescences at different time interval in Jharkhand

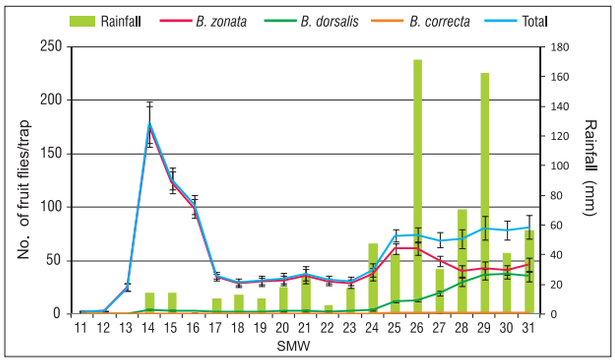


Fig. 12. Fruit flies population dynamics on parapheromone traps in mango orchards

Development of adaptation strategy for management of fruit fly

Mixed para pheromone based fruit fly trap was developed to manage the fruit flies in fruit and vegetable crops with a single trap. Presently, single lure fruit fly traps are available in the market for the management of fruit flies species in fruits and vegetables, separately. A cardboard with 3x 2x 1.5 cm were used for the absorption of different combinations of mixed lure solutions (cue lure and methyl eugenol) with DDVP as insecticide in the lure solution. This trap was preliminarily tested at ICAR-RCER, Patna and its centre Ranchi and found effective as compared to single lured one and market available traps (Fig. 13). This trap can be used in mango, sapota, guava, citrus, litchi, bottle gourd, bitter gourd, pumpkin, cucumber and other cucurbit crops as well in fruit trees intercropped with vegetables.

Fig. 13. Efficacy of para-pheromone trap against fruit fly

5. *Cereals*

RICE

Performance of Different Rice Variety

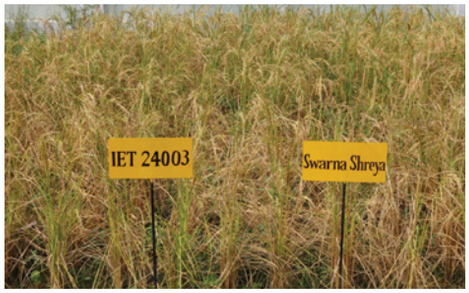
Sixteen promosing rice varieties have been evaluted for their performance in transplanted conditions. On average, the early duration varieties exhibited the average productivity of 3.75 t/ha (range 3.29-4.26 t/ha), followed by medium duration vareities. Highest productivity was, however, recorded in long duration varieties (Table 7).

Table 7. Evaluation of rice genotypes under transplanted condition

Varieties	Duration (days)	Productivity (t/ha)
Early Duration		
Vandana	95-100	3.41
CR Dhan 40	95-100	3.29
Hazaridhan	110-115	3.64
Susk Samrat	115-120	4.26
Sahbhagi Dhan	115-120	4.15
Medium Duration		
IR64	120-125	4.64
IR64 Sub 1	120-125	4.49
Rajendra Sweta	135-140	4.59
Rajendra Bhagwati	120-125	4.27
Naveen	120-125	4.58
Lalat	125-130	4.22
Swarna Shreya	120-125	4.99
Long Duration		
Swarna	145-150	6.37
Swarna Sub 1	145-150	6.60
Sambha Mahsoori	150-155	6.03
Sambha Mahsoori Sub 1	150-155	5.87

Screening and Identification of Rice Genotypes for Tolerance to Drought Stress at Different Growth Stages

Forty rice genotypes were evaluated during *kharif* 2015 under dry direct seeded condition for drought stress tolerance at various growth stages (Fig. 14). Under stress condition, only one irrigation was applied after sowing to ensure proper germination. Crop faced 5, 13, 12 and 25 days water stresses at seedling, vegetative, reproductive and physiological maturity stages, respectively. The control (non-stress) plot was maintained by applying irrigation as and when required. Results revealed that 07 rice genotypes were found



IR 84899-B-179-16-1-1-1

Check-Sehbhagi Dhan

Check-IR-64

Fig. 14. Screening of rice genotypes under drought stress condition at reproduce time stage

promising under multiple stages drought stress conditions as compared to checks (Table 8). Grain yield of different genotypes varied from 0.10 to 1.83 t/ha and 3.87 to 6.28 t/ha under drought stress and non-stress conditions, respectively. Irrespective of genotypes, drought stress at various growth stages caused significant reduction in grain yield (91.7%), plant height (23.1%), plant biomass (54.5%), test weight (25%), relative water content (29.5%), photosynthetic rate (31.6%), stomatal conductance rate (31.0%), chlorophyll content (21.5%), spikelet fertility (52.8%), proline content (73.8%) and transpiration rate (31.9%) in rice genotypes. Minimum yield reduction (68.2%) was observed in IR 84899-B-179-16-1-1-1 and maximum in IR 64 (97.7%) (Fig. 15).

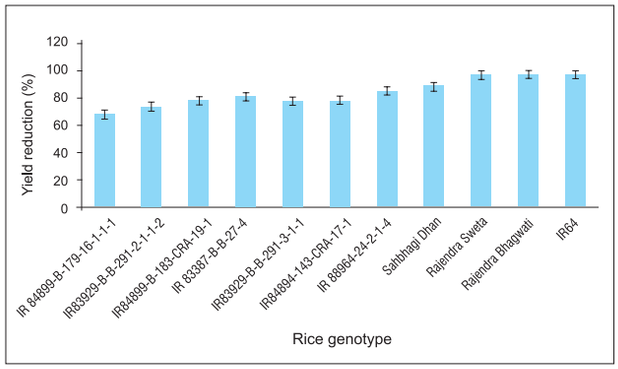


Fig. 15. Percentage yield reduction in rice genotypes under drought stress condition.

Evaluation and Characterization of Rice Genotypes for Aerobic Condition

Forty rice genotypes were evaluated during *kharif* season, 2015 under direct seeded aerobic and irrigated control conditions. There was significant reduction (46.3%) in grain yield under aerobic condition as compared to irrigated condition. Among genotypes, IR84899-B-179-16-1-1-1, IR84898-B-168-24-1-1-1, IR77298-14-1-2-130-2, IR84898-B-165-9-1-1, IR88867-9-1-1-4, IR84899-B-185-8-1-1-2, IR84899-B-183-20-1-1-1, IR84899-B-179-13-1-1-1, IR 84899 -B-182-3-1-1-2, IR83929-B-B-291-2-1-1-2, IR88964-24 -2-1-4 and IR83929-B-B-291-3-1-1 were identified promising under aerobic condition. Grain yield of different genotypes varied from 1.68 to 3.43 t/ha and 3.50 to 5.89 t/ha in aerobic and irrigated conditions, respectively. Under aerobic condition, maximum grain yield was recorded in IR84899-B-179-16-1-1-1(3.43 t/ha) followed by IR84898-B-168-24-1-1-1(3.36 t/ha) and IR77298-14-1-2-130-2 (3.24 t/ha).

Evaluation and Identification of Rice Genotypes for Tolerance to Multiple Stresses (Drought and Submergence)

Eleven rice genotypes were evaluated during *kharif* 2015 under drought and submergence condition. Under drought stress experiment, crop faced stress at reproductive stage. Sixty days old seedlings were subjected to drought by with-

Table 8. Performance of promising rice genotypes and check varieties under drought stress and non-stress condition.

Rice genotypes	Grain yield (t/ha)		Spikelet sterility (%)		Test weight (g)		Photosynthetic rate [μ mol (CO_2) m^{-2} s^{-1}]		Chlorophyll (mg g^{-1} FW)	
	S	NS	S	NS	S	NS	S	NS	S	NS
IR 84899-B-179-16-1-1-1	1.83	5.86	12.5	9.6	17.4	24.1	23.0	25.9	5.63	6.46
IR83929-B-B-291-2-1-1-2	1.45	5.50	18.2	7.3	20.4	23.6	21.0	22.7	4.78	6.22
IR84899-B-183-CRA-19-1	1.19	5.51	17.3	5.2	19.1	24.5	19.9	24.8	2.97	3.59
IR 83387-B-B-27-4	1.17	6.28	18.2	9.1	17.9	23.4	16.2	24.1	3.02	3.37
IR83929-B-B-291-3-1-1	1.15	5.27	28.2	11.1	19.4	25.5	18.9	22.8	4.19	4.70
IR84894-143-CRA-17-1	1.01	4.65	18.0	13.4	19.7	25.0	19.4	23.2	2.48	3.85
IR 88964-24-2-1-4	0.82	5.55	43.4	9.5	22.8	23.5	18.6	27.6	3.63	4.48
Sahbhagi Dhan	0.45	3.87	45.5	13.3	19.2	19.8	17.2	21.8	2.17	2.98
Rajendra Sweta	0.16	5.02	86.9	12.6	11.4	12.8	10.8	22.9	2.07	3.81
Rajendra Bhagwati	0.10	4.48	86.7	14.9	20.3	27.5	14.9	21.9	1.23	4.14
IR64	0.12	5.41	92.4	9.7	18.3	26.2	18.9	22.8	2.03	2.63
Mean	0.43	5.14	59.7	15.8	17.9	23.8	14.9	21.8	3.09	3.94
LSD (P=0.05)	0.24	1.02	28.0	8.4	1.20	3.60	1.03	1.29	0.32	0.74

S = Stress, NS = Non-stress

holding irrigation and withdrawing water from the field. Thereafter, crop was left rainfed. Under submergence experiment, after ten days of transplanting, the crop was completely submerged by filling water at 1.0 to 1.25 m depth for 16 days and thereafter water was drained out. The control (irrigated) trial was maintained by applying irrigations as and when required. Results revealed that irrespective of the genotypes, there was significant reduction (58.7%) in grain yield of rice under drought and submergence (34.5%) stress condition as compared to non-stress (irrigated). Among various rice genotypes, 05 genotypes were found promising for cultivation under multiple stresses (drought and submergences) conditions (Table 9). Grain yield of different genotypes varied from 1.96 to 4.11 t/ha, 3.13 to 5.68 t/ha and 4.86 to 8.40 t/ha under drought, submergence and non-stress conditions, respectively. Rice genotype IR96321-558-257-B-4-1-2 showed maximum grain yield under drought (4.11 t/ha) as well as submergence condition (5.68 t/ha).

Table 9. Performance of rice genotypes under drought and submergence condition

Rice genotypes	Grain yield (t/ha)		
	Drought	Submer-gence	Control (Irrigated)
IR96321-315-323-B-3-1-1	3.37	5.17	7.36
IR96321-558-209-B-6-1-1	2.83	4.40	7.40
IR96321-558-257-B-4-1-2	4.11	5.68	7.71
IR96321-1099-227-B-3-1-3	3.24	4.89	6.97
IR96321-558-563-B-2-1-1	3.64	5.24	8.40
IR6321-558-563-B-2-1-3	2.55	4.93	7.11
IR96321-315-323-B-3-1-3	2.72	3.95	6.68
Swarna Sub 1	2.06	4.57	7.30
Swarna	1.96	3.13	7.54
MTU 1010	2.58	—	5.82
Sahbhagi Dhan	2.76	—	4.86
Mean	2.89	4.66	7.01
LSD (P=0.05)	0.61	0.89	1.60

Evaluation of Rice Genotypes for Submergence Tolerance

Seventeen elite rice genotypes were evaluated for submergence tolerance along with 'Swarna sub-1' as tolerant and 'Swarna as susceptible checks (Fig. 16a). Thirty days old seedlings were transplanted in the main field on 14th July, 2015. After ten days of transplanting, the crop was completely submerged by filling water in the field to a depth of 75.0 cm to 1.0 m for 16 days and thereafter water was completely drained out (Fig. 16b & 16c). The survival percentage was recorded on regenerated plants after 10 days of de-submergence (Fig. 17). Survival percentage of HHZ9-DT12-DT1-Sub-1, IR10F198, IR 10F602 and IR 11F239 genotypes were better than other genotypes and at par with Swarna Sub-1 (87%). The highest grain yield was produced by IR 11F190 (4.84 t/ha) with 82% survival, followed by IR 07L320 (4.71 t/ha) and IR 11F239 (4.69 t/ha). Swarna Sub-1 and Swarna produced grain yield of 4.73 and 4.15 t/ha, respectively.

Fig. 16a. Crop view just before submergence

Fig. 16b. Submerged crop of paddy

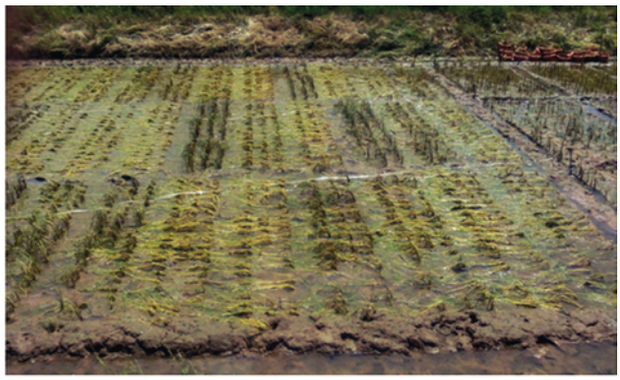


Fig. 16c. Crop view just after de-submergence

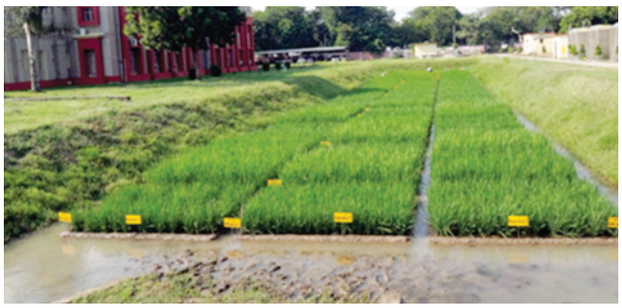


Fig 17. Regenerated crop at panicle initiation stage

Evaluation of elite rice genotypes under rainfed shallow lowland

Fifteen elite rice genotypes from IRRI were evaluated during *kharif* 2015 under rainfed shallow lowland along with Naveen, Swarna, Swarna sub-1 and Rajendra Sweta as checks. Among test genotypes, IR 10L182 produced the highest grain yield (5.95 t/ha) followed by IR 09L311 (5.77 t/ha), IR 09L337 (5.66 t/ha) and IR 09L204 (5.62 t/ha) with 100 days to 50% flowering. These genotypes were three weeks earlier than Swarna. The check varieties Naveen, Swarna, Swarna Sub-1 and Rajendra Sweta produced 5.17, 5.57, 5.31 and 4.51 t/ha under same condition.

Field Testing of Rice Crop Manager for Submergence-Prone Ecology

Rice crop manager (RCM), a nutrient recommendation package developed by IRRI and validated by the institute and SAUs for submergence-prone ecology, indicated that application of fertilizer should be as follows : DAP (89 kg basal), urea (104 kg at active tillering and 104 kg at PI stages), MOP (38 kg basal and 38 kg at PI stage) and zinc sulphate (20 kg as basal) against the recommended dose of nutrients (BMP) (80:40:20:5 kg/ha of N,P,K and Zn). Four varieties of rice (Swarna sub-1, Samba Mahsuri (SM) sub-1, IR 64 sub-1 and Swarna) were evaluated under RCM and BMP. Thirty five days old seedlings were transplanted in the submergence tank on 14th July, 2015 with 2-3 seedlings per hill. After 10 days of transplanting, the crop was completely submerged with water level of 1.0-1.25 m for a period of 16 days. Results revealed that there was no significant difference in plant survival between RCM and BMP. However, rice varieties with sub1 gene had significantly higher survival percentage and grain yield than the susceptible check 'Swarna' (Fig. 18) under submergence (Table 10).

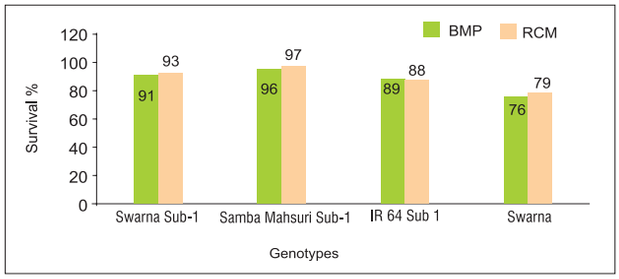


Fig. 18. Survival percentage of rice genotypes 21 days after de-submergence under RCM and BMP.

Post-flood nutrient management in submergence tolerant rice

Ensuring proper nutrient management during pre and post-submergence period may improve survival and productivity of flood-prone rice.

Twenty one days old rice seedlings (cultivar-Swarna Sub-1) were completely submerged in water for 3, 7, and 11 days in pond. The depth of water for submergence was 1.25 m. Pots were removed from the pond after respective duration of submergence. Survival percentage was computed 5 days after de-submergence. In addition to RDF (80-40-40-25 kg N-P_2O_5-K_2O-$ZnSO_4.7H_2O$/ha), 7 post-flood nutrient treatments were applied 5 days after de-submergence. It is evident from the study that survival under submergence is dependent both on ability to store a high level of non-structural

Table 10. Yields and harvest index of rice genotypes under RCM and BMP

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Harvest index		
	BMP	RCM	Mean	BMP	RCM	Mean	BMP	RCM	Mean
Swarna-Sub1	6.31	6.42	6.36	9.52	9.97	9.75	0.40	0.39	0.39
Samba Mahsuri-Sub1	7.18	8.32	7.75	9.83	11.23	10.53	0.42	0.43	0.42
IR 64-Sub1	5.66	6.16	5.91	7.91	9.02	8.46	0.42	0.41	0.41
Swarna	5.76	6.03	5.90	8.64	9.47	9.06	0.40	0.39	0.40
Mean	6.23	6.73		8.98	9.92		0.41	0.40	
LSD (P=0.05)	M =757 V=1071 M x V=1515			M =782 V=1106 M x V=1563			M =0.02 V=0.03 M x V=0.05		

carbohydrate (NSC) and slower degradation of protein and chlorophyll content under varying degree of submergence condition. Moreover, the higher level of anti-oxidants was also positively co-related with plant survival. Application of basal P maintained the level of NSC and retained more energy to survive and recover from submergence. N and K application after post flood help in plant survival, their growth and improvement in total yield in term of higher grain number, panicle length and harvest index (Table 11).

Table 11. Effect of duration of submergence and post-flood nutrient management

Treatment	Plant survival (%)	Panicles/ plant	Grain filling (%)	Grain yield (g/ plant)
Duration of submergence				
3 days	75	11	74	18.2
7 days	67	12	73	16.0
11 days	65	11	67	12.8
LSD (P=0.05)	9	NS	NS	1.4
Post-flood nutrient management				
20-20 kg N-K_2O/ha	72	73	18.2	42
20-10 kg N-K_2O/ha	67	70	18.3	41
10-10 kg N-K_2O/ha	69	76	20.3	41
20 kg N/ha	67	78	15.2	40
10 kg N/ha	75	76	14.2	43
2% foliar spray of urea	64	70	14.1	35
Control	69	57	10.3	35
LSD (P=0.05)	NS	14	2.2	7

WHEAT

Forty two genotypes were evaluated under three different date of sowing (25th Nov, 20th Dec 2014 and 5th Jan 2015) for terminal heat stress tolerance (Fig. 19). The mean relative water content (RWC) and membrane stability index (MSI) of wheat genotypes showed declining trend from timely sown (TS ~ 90 and 80%) to very late sown (VLS ~ 60 and 50%) conditions. The promising genotypes *viz*. HD2987, HD 3093, NW 1014 and NW 1012 were able to maintain higher RWC and MSI. Wheat genotypes HD 3093, NW 1014, HD 3120 and HD 2987 have higher photosynthetic rate as compared to others. Oxidative stress caused severe damage to cell membrane stability and integrity. Thus the performance of antioxidant is important to scavenge these free radicals (ROS).

Fig. 19. Performance of wheat genotypes under timely sown (25.11.2014), late sown (20.12.2014) and very late sown (05.01.2015) conditions

Catalase (CAT) is an important antioxidant which helps in scavenging of free radicals. The mean CAT activity showed an increasing trend from timely sown to very late sown condition. Moreover, wheat genotypes Raj 4238, GW 273, HI 1531 and NW 1014 have higher CAT activity as compared to other promising genotypes. However, the level of proline content showed an increasing trend from timely sown to very late sown condition. Genotypes Raj 3765, HD 2733, Kundan and NW 1014 have higher proline content as compared to other promising genotypes. The genotypes; HD 3120, HD 3093, NW 1012, Raj 4238, Kundan, WH 760 and NW 1014 performed better in terms of yield and yield attributes under heat stress condition as compared to other genotypes (Table 12).

In another experiment conducted under ICAR-CSISA colloborative project, 12 wheat cultivars were evaluated for their relative productivity under late-sown conditions of Eastern IGP. Results revealed that wheat cultivar Bazz (4.13 t/ha) followed by Lok 1 (3.83 t/ha) produced the higher grain yield under late sown conditions.

Table 12. Yield of promising wheat cultivars along with checks (HD 2733 and HD 2967) under timely, late and very late sown condition

Sowing condition	Grain yield (t/ha)				Grain yield (t/ha)				
	TS	LS	VLS	Mean		TS	LS	VLS	Mean
Genotypes									
NW 1014	4.70	4.31	3.57	4.19	NW 1012	4.38	4.10	3.31	3.92
HD 2987	4.56	4.14	3.54	4.08	RAJ 3765	4.27	4.12	3.43	3.94
HD 3093	4.36	4.06	3.49	3.97	WH 760	4.35	4.03	3.40	3.92
GW 273	4.33	4.03	3.40	3.91	Kundan	4.21	3.99	3.36	3.85
RAJ 4238	4.51	4.12	3.42	4. 01	DBW 17	4.15	3.97	3.38	3.83
HI 1531	4.55	3.96	3.42	3.98	HD 2967	4.21	3.80	2.89	3.63
HD 3120	4.53	4.20	3.40	4. 04	HD 2733	4.00	3.60	3.12	3.57
LSD (P=0.05)	Variety= 0. 08, Sowing date: 0. 02, SXV= 0.14								

TS= timely sown; LS= late sown; VLS= very late sown

Evaluation of Wheat Germplasm for Terminal-Heat Stress Tolerance

Under ICAR-CSISA colloborative project, 21 promising wheat germplasm (out of 183 evaluated at BISA, Samastipur) were evaluated for early sowing conditions to avoid terminal heat. Wheat germplasm, 3rd CSISA-HT-EM-10212, 3rdCSISA-HT-EM-10225, 6EBWYT-518, 6EBWYT-528 and 3rdCSISA-HT-EM-10229 were found superior in terms of grain yield (Fig. 20).

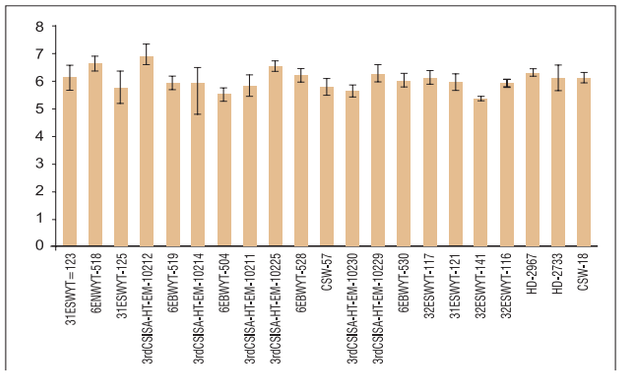


Fig. 20. Performance of wheat germplasm for early sowing

Evaluation of Hand Held Crop Cutter in Wheat and Rice

Performance of crop cutter was evaluated in rice and wheat (Fig. 21). Results showed that the field capacity of crop cutter was 2.44 times higher than the manual operation. The labour requirement was 32.74 and 149.25 man-hr/ha for crop cutter and manual operation, respectively. In case of wheat, the field capacity of crop cutter was 2.23 times greater than manual harvesting and labour involvement was 23.20 and 115.74 man-hr/ha for

Fig. 21. Testing of crop cutter for rice harvesting

crop cutter and manual operation, respectively. The cost of wheat harvesting operation for one hectare was ₹ 2,340/- in case of crop cutter and ₹ 3,750/- for manual operation. Whereas in rice harvesting the cost was ₹ 2,464/- for crop cutter and ₹ 5,596/- for manual operation, respectively. The data indicated that use of crop cutter can reduce the cost of operation up to 37.6% in case of rice and 56.0% in wheat, respectively.

Similarly, the labour requirement of spring maize weeding is depicted in Fig. 22.

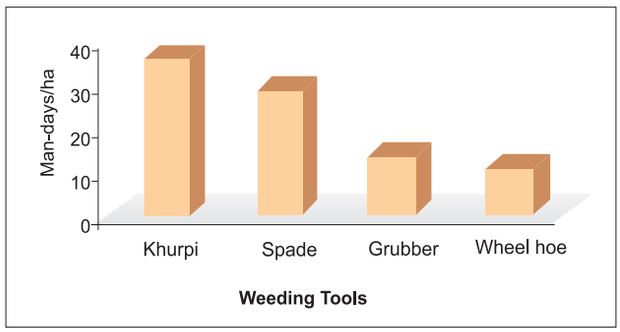


Fig. 22. Mandays requirement under various weeding tools of maize

6. Pulses and Oilseeds

PULSES

Lentil

Effect of auxin and zinc on the performance of late-sown lentil

A field experiment was conducted to study the effect of foliar spraying of auxin and zinc on performance of lentil under varying dates of sowing (Fig. 23). Results revealed that lentil yield declined considerably when sown after 20th November (Table 13). Further, application of auxin @2 ppm significantly increased the grain yield (1.40 t/ha) as compared to control (0.91 t/ha). Combined application of auxin+zinc reduced the grain yield of lentil as compared to auxin alone. Lentil sown on 10th November and foliar spraying of auxin @ 2.0 ppm produced the highest seed yield (1.62 t/ha).

Fig. 23. Overview of lentil field at different growth stage

Table 13. Effect of auxin and zinc on performance of late sown lentil seed yield (t/ha)

Hormonal treatments	Time of Planting				Mean
	10 Nov	20 Nov	30 Nov	10 Dec	
Control	1.01	0.96	0.89	0.75	0.91
Zn (10ppm)	1.10	1.07	1.07	0.93	1.04
Auxin (2.0 ppm)	1.62	1.45	1.33	1.19	1.40
Auxin (4.0 ppm)	1.56	1.54	1.07	1.25	1.36
Auxin (2.0 ppm) + Zinc (10 ppm)	1.51	1.48	0.98	0.90	1.23
Auxin (4.0 ppm) + Zinc (10 ppm)	1.25	1.28	0.98	0.84	1.09
Mean	1.34	1.30	1.06	0.97	

In another experiment, 125 accessions (indigenous as well as exotic) including 5 released cultivars of lentil were evaluated. Five lines namely, IGP 105 (1.13 t/ha), IGP 62 (0.99 t/ha), IGP 75 (0.97 t/ha), GP 130 (0.87 t/ha) and IGP 129 (0.84 t/ha) were selected for further evaluation. Three accessions (IGP 136, IC 560299 and IGP 135) appeared to be the earliest maturing (105 days) and high-yielding (> 900 kg/ha). Besides, segregating population from a cross, ILWL 118 × DPL 58, was also advanced, and 16 single plant selections (SPS) were performed based on biomass, earliness and no. of pods.

Chickpea

The genotype 'Pusa 547' recorded the highest grain yield (1.51 t/ha) followed by 'Pusa 1103' (1.39 t/ha) and 'Pusa 256' (1.31 t/ha) under timely sown condition, however, under late sown condition (first week of January) chickpea variety. 'Pusa 256' appeared to be the best.

Two F_1's (Shubhra × BGD 9971 and JG 16 × BGD 9971) were advanced to second filial generation. One F_1 (Shubhra × BGD 9971) showed only partial dominance of NDT (Shubhra) over the DT (BGD 9971) type. However, the second cross (JG 16 × BGD 9971) indicated complete dominance of NDT over DT types. Besides 5 F_3 progenies were also evaluated to assess their suitability for mechanical harvesting. Out of these, 3 progenies (BGD 103 × TL-II 109) seemed to be promising on account of no. of pods, plant height and stem thickness and girth. 8 back cross derived F_3 progenies were also grown; observations revealed that 2 progenies (KWR 108 × ICC 4958) were the earliest ones with respect to days to 50% flowering (< 65 days) and maturity period (125 days). 3 other progenies (Pusa 256 × WR 315 and Pusa 256 × Vijay) also appeared to be promising for most agronomic and yield attributes.

Grass pea

Fourteen accessions obtained from Regional Centre of ICARDA, Bhopal were evaluated. These lines have low ODAP content. Data on days to flowering, early vigour, etc have been recorded. Three lines (63104, 63115 and 63101) were found promising for heat stress; these lines could be utilized in further breeding programmes. Besides, 4 indigenous collections were also grown. These locally adapted types performed better with average yield of more than 1.5 t/ha.

Pigeonpea

'IPA 203', a variety of long-duration pigeonpea for NEPZ, was grown on rice bunds during 2014-15. Its performance was highly noticeable (> 4 t/ha). More than 100 kg seeds of 'IPA 203' were provided to > 40 farmers of Darbhanga, Madhubani, Samstipur and Purnea districts. Fifty kg seed of this variety was also provided to KVK, Buxar for demonstration at farmers' fields. Another advance breeding line 'DBGA 7-10' was also grown and genetically pure seeds were produced under nylon net. This genotype has been put to station trial (Darbhanga) and wilt sick nursery (Dholi) for evaluation of agronomic performance and disease reaction during 2015-16. Backcross derived F_2 populations were grown to select plants having true 'cleistigamous' flowers (Fig. 24a). A total of 11 such *cleistogamous* plants were isolated; the no. of pods and other agronomic and yield traits seemed to be at par with the parental variety 'IPA 203'. Ten out of 11 progenies showed zero per cent outcrossing, which is a significant achievement. The F_1, backcross and F_2 populations have revealed that 'obcordate' leaf is a recessive monogenic trait (Fig. 24b). However, utilization of this marker trait (obcordate leaf) in hybrid breeding would be difficult as the gene governing this trait appears to have so many undesirable pleiotropic effects such as photo-thermosensitivity and floral deformity.

Fig. 24a. Left: normal flower, right: 'cleisto' flower; standard: top, wings: extreme sides and keels: middle ones

Fig. 24b. Extreme left and right: lanceolate and obcordate types, respectively; middle one: obovate type

OILSEEDS

Evaluation of Mustard Cultivars for Yield Maximization

In rice-mustard-maize system, the seed setting in spring maize is adversely affected due to high temperature during May. To solve this problem 14 mustard cultivars of different durations were evaluated for their suitability of fitting in to rice-based cropping system (Fig. 25). Results revealed that though the cultivar 'Pioneer 45J21' produced the maximum yield (2.58 t/ha), but it took longer duration (123 days) for maturity. However, 'Proagro-5111' with seed yield of 2.19 t/ha matured in 112 days. Hence, the subsequent maize can be sown 10-12 days early and can escape the high temperature stress. The oil percentage of different varieties ranged from 38.65 to 39.65%.

Fig. 25. Overview of mustard experiment

7. Fruits

Mango

Out of 108 genotypes evaluated for fruit quality such as peel content, seed content, pulp content, TSS, average fruit weight, Langra, Jhapatta, C.H.M.-4, Rataul, Bara Sinduria, Barbelia, Jalal and Bag-e-Bahar (Fig. 26) were found to be the most promising.

Principal Component Analysis (PCA) was also carried out using 108 genotypes with 17 traits. The results showed that 91.06 % of variability was explained by only first seven principal components (PC). Out of seven, first and the second explained 45.71 and 13.76 % of the variation, respectively. The highest positive values for PC1 indicated by Fazli, followed by Helmet, Sahabale and Sesar genotypes. The highest positive value for PC2 correspond to Bombaiya, Lahutia, Lucknow Safeda, Rani Pasand, Hamlet, Peddarasam and Raspuri genotypes.

Hierarchical clustering was attempted by using paired group algorithm with Euclidean distance measure. The dendrogram (Fig. 27) of fruit traits grouped the genotypes into two groups with additional subgroups in each group. Group I composed of only three genotype and group II composed of 105 genotypes. Results indicated that the mango genotypes showed fruit quality traits that distinguish them from each other, which may be the result of the intense artificial selection for the purpose of agronomic cultivation and fruit quality-related traits.

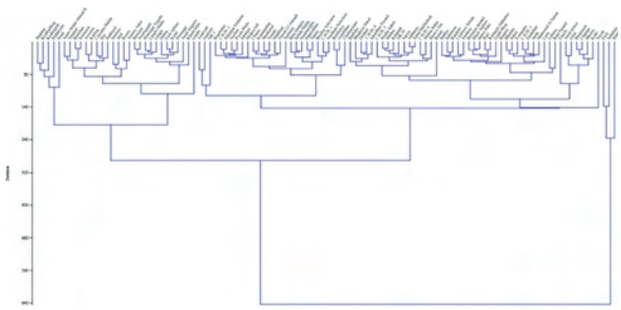


Fig. 27. Dendrogram of 108 mango genotypes obtained by average distance between cluster analyses based on 17 fruit traits

Mango hybridization

Mango crossing was performed with the objective to impart red peel colour and resistance against malformation in the commercial varieties of eastern region (Fig. 28). The mango genotypes Sensation, Vanraj and Lal Sinduri were used as donor for red peel colour and genotype Illaichi was used as donor for resistance against malformation. A total of 1044 number of crosses in different combinations

Fig. 26 Fruit shape of mango genotype Baag-e- Bahar

Fig. 28. Performing hybridization in mango

were made out of which a total of four hybrids were obtained (Table 14).

Table 14. Details of crosses made in mango

Cross combinations	No. of crosses made	No. of hybrids obtained
Langra x Sensation	428	1
Langra x Vanraj	346	2
Himsagar x Sensation	88	1
Himsagar x Illaichi	107	0
Lal Sinduri x Illaichi	75	0
Total	1044	4

Jackfruit

Evaluation of jackfruit germplasms for vegetable purpose

Twenty seven genotypes were evaluated for vegetable purpose based on per cent edible portion and firmness of edible portion after boiling. The per cent edible portion varied from 35.3 (ICARRCER JS 8/9) to 55.94 % (ICARRCER JS 6/3). Genotypes ICARRCER JS 7/4, ICARRCER JS 3/4, ICARRCER JS 10/3 and ICARRCER JS 6/3 had more than 50% edible portion. The maximum firmness was recorded in the ICARRCER JS 4/1 (7.32 lbs). Jackfruit genotype ICARRCER JS 10/1, ICARRCER JS 6/5, ICARRCER JS 3/4, ICARRCER JS 8/1, ICARRCER JS 6/3 and ICARRCER JS 3/1 were found to be soft (firmness <2 lbs) after boiling and suited well for vegetable purpose (Fig. 29). Hence, based on per cent edible portion and firmness, ICARRCER JS 3/4 and ICARRCER JS 6/3 were found promising for vegetable purpose.

Fig. 29. Fruit and boiled cubes of jackfruit genotype ICARRCER JS 3/4

Bael

Evaluation of bael germplasm

Seventy five bael genotypes conserved at the field gene bank of the institute were evaluated for their performance under Eastern Plateau and Hill conditions based on fruit quality. Based on overall performance (average fruit weight- > 1 kg, peel % < 20, seed % < 5, pulp % >75, TSS -> 40°B, peel thickness < 2 mm), the genotype ICARRCER BS 10/2, ICARRCER BS 8/1 (Fig. 30) and ICARRCER BS 6/1 were found promising during the year.

Fig. 30. Promising bael genotype

Principal Component Analysis showed that more than 94% of the observed variance could be explained by the first eight components. PC1, PC2, PC3, PC4, PC5, PC6, PC7 and PC8 which accounted for 34.09, 21.50, 13.27, 8.15, 5.36, 4.62, 4.19 and 3.41% of total variability, respectively. PC1 indicate genotypes with higher fruit weight, fruit width pulp weight, pulp per cent and volume of the fruit which comprise of ICAR-RCER BS 8/7, ICAR-RCER BS 1/11, ICAR-RCER BS 10/2, ICAR-RCER BS 6/2, ICAR-RCER BS 8/1, ICAR-RCER BS 10/6, ICAR-RCER BS 5/1, ICAR-RCER BS 7/5 and ICAR-RCER BS 13/4. PC2 values correspond to varieties with higher skin weight and skin per cent such as ICAR-RCER BS 9/6, ICAR-RCER BS 12/7, ICAR-RCER BS 7/3, ICAR-RCER BS 6/1, ICAR-RCER BS 4/4 and ICAR-RCER BS 1/5.

The dendrogram was generated by a Pearson similarity correlation coefficient and classified 75 germplasm into the two major clusters primarily based on fruit traits (Fig. 31). The first cluster comprised of 12 germplasm and contributed to 16% of the total germplasm. The second cluster constituted remaining 63 germplasm which were found similar in various fruit traits. The genetic distance ranged from 0-980, indicating a high degree of dissimilarity among the germplasms.

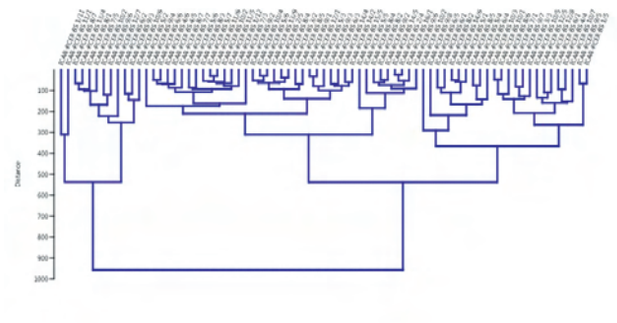


Fig. 31. Dendrogram of 75 bael germplasms obtained by average distance between clusters based on 16 fruit quality traits.

Survey and surveillance of pest complex

At ICAR RCER RC, Ranchi, surveillance result on one time data harvest showed that fruit borer, *(Cryptophlebia ombrodelta)* alone caused up to 40% fruit damage through mining and fruit drop in Godda collection accession. Fruit fly (*Bactrocera zonata)* was found to cause fruit pulp rotting after harvesting resulting up to 46.5% fruit damage (Fig. 32).

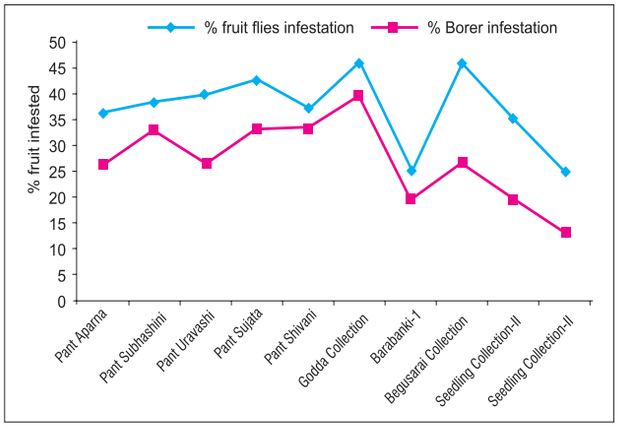


Fig. 32. Incidence level of fruit borer, and fruit flies in bael at the time of harvest

Litchi

Collection and evaluation of litchi germplasm

One promising genotype of litchi (ICAR RCER LS-8) was identified and collected from Murhu village of Khunti district of Jharkhand. The fruit of the genotype are small seeded, fruit weight (22.8 g), has high pulp content (81.4%) TSS (20.6^{0}B). The air layers were prepared from the mother plant for propagation. A total of 29 genotypes conserved in the field gene bank were evaluated for fruit quality and yield. The genotypes differed significantly among each other with respect to all the fruit quality parameters except reducing sugar and total sugar content. The maximum fruit weight was recorded in Bedana (23.8 g) and the other large fruited genotypes were Ajhauli, CHES-2, China, Dehra Rose, Deshi, Kasba, Purbi, Rose Scented and Shahi. The highest pulp % was recorded in Yogada Selection (83.13%) while the genotypes Bedana, CHES-5, CHL-8, CHL-9, Selection 4/36, Selection 7/104, Selection 8/1 were at par. The maximum TSS was recorded in Deshi (24.09 ^{0}B) whereas the highest TSS/acidity ratio was recorded in Shahi (258.5). The minimum fruit cracking was recorded in Swarna Roopa (2.6%) which was at par with Bedana, CHES 2, CHL-7, Late Bedana, Longia and Yogada Selection. The genotypes with high yield (>30 kg/plant) were Ajhauli, CHES-2, China, Deshi, Green and Rose Scented (Fig. 33). Hence, based on fruit quality and yield, the litchi genotypes Rose Scented and Deshi were found most promising during the year.

Fig. 33. Litchi cultivar 'Rose Scented' found promising during 2015

Extending the harvesting period of litchi cv Shahi

A trial is being undertaken to standardize the technique for extending harvesting period in litchi cv Shahi (Fig. 34). The harvesting period was extended up to 11 days with the use of 30% and 50% light transmission shade net. Application of GA_3 at 40 mg resulted in maximum fruit weight (23.01g), fruit volume (21.67 cc), fruit length (37.67 mm) and fruit diameter (34.07 mm) followed by use of 50% light transmission shade net. Pulp per cent was found to be significantly higher with the use of 50% light transmission shade net (73.08 %)

Fig. 34. Litchi cv Shahi covered with shadenet (50%)

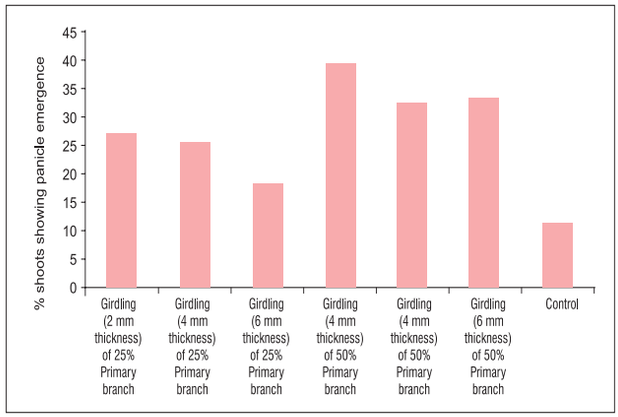


Fig. 36. Effect of girdling on % panicle emergence in litchi cv China

whereas, acidity was found to be higher with the use of 30% light transmission shade net. However, TSS, reducing sugar and total sugar were not influenced by the treatments.

Improving the bearing potential of litchi through girdling of branches

A trial is being undertaken to improve the bearing potential of litchi cv China through girdling of 50% & 25% with 2m, 4m and 6m girdling branches thickness (Fig. 35). Girdling of 50 per cent of primary branches with 2 mm width showed the maximum flowering shoots (39.72 %) followed by girdling of 50 per cent of primary branches with 4 and 6 mm width (Fig. 36). There was no significant effect of the treatments on fruit quality parameters except for TSS. TSS was found significantly higher (22.34° Brix) with girdling of 25 per cent of primary branches with 6 mm width followed by girdling of 50 per cent of primary branches with 2 and 4 mm width.

Fig. 35. Girdled primary branch

Standardization of grafting in litchi

The experiment was conducted to investigate the effect of girdling and defoliation on the success and growth of grafts in litchi cv. Shahi. The branches were girdled (removing 3 mm ring from branches of 40-50 mm girth) one month before the collection of scion for grafting. Defoliation was performed 7 days before the collection of scion. The graft success percentage and vegetative growth were markedly improved as a result of girdling and defoliation (Table 15). Hence, it was concluded that girdling of branches, one month prior to collection of scions and defoliation performed 7 days before the collection of scion can increase the success rate of grafting and plant growth of grafts (Fig. 37).

Fig. 37. Grafted plants of litchi

Table 15. Effect of girdling and defoliation on litchi grafting performance

Treatment	Days required for sprouting	Scion height (cm)	Scion girth (mm)	No. of sprout / graft (nos.)	Sprout length (cm)	Graft success (%)	No. of compound leaves (nos.)	Rachis length (cm)	Leaflet length (cm)	Leaflet width (cm)
Girdling + Defoliation	15.40c	24.25a ± 2.19	7.14a ± 0.59	2.64a ± 0.28	4.80a ± 0.81	56.43a	8.34a ± 0.98	9.33a ± 1.29	9.37a ± 0.97	3.37a ± 0.22
Defoliation	28.76a	16.95b ± 2.94	5.93b ± 0.21	1.50b ± 0.58	2.31b ± 0.81	43.06b	5.35b ± 0.82	6.18b ± 1.14	6.78b ± 0.54	2.53b ± 0.26
Control	30.18a	13.75b ± 2.63	5.67b ± 0.87	1.50b ± 0.58	1.21b ± 0.62	35.27c	4.80b ± 0.91	6.45b ± 0.48	6.47b ± 0.49	2.39b ± 0.20

Survey and surveillance of pest complex of litchi

Surveillance data on infestation of fruit borer complex in litchi at the time of harvest from research farm of ICAR RCER, RC Ranchi were recorded and it was observed that borer infested fruit ranged between 0.0 to 4.0 per cent at the end of May, 2015. The infestation level in late variety (i.e. China) was found to be increased suddenly and reached upto 54.5 ± 12.4% due to rain in the last week of May. Molecular data revealed that three species of borer were found to infest litchi *viz*, *Conopomorpha sinensis, Conopomorpha litchiella* and *Cryptophlebia ombrodelta.*

Diversity, Species Composition and Percent Infestation of Fruit fly in Eastern Uttar Pradesh

The fruit fly trapping was carried out by fruit fly traps (Fig. 38) containing parapheromones like methyl eugenol and cue lure in two districts *viz* Faizabad and Varanasi of Eastern U.P. Five traps of each lure were placed for overnight at Crop Research Station (CRS) Masaudha, Faizabad and India Institute of Vegetable Research (IIVR), Campus, Varanasi. Fifty ripe fruits freshly fallen/ picked from trees were also randomly collected from each selected locality and examined under hand lens to detect the oviposition marks on the fruits to know the percent fruit infestation. Some of the fruits were also dissected to confirm the larval presence inside the fruits (Fig. 39).

Fig. 38. Fruit fly trap

Fig. 39. Fallen damaged guava fruits

Flies per trap per day index was recorded 15.6 and 16.2 at CRS Masaudha, Faizabad and IIVR campus, Varanasi, respectively. The collected specimen was identified with help of taxonomical keys. Five fruit flies species *viz Bactrocera dorsalis, B. correcta, B. zonata, B. tau* trapped in methyl eugenol while *B. cucurbitae* in cue-lure parapheromone traps from CRS Masauda, Faizabad and IIVR, Varanasi. However, *B.tau* was trapped only in Faizabad and *B. zonata* from Varanasi.

The species composition indicated that out of five species of fruit flies, *B cucurbitae* was observed to be most dominant with 87.17% (68) at Faizabad and 48.14% (39) at Varanasi followed by *B. dorsalis* with 46.91% (38) at Varanasi and 6.41% (5) at Faizabad. The per cent fruit fly infestation was recorded at the tune of 44 % and 38% at Faizabad and Varanasi localities, respectively.

8. *Vegetables*

Tomato

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

Evaluation of F_1 pair crosses for bacterial wilt: Among the nine F_1 pair crosses evaluated for bacterial wilt resistance under artificial inoculation conditions in wilt sick plot, HAT-311 x Swarna Lalima (85%) (Fig. 40), HAT 296 x HAT-310 (82.5%), HAT-296 x HAT-311 (80%), HAT-296 x HAT-302 (81.4%), Swarna Lalima x HAT-310 (80.5%) and Swarna Lalima x HAT-311 (80%) were found wilt resistant.

Fig. 40. HAT-311 x Swarna Lalima

Evaluation of F_1 pair crosses for fruit quality

Twenty crosses selected for fruit yield and twenty three pair crosses selected for bacterial wilt and nematode resistance were evaluated for fruit quality (acidity, ascorbic acid, pH, TSS and total sugar) and results are given in Table 16.

Molecular characterization for nematode and wilt resistance: Characterization of parents and F_1s with RAPD markers OPS-16, S401 and S264 for wilt resistance and SSR marker Mi-23 for nematode resistance is depicted in Fig. 48-50. A 500bp band with OPS 16 and a 450bp band with S 264 was obtained in wilt resistant parent HAT-302. Swarna Lalima and EC-594647 also amplified with S 264. A 500bp band with OPS 16, a 400bp band with S 401 and a 450 bp band with S 264 was obtained in wilt resistant crosses Swarna Lalima X HAT-311, HAT-296 X HAT-310, HAT-296 X HAT-311, HAT-296 X HAT-302, EC-594647 X HAT-311 and HAT-311 X Swarna Lalima.

Table 16. Performance of F_1s for fruit quality characters

Parameters	Maximum	Minimum
Acidity (%)	HAT-296 x EC-596743 (0.29)	HAT-305 x HAT-302 (0.13)
Ascorbic acid (mg/100g)	HAT-305 x EC-596743 (33.33)	EC-596748 x HAT-297 (8.29)
pH	HAT-302 x EC-596743 (4.11)	HAT-296 x EC-596743 (3.56)
TSS (^{0}B)	EC-596743 x HAT-305 (7.87)	Swarna Lalima x HAT-311 (2.97)
Total sugar (%)	HAT-296 x HAT-310 (3.90)	EC-596743 x HAT-311 (1.90)

Nematode resistance marker Mi 23 showed 430 bp amplicon in HAT-302 and in crosses Swarna Lalima X HAT-311, HAT-296 X HAT-310, HAT-296 X HAT-311, HAT-296 X HAT-302 and EC-594647 X HAT-311. Another 380 bp amplicon was produced in HAT-296 X HAT-310, HAT-296 X HAT-311 and EC-594647 X HAT-311.

Labelling of each gel: 1st lane Marker 1kbp, Lanes 2 to14: HAT-310, HAT-311, HAT-302, HAT-296, Swarna Lalima, EC-594647, Swarna Lalima X HAT-310, Swarna Lalima X HAT-311, HAT-296 X HAT-310, HAT-296 X HAT-311, HAT-296 X HAT-302, EC-594647 X HAT-311, HAT-311 X Swarna Lalima.

Dendrogram using Jaccard's coefficient for the 3 RAPD primers

Clear and distinct bands amplified by RAPD primers were scored for the presence (1) and absence (0) of the corresponding band through OPS16, S401 and S264, among the genotypes. Coefficients of similarity were calculated by using Jaccard's similarity coefficient and cluster analysis was performed by agglomerative technique using

the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method. Relationships between the genotypes were graphically represented in the form of dendrogram (Fig. 41). All the resistant crosses except Swarna Lalima x HAT-310, grouped into a single large cluster connected to the main branch indicating segregation of the resistance genes. Swarna Lalima and EC-594647 were grouped into a single cluster indicating presence of the same wilt resistance gene in both of them. HAT-296 and HAT-302 grouped separately indicating separate resistance genes. HAT-310 and HAT-311 which are nematode tolerant genotypes, grouped separately.

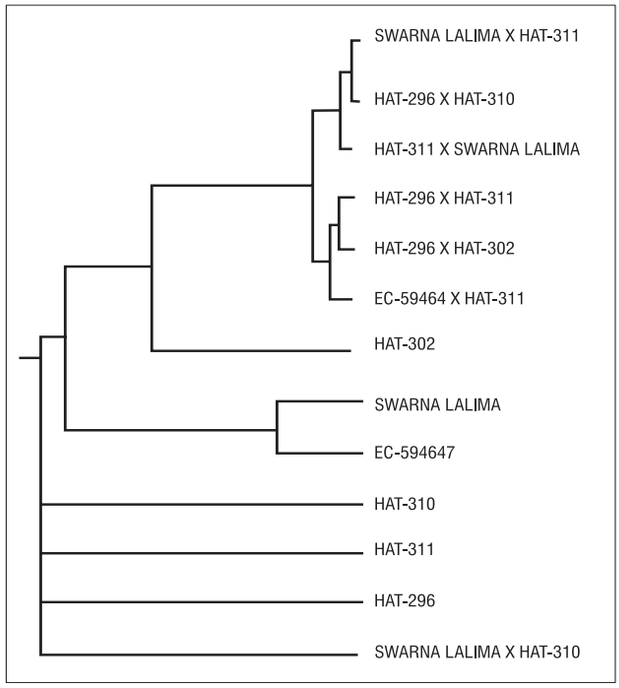


Fig. 41. Dendrogram showing relationship between genotypes

Quality evaluation of tomato varieties/ hybrids released by the institute

Fruits of six tomato hybrids ie., Swarna Vaibhav, Swarna Sampada, Swarna Samriddhi, Swarna Vijaya, Swarna Deepti, Swarna Anmol, and two open pollinated varieties i.e., Swarna Lalima and Swarna Naveen were evaluated for antioxidant properties. The fruits were harvested at three maturity stages *viz*, Green, Turning and Fully ripe stage. Analysis showed an increase in antioxidant activity (Fig. 42), ascorbic acid (mg/100g) (Fig. 43) as the maturity advances from green to fully ripe stage.

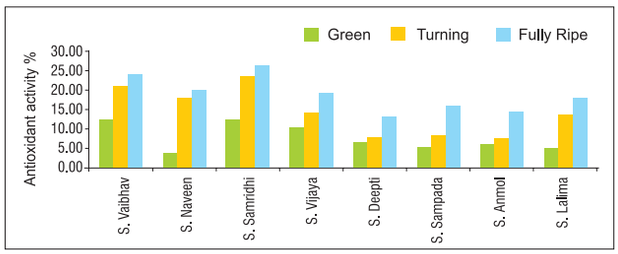


Fig. 42. Changes in antioxidant activity % of tomato fruits with ripening

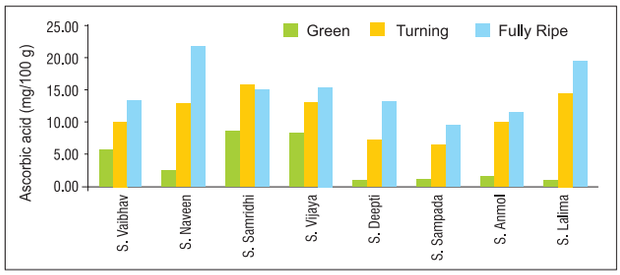


Fig. 43. Changes in ascorbic acid (mg/100g) content of tomato fruits with ripening

Bitter Gourd

Improvement in seed quality of solanaceous and cucurbitaceous vegetables

Effect of on-farm priming treatments on seed quality par ameters in bitter gourd var. Swarna Yamini under field conditions

Different on-farm farmers' friendly priming treatments were evaluated. All the priming treatments were given for 18 hrs at temperature of 25-30°C. Seeds of bitter gourd which exhibited a significant dormancy responded to pre-soaking treatments. Hydropriming increased the seed germination from 63 to 72%, osmo priming in a solid matrix (sand+water in a ratio of 5:2) to 76% as compared to control (63%). Use of commonly available chemicals like 5% table salt and 1% KNO_3 also gave positive results which increased the germination upto 67% & 86%, respectively. Similarly, Ethrel@ 200 ppm and 500 ppm raised the germination per cent to 85% and 93%, respectively, as compared to control.

Four seed treatment formulations based on *Trichoderma* species (culture filtrate) were prepared and their biological efficacy was tested at 50 and 100% conc. against seed mycoflora in vitro (Fig. 44). Results were highly promising which inhibits 100% seedborne mycolora of bitter gourd and bottle gourd *viz*, *Curvularia* sp., *Fusarium* sp., *Alternaria* sp. and *Heterosporium* sp. at both the test concentra-

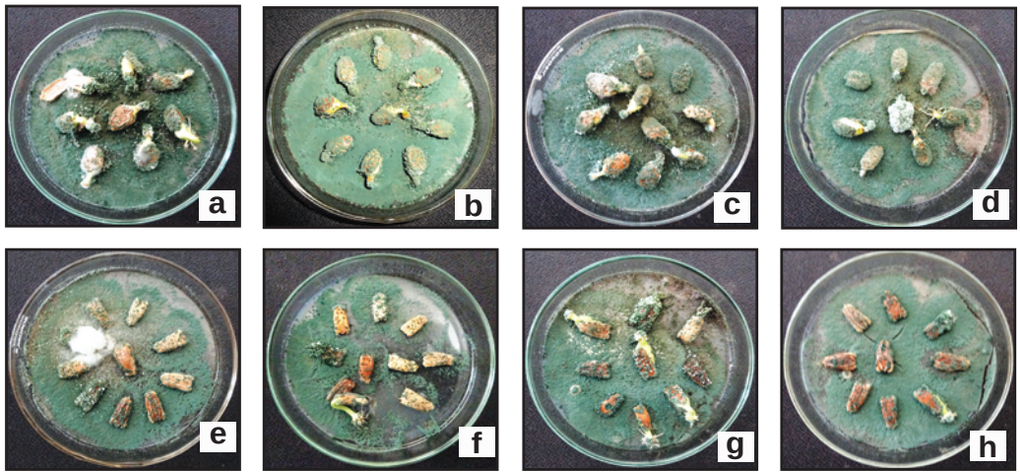


Fig. 44. Seed treatment with culture filtrate of ***Trichoderma*** spp. based formulations against seed mycoflora of vegetable seeds. a. bitter gourd coated with T-7/50%, b. T-7/100%, c. T-14/50%, d. T-14/100%, e. Bottle gourd seed coated with T-7/50%, T-7/100%, T-14/50%, T-14/100% culture filtrate

tion while mean germination of 100% was observed in bitter gourd and 90% in bottle gourd.

Tuber Crops and Wild Edibles

A survey was conducted in nine districts of Nagaland (Dimapur, Peren, Kohima, Phek, Zunheboto, Wokha, Mokokchung, Mon and Longleng) and coastal districts of Odisha. Forty germplasm of taro from Nagaland (Fig. 45) and 02 germplasm of arrowroot & 06 germplasm of greater yam have been collected from Odisha and maintained in the field.

Fig. 45. Promising collections of taro germplasm from Nagaland

The germplasm (201) collected previously from 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 were evaluated for tuber yield. ACC-173 (Fig. 46), a collection from Rampur Bazar under Namkum block of Ranchi performed the best and recorded tuber yield of 17.10 t/ha with a yield increase of 82.10% over the check variety Sree Bhadra (9.39 t/ha).

Fig. 46. Sweet potato ACC-173

Taro/Colocasia

Out of 11 lines including check evaluated for tuber yield, ACC-37 (Fig. 47), a collection from Barapalasi village under Jama block of Dumka district

Fig. 47. Taro ACC 37

of Jharkhand performed the best and recorded corm yield of 52.16 t/ha with a yield increase of 78.93% over the check variety Muktakeshi (29.15 t/ha).

Cassava

Out of 7 lines including check evaluated for tuber yield, ACC-152 (Fig. 48), a collection from Rupupiri village under Khijri block of Ranchi district of Jharkhand performed the best and recorded tuber yield of 35.17 t/ha with a yield increase of 216.84% over the check variety Sree Vijaya (11.10 t/ha).

Fig. 48. Cassava ACC 152

Greater yam

Out of 7 lines including check evaluated for tuber yield, ACC-34 (Fig. 49), a collection from Tunko village under Khijri block of Ranchi district of Jharkhand performed the best and recorded tuber yield of 42.24 t/ha which is more than that of the check variety Orissa Elite (37.93 t/ha).

Fig. 49. Greater yam ACC 34

Lesser yam

Seven lines including check were evaluated for tuber yield. Lotni (Fig. 50), a line of RAU, Pusa, Bihar performed the best and recorded tuber yield of 30.76 t/ha with a yield increase of 75.87% over the check variety Sree Lata (17.49 t/ha).

Fig. 50. Lesser yam Lotni

Elephant-foot-yam

Out of 11 lines including check evaluated for tuber yield. ACC-85 (Fig. 51), a collection from Palma village under Itki block of Ranchi district recorded corm yield of 36.17 t/ha which was at par with the check variety Gajendra (36.88 t/ha).

Fig. 51. Elephant foot yam ACC 85

Wild muskmelon/kachri

Seven lines including check were evaluated. Kachri-4 (Fig. 52) recorded fruit yield of 18.58 t/ha with a yield increase of 62.12% over the check variety AHK-119 (11.46 t/ha).

Fig. 52. Wild muskmelon Kachri-4

Underutilized Leafy Vegetables

Antioxidant and nutritional evaluation of underutilized leafy vegetables of Jharkhand

A total of 20 markets in seven districts (Ranchi, Khunti, Gumla, Lohardaga, West Singhbhum, Ramgarh and Hazaribagh), covering 306 vendors, including both primary and secondary vendors were surveyed for underutilized leafy vegetables. Twenty species of locally available underutilized leafy vegetables consumed by tribal people were identified and were subjected to biochemical analysis. Among the leafy vegetables sold in fresh form, *Amaranthus gangeticus* L. was found highest in quantity followed by *A. viridis* L., *Ipomoea aquatica* L., *Chenopodium album* L., *Basella alba* L., *Centella*

asiatica (L.) and *Hygrophylla spinosa* T. (Fig. 53). Similarly, among the leafy vegetable sold in dried form, *Cassia tora* L. was found highest in quantity followed by *Vangueria spinosa* Roxb., *Ipomoea batatas* (L.), *Antidesma diandrum* (Roxb.) and *Ficus geniculata* Kurz (Fig. 54). These leafy vegetables were found to be rich in antioxidant activity which ranged from 151.4 to 2159.8 mg AEAC/100g (Fig. 55), Vitamin C (2.41 to 56.25 mg/100g) (Fig. 56) and various minerals *viz*, Calcium (125.8 to 1737.8 mg/100g), Phosphorus (26.7 to 525.3 mg/100g), Magnesium (254.3 to 1233.7 mg/100g), Sodium (189.6 to 473.3 mg/100g), Potassium (98.5 to 4516.1 mg/100g), Sulphur (52.0 to 840.6 mg/100g), Iron (7.2 to 61.3 mg/100g), Zinc (1.5 to 9.9 mg/100g), Copper (0.4 to 5.1 mg/100g) and Manganese (0.9 to 80.7 mg/100g). Hence, there is a need to commercialize these nutritious underutilized leafy vegetables in prevailing cropping/farming situations of hill and plateau region.

Amaranthus gangeticus L. | *Amaranthus viridis* L. | *Ipomoea aquatica* L. | *Chenopodium album*

Hygrophylla spinosa L. | *Basella alba L.* | *Ficus geniculata Kurz* | *Centella asiatica*

Fig. 53. Leafy vegetables sold in the rural markets

Cassia tora L. | *Antidesma diandrum* (Roxb.) | *Ficus geniculata Kurz* | *Vangueria spinosa* (Roxb. ex Link)

Fig. 54. Major underutilized leafy vegetables sold in dried form in tribal market of Jharkhand

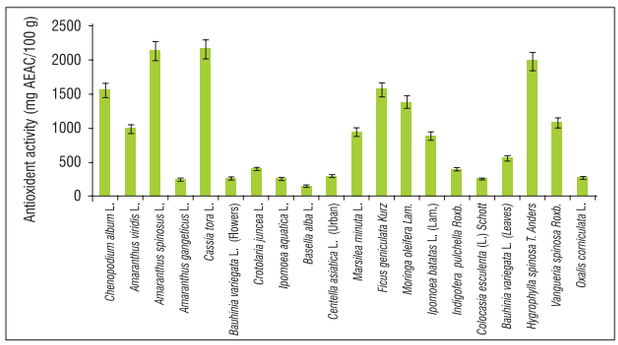


Fig. 55. Antioxidant activities of potential underutilized leafy vegetables of Jharkhand

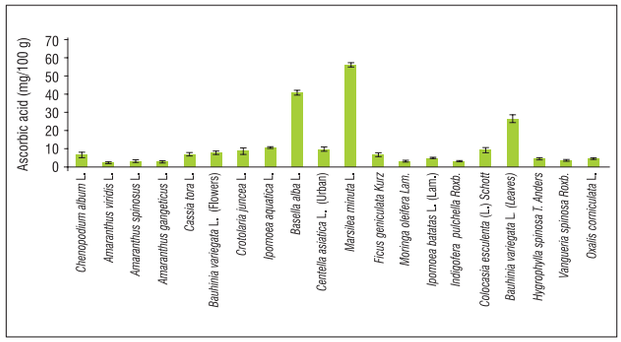


Fig. 56. Ascorbic acid content of potential underutilized leafy vegetables of Jharkhand

9. *Mushroom*

Strain evaluation of Oyster (***Pleurotus*** spp.) and paddy straw (***Volvariella volvacea***) mushroom

A native and edible Oyster mushroom (*Pleurotus* spp. DMRP-329) was isolated in the locality of Ranchi, Jharkhand. Sixty per cent biological efficiency was observed in single picking within 10-12 days of spawning (Fig. 57).

Fig. 57. Fruiting bodies of the isolated strain of ***Pleurotus*** sp.

Among nine strains of paddy straw mushroom (*Volvariella volvacea*) evaluated twice in the month of September, 2015 , seven strains (Vv-15/01, Vv-15/02, Vv-1 Vv-15/03, Vv- Vv-15/04, Vv-15/05, Vv-15/06 and Vv-15/07) performed well while two strains (Vv-15/08 and Vv-15/09) did not perform well due to weak proliferations of mycelium in paddy straw. The data revealed that the strain Vv-15/02 showed the highest biological efficiency and the highest average fruit weight of 1.1 and 0.97 kg/bed, respectively. Vv-15-06 (0.8 and 0.67 kg/bed) and Vv-15/05 (0.7 and 0.73 kg/bed) were the next highest performers. However, strain Vv-15-05 was highly attractive in shape, size, colour and taste (Fig. 58).

Evaluation of biological efficiency, number of sporophores and weight of sporophores and time required in sporophore formation was carried out. Among the six strains of *Pleurotus* spp, evaluated highest biological efficiency was observed in strain PL-15-05 (73.15%) (Fig. 59) followed by PL-15/03 (71.3%), PL-15-04 (67.55%) and PL-15-02 (66.95). In sporophores (fruiting bodies) formation, PL-15-05 showed highest number of sporophores.

Fig. 58. Fruiting bodies of paddy straw mushroom strain Vv-15-02

Fig. 59. Fruiting bodies of Oyster mushroom strain PL-15/05

10. *Makhana*

Integrated Nutrient Management in Makhana

The effect of different INM treatments on soil reaction and salt concentration was not noticeable. No appreciable increase in concentration of different nutrients was observed due to application of INM treatments (Fig. 60) in makhana cultivation. However, treatments like 100% NPK + compost and compost only brought slight increase in the concentration of most of the available nutrients. The maximum yield of makhana was also recorded with 100% NPK + compost. The variation in yield potential due to different INM treatments was not appreciable.

Fig. 60. Juvenile makhana plants growing in INM treated plots

Evaluation of Different Genotypes of Water Chestnut *(Trapa bispinosa)*

Water chestnut (*Trapa bispinosa*) is mainly grown in Madhya Pradesh, Uttar Pradesh, Bihar and Odisha. On the basis of fruit morphology, waterchest nut could be divided into thorny and thorn less categories. Since, there is no recognised variety of water chestnut, a varietal development programme of water chestnut was initiated. Germplasms of water chestnut was collected from north Bihar, Ranchi, Odisa and Madhya Pardesh having green (Fig. 61) and red colour (Fig. 62).

Fig. 61. A green colour thornless water chestnut plant

Fig. 62. A green colour thornless water chestnut plant

The nutritive values of water chestnut are depicted in Table 17 and 18. Similarly, the morphological details of water chestnut germplasm is depicted in Table 19.

Table 17. Nutritional value of raw fruit of water chestnut (Local cultivar)

Parameters	% (g/100 g)
Water	70.0
Starch (Carbohydrate)	23.3
Protein	4.7
Fat	0.3
Fiber	0.6
Minerals	1.1

Table 18. Nutrient content of tissues of water chestnut (Local cultivar)

Elements	Leaves	Roots	Ratio of roots/ leaves	Fruit
C	32%	23%	0.718	
N	0.42%	0.26%	0.620	0.80%
P	0.80%	0.68%	0.850	0.41%
K	0.85%	0.70%	0.823	0.11%
S	0.03%	0.05%	1.666	0.04%
Fe	1989 mg/kg	2080 mg/kg	1.045	118 mg/kg
Mn	350 mg/kg	550 mg/kg	1.571	22 mg/kg
Cu	15 mg/kg	17 mg/kg	1.133	10 mg/kg
Zn	280 mg/kg	200 mg/kg	0.714	120 mg/kg

Table 19. Morphological features of water chestnut plants

Name of place	No. of clusters	No. of fruiting branches	Length of fruiting branches (cm)	No. of fruit per cluster	Days to Ist picking	Days to last picking	No. of pickings	Wt of 5 fruits (g)	Fruit length (cm)	Fruit girth (cm)
M.P. Red										
Paanumaria	5	5	49.2	3	88	98	2	105	6.2	14.0
Panagar	5	3	60.0	2	88	98	2	95	6.5	13.5
Gandhigram	4	4	48.2	2	88	98	2	100	7.0	14.0
Jabera	3	2	44.3	3	88	98	2	95	5.2	12.5
Poraina	4	4	32.2	2	88	98	2	100	7.1	14.2
Singhaud	5	5	43.8	2	88	98	2	95	7.0	14.0
Dindori	2	2	56.0	2	88	98	2	95	7.3	14.0
Khamaria	2	2	48.0	1	88	98	2	95	6.1	13.8
M.P. Green										
Paanumaria	3	3	16.0	3	88	98	2	100	6.1	13.2
Poraina	5	5	36.8	2	88	98	2	100	5.0	12.5
Sighaud	5	5	45.0	3	88	98	2	100	5.2	12.6
Khamaria	5	4	46.5	4	88	98	2	90	6.0	13.0
Bodagarh	4	4	49.0	2	88	98	2	90	5.4	12.8
Bihar										
Darbhanga	5	5	37.0	2	100	114	3	63	5.5	11
Madhubani	3	3	62.3	2	100	114	3	62	5.0	9

Nutrient Contribution to the Soil by Water Chestnut (*Trapa bispinosa*)

In case of water chestnut, it was found that the quantum of contribution of nutrients on decomposition of its biomass to the soil system was not appreciable. However, it contributed 7.54, 14.40, 16.20, 3.66 and 0.85 kg/ha/yr of nitrogen, phosphorus, potassium, iron and mangnese, respectively, into the soil. Accordingly, total uptake of nutrients by water chestnut was recorded to be 21.91, 21.58, 17.40, 1.48 and 3.83 kg/ha of the same nutrients.

Fig. 63. Integation of Alocasia + Sweet Flag in Makhana based cropping system

Introduction of Sweet Flag and Vegetable Alocasia with Makhana

Twenty alocasia germplam were evaluated during 2014-15 at Darbhanga (Fig. 63). The dwarf *Alocasia macrorrhiza* cv. RKM-3 (Fig. 64) was precaucous, weighing rhizome about 2.17 kg with yield of 2.17 t/ha. Alocasia cultivar Ranchi-3 (Fig. 65) was collected from farmer's field at Ranchi. It is very attractive vegetable like colocasia except that the tubers are formed in the horizontal runners and yields about 984 g tubers /plant. Sweet flag cultivars Bach Sel-1 and 2 showed luxurious growth. Out of these two cultivars, Bach Sel-1 was found to be the best which recorded the maximum production of 2.6 t/ha as compared to Bach Sel-2 (2.4 t/ha). Makhana which was grown at the base of the pond gave maximum yield of 1.4 t/ha whereas makhana cultivated as sole crop had the yield of 2.37 t/ha.

Fig. 64. Alocasia cv. Ranchi-3

Fig. 65. Alocasia *macrorrhiza* cv. RKM-3

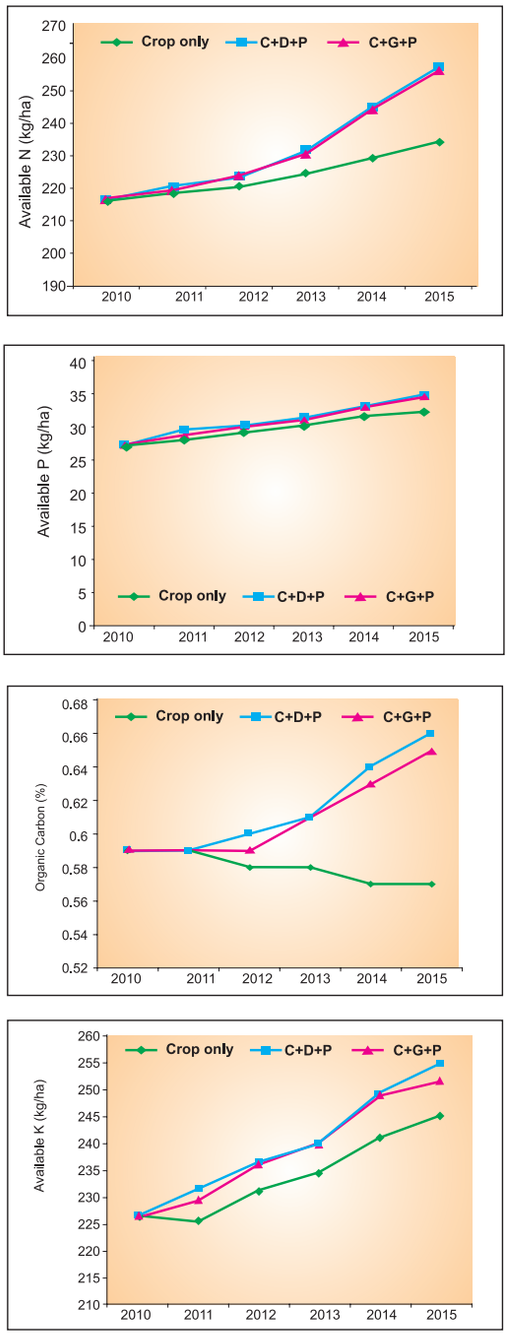
11. *Farming System Research*

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

One acre IFS model (Crop + goat + poultry + mushroom) and two acre IFS model (Crop + dairy + fish) was developed in view of midland irrigated and lowland irrigated areas where more than 80 per cent farmers have an average land holding size of 0.32- 0.48 ha and could not fulfill the family needs by growing crops alone. In the developed models allocation of area under crops, livestock, fishery, horticulture and other enterprises have been made in such a way that it could fulfill the demand and needs of farm families (nutrition and income) and system (nutrient/resource recycling) at the same time. Under crop components, rice-wheat, rice-maize, rice- gram and rice- mustard- moong (cereal based cropping system) and cowpea-okra-tomato, okra- cabbage- cucurbits- cabbage and okra - cauliflower - onion (vegetable based cropping systems) were followed. Pattern of nutrient recycling within the system was also studied.

Under one acre model, cowpea - cauliflower-onion cropping system along with poultry + mushroom + goatry fetched the highest net income of ₹ 76,628/annum (₹ 210/day, B:C:: 1.5) with an initial investment of ₹ 1,02,220/-, while under two acre IFS model, a net return of ₹ 1,26,160/annum (₹ 346/day, B:C:: 1:7) was achieved with an initial investment of ₹ 2,05,500. An additional employment of 67 and 197 man-days were also generated through one acre and two acre models, respectively.

Studies on nutrient recycling revealed that about 47.9 kg of N, 38.8 kg P, 38.2 kg K per hectare under one acre IFS model, and 65.6 kg N, 48.5 kg P and 47.7 kg K in two acre IFS model were added in the soil due to resource recycling within the system. An appreciable increasing trend was also recorded in case of NPK organic carbon status of soil while in rice-wheat cropping system, organic carbon was found in decreasing trend (Fig. 66).



Note: C= Crop, D= Dairy, P= Poultry, G= Goat

Fig 66. NPK & Organic carbon trend under different integrations

12. *Cropping System*

Effect of Rice Nursery Seeding date, Seedling age and Cultivars on Rice-Wheat System Productivity

Long duration rice delays the wheat sowing in Eastern IGP, resulting in lower wheat yields due to terminal heat stress. Keeping this fact in view, an experiment was conducted under ICAR-CSISA collaborative project to evaluate the performance of rice cultivars of different duration, age of seedling and sowing dates on the productivity of rice-wheat system (Fig. 67 & 68). Results (Table 20) revealed that seeding early duration rice (Arize 6129) being on a par with medium duration (Arize 6444) produced significantly higher grain yield of succeeding wheat crop as compared to long duration rice (MTU 7029). Seeding of rice up to 1st July had not shown adverse affect on wheat yield. Further delay in rice seeding significantly reduced the subsequent wheat yield.

Fig. 67. Rice sown at different dates

Fig. 68. Wheat sown at different dates according to rice harvesting

Table 20. Effect of rice nursery seeding date, seedling age and cultivar on grain yield of succeeding wheat (2014-15)

Date of seeding rice nursry	Age of rice seedlings							
	15 days			Mean	30 days			Mean
	Arize-6129	Arize-6444	MTU-7029		Arize-6129	Arize-6444	MTU-7029	
01-Jun	5.09	4.51	5.09	4.90	4.82	5.03	5.27	5.04
15-Jun	4.98	5.16	4.61	4.92	4.92	5.01	4.60	4.84
01-Jul	5.00	5.02	4.69	4.90	5.38	4.73	4.85	4.99
15-Jul	5.08	4.85	3.74	4.56	4.51	4.17	2.60	3.76
01-Aug	3.46	3.06	2.24	2.92	2.56	2.71	2.14	2.47
Mean	4.72	4.52	4.07	4.44	4.44	4.33	3.89	4.22

LSD: Seeding date (D): 0.33, Cultivar (C): 0.25, Seedling age (A): 0.21, D x A: 0.46, C x A: 0.36, D x C x A: 0.80

In rice, transplantation of 15 days old seedlings produced significantly higher grain yield (6.93 t/ha) as compared to 30 days old seedlings (6.14 t/ha). Among cultivars, medium duration rice (7.25 and 6.56 t/ha) yielded better than that of early (6.79 and 6.00 t/ha) and long (6.74 and 5.87 t/ha) durations with 15 and 30 days old seedlings, respectively (Table 21).

Diversification of Cereal -Legume Cropping System

In rice-legume cropping system under rainfed upland situation in *kharif* season, the upland rice (var. Anjali) and legumes like soybean (var. Swarna Vasundhara), groundnut (var. Birsa Bold), black gram (var. Uttara), green gram (var. CN 9-5) and cowpea (line EC 452) were grown both as sole crop (each of 12 rows) and in combination

Table 21. Effect of rice nursery seeding date, seedling age and cultivar on grain yield (t/ha) of rice (2015)

Date of seeding rice nursry	Age of rice seedlings							
	15 days			Mean	30 days			Mean
	Arize-6129	Arize-6444	MTU-7029		Arize-6129	Arize-6444	MTU-7029	
01-Jun	5.70	7.40	5.40	6.17	5.16	7.03	5.63	5.94
15-Jun	7.76	8.03	8.23	8.01	5.83	6.33	7.23	6.46
01-Jul	7.23	7.26	7.86	7.45	6.26	6.60	6.10	6.32
15-Jul	6.40	7.66	6.33	6.80	6.60	6.90	6.30	6.60
01-Aug	6.86	5.90	5.86	6.21	6.13	5.93	4.10	5.39
Mean	6.79	7.25	6.74	6.93	6.00	6.56	5.87	6.14

of 6 row of rice and 6 row of each legume (Fig. 69). Results revealed that sole crop of soybean recorded the maximum rice equivalent yield of 10.80 t/ha, followed by groundnut (7.92 t/ha). Among the combinations, the treatment of 6 row rice + 6 row soybean (6.63 t/ha) was the best followed by 6 row rice + 6 row groundnut (4.99 t/ha). The results indicated that growing of sole crop of soybean in rainfed upland situation during *kharif* season would be more profitable in respect of rice equivalent yield.

Fig. 69. Different rice-legume cropping systems for diversification in rainfed of eastern pleateu and hill region

13. *Soil Science*

Evaluation of Different Production Systems for Carbon Sequestration Potential

A long-term field experiment was initiated with three crop sequences i.e. C_1: rice-wheat (RW), C_2: rice-maize (RM), C_3 : rice-lentil (RL) and three tillage practices (T_1: conventional tillage without residue, T_2: reduced tillage without residue, T_3: reduced tillage with 30% residue). After 3 years, results revealed that in the upper layer, highest amount of water stable aggregates was recorded in rice-maize-RT30 (89.6 g /100g) and was at par in rice-maize -RT (83.1 g /100g), rice-lentil RT30 (82.1 g /100g), rice-wheat RT30 (80.8 g /100g). Systems that adopted conservation agriculture recorded higher macro aggregate content to the tune of 19-35 % (for reduced tillage) and 42-57 % (for reduced tillage with 30 % residue) than conventional one (CT) in the upper layer.

An increased amount of organic carbon in reduced tilled and crop residue added treatments compared to CT was found in both 0-15 and 15-30 cm soil depth (Table 22). Soil organic C stock was significantly different in scenarios in surface 0-15 cm and 15-30 cm soil layer. The highest C stock of 11.4 Mg/ha was recorded in RM-RT30 followed by RW-RT30 (10.79 Mg/ha). After 30 cm, no significant variation in soil carbon stock was observed among treatments. The maximum variation in BD value was registered in the upper 0-10 cm soil layer. Lowest BD value of 1.42 g/cm^3 was recorded in RM-CT and it was significantly different from other treatment while highest BD value of 1.50 g/cm^3 was recorded in RM-RT and that was at par with RL-RT & RM-RT30.

Yield Limiting Nutrients and Diagnostic Leaf Nutrients Norms of Mango Grown in Eastern Plateau and Hill region of India

Identification of yield limiting nutrients

Yield limiting nutrients and diagnostic leaf nutrient norms of mango (cv. Amrapali) grown in Gumla, Lohardaga and Ranchi district of Jharkhand was assessed in 6-7 and 9-10 year old orchards. Mature leaves of different ages were analyzed for macro and micro nutrients.

Twenty eight nutrient expressions were chosen as diagnostic norms from high yielding popula-

Table 22. Organic C, Soil organic C stock, total SOC stock and C sequestration rate in different treatments

Treatments	Organic C (g /100g)				Soil Org C Stock (Mg/ha)				Total SOC stock (Mg/ha)	C sequestration rate (Mg/ha/yr)
Soil depth (cm)	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-60	0-60
RW-CT	0.62^{a}	0.46^{ab}	0.46	0.42	8.93^{a}	7.02^{ab}	7.09	6.49	29.53^{a}	0.01^{a}
RM-CT	0.61^{a}	0.46^{a}	0.50	0.46	8.64^{a}	6.98^{ab}	7.73	7.02	30.37^{a}	0.29^{a}
RL-CT	0.65^{ab}	0.45^{a}	0.47	0.45	9.31^{ab}	6.95^{ab}	7.37	6.86	30.49^{a}	0.33^{a}
RW-RT	0.63^{a}	0.51^{ab}	0.52	0.43	9.35^{ab}	7.57^{ab}	8.15	6.51	31.58^{abc}	0.69^{abc}
RW-RT30	0.73^{bc}	0.52^{ab}	0.52	0.45	10.79^{bc}	7.78^{b}	7.98	6.81	33.35^{bc}	1.28^{bc}
RM-RT	0.68^{abc}	0.47^{ab}	0.46	0.47	10.17^{abc}	6.99^{ab}	7.19	7.14	31.48^{abc}	0.66^{abc}
RM-RT30	0.76^{c}	0.54^{b}	0.50	0.44	11.40^{c}	8.13^{b}	7.84	6.64	34.00^{c}	1.50^{c}
RL-RT	0.67^{abc}	0.43^{a}	0.51	0.43	10.11^{abc}	6.49^{a}	7.78	6.57	30.96^{ab}	0.49^{ab}
RL-RT30	0.65^{ab}	0.52^{ab}	0.50	0.43	9.69^{ab}	7.84^{b}	7.73	6.55	31.81^{abc}	0.77^{abc}
Mean	0.67	0.48	0.49	0.44	9.82	7.31	7.65	6.73	31.51	0.67

Note: Means followed by different letters are significantly different between treatments at P ≤ 0.05 by Tukey's HSD test

tion. However, N/P (9.54), N/K (1.58), K/P (6.03), Ca/N (1.93), Ca/K (3. 06) and Ca/Mg (7.77) among macronutrients and Zn/N (16.4), Zn/P (155.5), Zn/K (25.9), Zn/Ca (8.61) and B/N (10.7) involving micronutrients have shown lower CV values compared to other nutrient expressions and might be having greater physiological rationale. DRIS index value mean that are oversupplied. DRIS indices of nutrients in leaf samples of mango tree orchard is shown in Table 23. The sum of the indices irrespective of sign, i.e., nutrient balance index (NBI) was highest (61.16) in 6-7 year old orchard, showing high imbalance of nutrient, and resulted in lowest yield (5.32 t/ha) among the age of orchards. Similarly, the NBI showed highest value of 228.8 at pH of 6.1 to 6.5 causing high imbalance of nutrients and thereby resulting into lowest yield (4.48 t/ha). When the NBI was more, the corresponding yield was low among different ages of orchards and orchards grown under different pH of soils.

Leaf nutrient standards of mango

Five leaf nutrient guides / ranges have been derived using mean and standard deviation as deficient, low, optimum, high and excess for each nutrient. Sufficiency ranges of nutrients derived from a nutrient indexing survey of mango orchards showed that the optimum leaf N and P for mango ranged from 1.21 to 1.40% and 0.13 to 0.15%, respectively. It was observed that P was generally much less limiting factor for mango production. The optimum K ranged from 0.76 to 0.88 % and thus the requirement of K is always next only to N as it is involved not only in the production but also in improving the quality of mango. The optimum concentration range for Ca was 2.10 to 2.93%, and Mg 0.24 to 0.43% indicating a lower requirement of Mg compared to N, K and Ca. The optimum concentration of S ranged from 0.12 to 0.18% and the requirement of S is next only to P. Among the micronutrients, the optimum B, Zn, Cu, Fe and Mn concentrations in leaf ranged from 13 to 16, 19 to 24, 17 to 31, 86-125 and 71-150 mg/kg, respectively. Wider optimum ranges of micronutrients observed in mango leaf was due to larger variations in soil properties.

Soil Organic Carbon Stocks in Different Orchards of Eastern Plateau and Hill region of India

Soil organic carbon and its fractions

The dynamics of total soil organic carbon (C_{tot}), oxidisable organic carbon (C_{oc}), very labile carbon (C $frac_1$), labile carbon (C $frac_2$), less labile carbon (C $frac_3$), non-labile carbon (C $frac_4$) and SOC sequestration was evaluated in a 6 year old fruit orchards (Table 24 & 25). The distribution of different carbon fraction followed the order C $frac_1$ > C $frac_4$ > C $frac_2$ > C $frac_3$ throughout the depth of soil profile of different orchard.

Table 23. DRIS indices of nutrients in leaf samples in orchards from Jharkhand

Age of orchard (Years)	DRIS indices								Nutrient balance index	Requirement order	Yield (t/ha)
	N	P	K	Ca	Mg	S	Zn	B			
6-7	1.30	5.92	-5.86	-11.58	11.50	-9.37	11.86	-3.77	61.16	Ca > S > K > B > N > P > Mg > Zn	5.32
9-10	1.29	3.60	5.97	0.27	-7.14	4.54	-6.68	-1.84	31.33	Mg > Zn > B >Ca > N > P > S > K	6.57

Table 24. Total and oxidisable organic C (Mg/ha soil) in soils in different layers (cm) of 6 year old orchards

Orchard	Soil organic carbon (Mg C/ha soil)									
	Total soil organic carbon (C_{tot})					Oxidizable organic carbon (C_{oc})				
	0-15	15-30	30-45	45-60	Total	0-15	15-30	30-45	45-60	Total
Control	19.10^a	13.44^b	11.20^b	9.55^a	53.28^b	14.36^a	10.12^b	8.43^b	7.17^a	40.10^b
Litchi	19.43^a	16.32^a	13.31^a	10.12^a	59.17^a	14.60^a	12.29^a	10.00^a	7.61^a	44.50^a
Guava	20.28^a	16.24^a	13.28^a	10.30^a	60.00^a	15.24^a	12.21^a	9.98^a	7.73^a	45.18^a
Mango	20.49^a	17.32^a	13.61^a	11.05^a	62.47^a	15.40^a	13.00^a	10.23^a	8.31^a	46.94^a
Mean	19.83	15.83	12.85	10.26	58.73	14.90	11.91	9.66	7.71	44.18

Within a column, values indicated by the same letters are not significantly different at the 0.05 level of probability (Duncan's Multiple Range Test)

Table 25. Oxidisable organic C fractions (Mg/ha soil) in soils in different layers (cm) of 6 year old orchards

Orchard	Soil organic carbon fraction (Mg C/ha soil)															
	Very labile carbon (C $frac_1$)				Labile carbon (C $frac_2$)				Less labile carbon (C $frac_3$)				Non labile carbon (C $frac_4$)			
	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
Control	6.44^{b}	4.36^{b}	4.22^{a}	3.10^{b}	4.14^{b}	3.31^{b}	2.87^{a}	2.28^{a}	3.19^{a}	2.44^{b}	1.93^{b}	1.80^{a}	4.73^{a}	3.33^{b}	2.78^{b}	2.35^{a}
Litchi	6.64^{b}	5.48^{a}	4.59^{a}	3.98^{a}	4.31^{ab}	3.48^{ab}	3.37^{a}	2.12^{a}	3.46^{a}	2.91^{a}	2.35^{a}	1.80^{a}	4.82^{a}	4.05^{a}	3.29^{a}	2.51^{a}
Guava	7.58^{a}	5.54^{a}	4.25^{a}	3.84^{a}	4.49^{ab}	3.76^{ab}	3.28^{a}	1.84^{a}	3.18^{a}	2.91^{a}	2.45^{a}	2.07^{a}	5.03^{a}	4.03^{a}	3.29^{a}	2.56^{a}
Mango	7.14^{ab}	6.00^{a}	4.73^{a}	4.02^{a}	4.75^{a}	4.07^{a}	3.17^{a}	2.33^{a}	3.52^{a}	2.97^{a}	2.34^{a}	1.95^{a}	5.08^{a}	4.29^{a}	3.38^{a}	2.74^{a}
Mean	6.95	5.35	4.45	3.74	4.42	3.66	3.17	2.14	3.34	2.81	2.27	1.91	4.92	3.93	3.19	2.54

Active and passive carbon pool

The active carbon pool in surface soil (0-30 cm) varied significantly among the different orchard, whereas it was non-significant in the sub-surface soil (Table 26). The mango and guava orchard recorded significantly higher active carbon pool over control in 0-30 cm depth. Irrespective of orchard systems, the maximum active carbon pool was recorded in the 0-15 cm layer being the highest in guava orchard (12.06 Mg/ha) and the lowest in control (10.57 Mg/ha). The maximum total active carbon pool was recorded under mango orcrhard (36.2 Mg/ha) followed by guava orchard (34.57 Mg/ha). The passive carbon pool corresponds to less labile and non labile pool of oxidisable organic carbon (Table 27). The maximum passive carbon pool in 0-15 cm depth was recorded in mango orchard (8.60 Mg/ha) and minimum in control (7.92 Mg/ha). The passive carbon pool gradually decreased with increasing depth of soil profile. The maximum total passive carbon pool was recorded under mango orchard (26.27 Mg/ha) followed by guava orchard (25.52 Mg/ha).

Table 26. Active carbon pool in soils in different layers (cm) of 6 year old orchards

Orchard	Active carbon pool (Mg/ha)			
	15-30	30-45	45-60	Total
Control	7.67^{b}	7.08^{a}	5.38^{a}	30.72^{b}
Litchi	8.96^{ab}	7.96^{a}	6.10^{a}	33.97^{a}
Guava	9.30^{a}	7.53^{a}	5.68^{a}	34.57^{a}
Mango	10.06^{a}	7.89^{a}	6.36^{a}	36.20^{a}
Mean	9.00	7.62	5.88	33.87

Table 27. Passive carbon pool in soils in different layers (cm) of 6 year old orchards

Orchard	Passive carbon pool (Mg/ha)			
	15-30	30-45	45-60	Total
Control	5.77^{b}	4.72^{a}	4.15^{a}	22.56^{b}
Litchi	6.96^{a}	5.64^{a}	4.31^{a}	25.20^{a}
Guava	6.94^{a}	5.74^{a}	4.63^{a}	25.52^{a}
Mango	7.26^{a}	5.72^{a}	4.69^{a}	26.27^{a}
Mean	6.73	5.46	4.45	24.89

Carbon build-up in orchards

The carbon build-up was the highest in mango orchard (17.3 %) followed by guava (11%). The carbon build-up rate is more important for a long term perspective, which was found more (1.53 Mg C/ha soil/yr) in mango orchard as against lowest of 0.98 Mg C/ha soil/yr in litchi orchard in 0-0.60 m depth of soil. The carbon build-up was less in litchi orchard soil compared to mango and guava was attributed to high N content in leaf litter of litchi (1.8%) associated with resistant lignolytic products slowing down their decomposition resulted in less carbon build-up. The orchards like mango and guava, which have leaf litter of low N content of 1.25 and 1.33%, respectively are likely to be more efficient in C sequestration in soil than the litchi orchard, which give leaf litter of higher N content.

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

The decomposition rate of different substrates was studied using litter bag technique. Decomposition for paddy wheat and maize straw was examined by keeping litter bags above soil surface, whereas for paddy, wheat and maize roots, litter bags were placed 10-15 cm deep, below soil surface. For each organic substrate, 24 litter bags were placed in each plot in replicates of four.

Substrate decomposition expressed as loss of dry matter at end of each month showed that paddy straw was completely decomposed after 10 month (Fig. 70) while that of maize straw took

9 months for complete decomposition (Fig. 71) of its placement in the field. In wheat straw about 80% of decomposition was observed after four months of its placement. In sub surface, placement of the paddy roots complete decomposition was observed after 7 month (Fig. 72) of its placement while in wheat roots 90 % and maize root 85% decomposition was observed after four months of its placement in field.

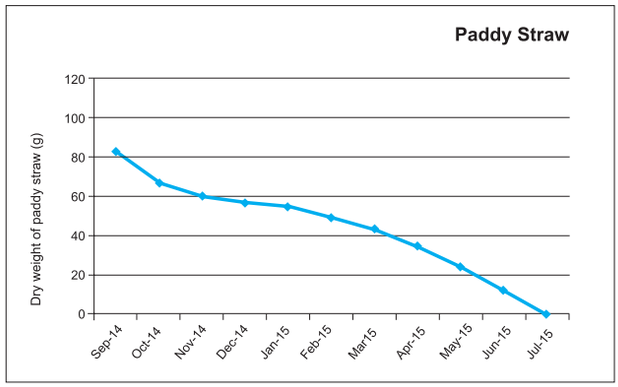


Fig. 70. Month wise decomposition rate of paddy straw

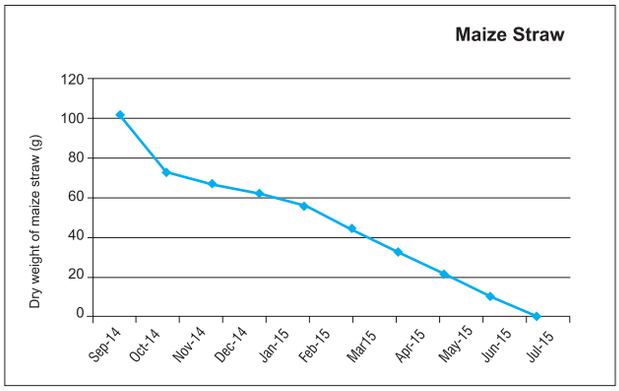


Fig. 71. Month wise decomposition rate of maize straw

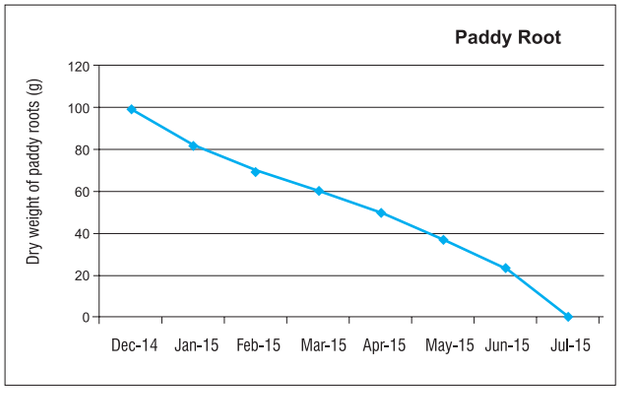


Fig. 72. Month wise decomposition rate of paddy roots

Land Suitability Classification for Different Crops using Remote Sensing and GIS

Georeferencing of toposheet and digitization of districts boundary for East Champaran and Purnia districts have been completed. Block wise different maps containing information about the availability of nitrogen, phosphorous, potassium, pH, organic carbon and electrical conductivity of the soils, soil texture, soil topography, availability of ground water, flooded area were developed for both the districts. These information were stored in a database linked to blockwise maps of East Champaran and Purnia districts. Soils from different blocks of both the districts were also subjected to analysis. Land suitability classification for Madhubani district has been prepared on the basis of soil properties. Status of nitrogen is mainly low whereas few pockets have medium range of nitrogen. The status of phosphorous and organic carbon is also low in the major parts of the district. The soils were found neutral or slightly alkaline. Acidic soils were also present in few pockets. The main crops were include rice, wheat, maize, sugarcane, greengram and vegetables. Land suitability maps for rice crop in Madhubani district have been created. Analysis of data revealed that 22% area, i.e., 72418 ha is highly suitable for rice cultivation.

14. *Conservation Agriculture*

Long-term Effect of Conservation Agriculture (CA) in Rice-based Cropping Systems

To monitor the long-term performance of cereal-based cropping systems, field experiments were initiated in 2009 under ICAR-CSISA collaborative project in 4 scenarios. Results revealed that grain yield of wheat (5.2 t/ha), rice (5.6 t/ha), mung bean (2.0 t/ha) and the system productivity in terms of rice-equivalent yield (13.06 t/ha) increased significantly in complete CA-based rice-wheat-mung bean system (S_3) over conventional rice-wheat system (4.7, 5.3, 10.4 t/ha, respectively) (S_1). Based on the 6 years average, the respective wheat and rice productivity were 30.77 and 6.87% higher in complete CA (4.93 and 6.22 t/ha) over conventional system (3.77 and 5.82 t/ha). Complete CA-based system also reduced the bulk density (Fig. 73), improved soil structure (Fig. 74) and the infiltration rate (Fig. 75).

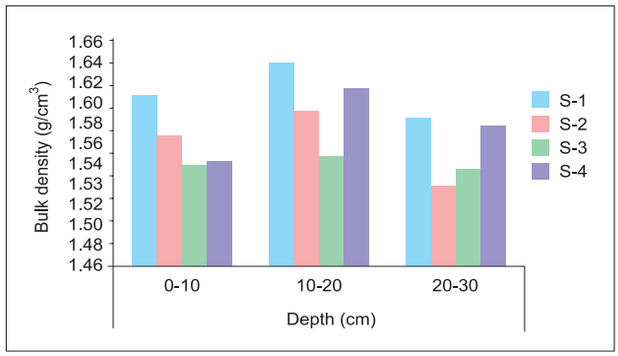


Fig. 73. Bulk density (g/cm^3) of soil after 6 years of experimentation

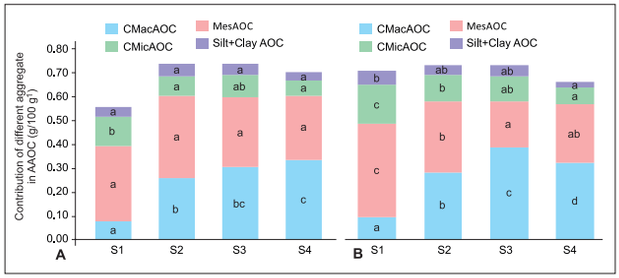


Fig. 74. Contribution of different soil aggregates at varying soil depth (A: 0-10 cm and B: 11-20 cm)

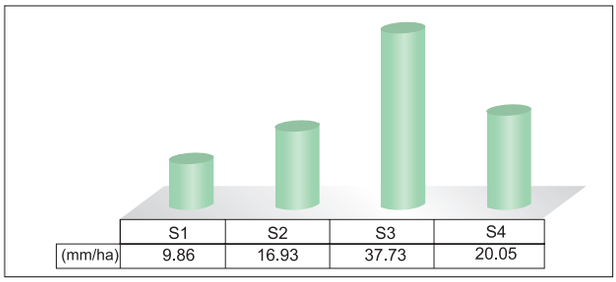


Fig. 75. Infiltration rate (mm/hr) after 6 years under different scenarios

Evaluation of vegetable varieties under different irrigation methods

Three varieties of brinjal (V_1- Swarana Pratibha, V_2- Swarana Shobha and V_3- Local) & tomato (V_1- Swarana Lalima, V_2- Swarana Naveen and V_3- Local) were evaluated during *rabi* season, and cucumber (V_1- S. Sheetal, V_2- S. Ageti and V_3- Local) & ridge gourd (V_1- S. Manjari, V_2- S. Uphar and V_3- Local) during summer season under drip and surface irrigation (farmer's practice). Drip irrigation was scheduled at two levels, i.e., 100 and 70 per cent PE with and without plastic mulch. Results revealed that mulched crop receiving drip irrigation at 100% PE produced the highest yield. In tomato, mulched crop produced 29 and 25.4% higher yield at IW:CPE=1.0 & 0.7, respectively, over non mulched crop under drip irrigation. Similarly mulching in brinjal (33.7 & 8.7%), cucumber (24 & 25%) and ridge gourd (23.4 & 22.8%) also produced higher yield at IW:CPE=1.0 & 0.7, respectively over non mulch condition.

Tomato variety Swarna Lalima- (33.6 t/ha) and Swarna Naveen- (35.3 t/ha) produced significantly higher fruit yield than local variety (30.4 t/ha). In brinjal, white coloured brinjal variety Swarna Shobha produced maximum yield (30.2 t/ha) than Swarna Pratibha and local variety. Drip irrigated crop recorded higher water use efficiency in all vegetables than surface irrigated crops (Fig 76). Irrigation through drip saved 33.8 to 59.3% water in tomato, 48 to 66 % in brinjal, 32.4 to 55% in cucumber and 25.6 to 50 % in ridge gourd as

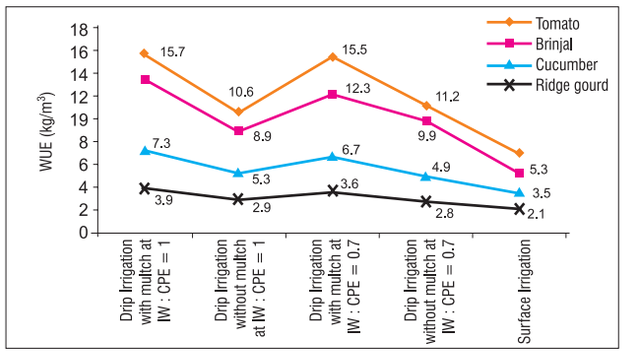


Fig. 76. Effect of irrigation and mulch on water use efficiency (kg/m^3)

compared to surface irrigation. The infestation of disease *Sclerotina* blight caused by *S. sclerotiorum* in drip irrigation with mulch was lower as compared to surface irrigation. Tomato variety 'Swarna Naveen' was found more susceptible to collar rot disease as compared to other two varieties.

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

During the second year of experimentation, different treatments on basin enrichment resulted in significant increase in the plant growth of bael plants (Fig. 77). The maximum plant girth and height was recorded with mulching or soil incorporation of biomass of *Tephrosia* and significantly lower values were recorded with soil incorporation or mulching of rice bean, subabul and weed biomass and fallow (Fig. 78).

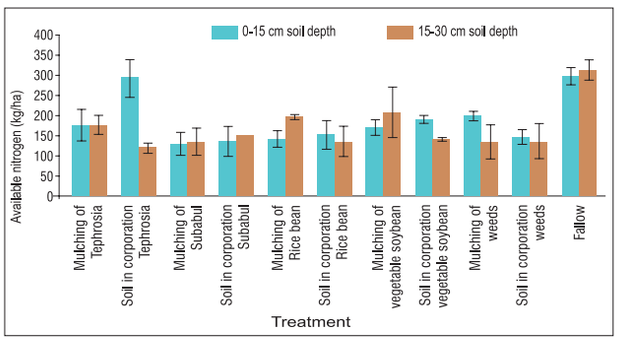


Fig. 77. Effect of basin enrichment on available nitrogen in the basin soil of bael plants

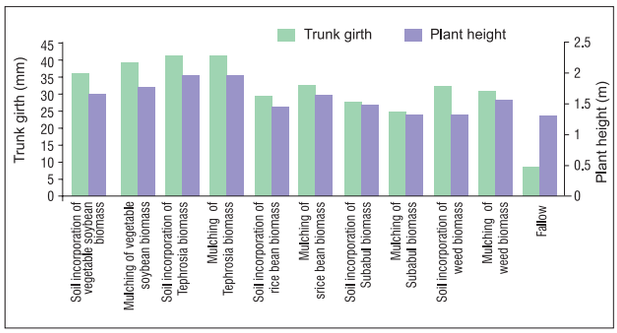


Fig. 78. Effect of basin enrichment on plant growth of bael

At soil depths of 0-15 and 15-30 cm, significant decline in available nitrogen content was recorded with all the treatments on basin enrichment except soil incorporation of *Tephrosia*. This can be attributed to initial immobilization of nitrogen during the process of organic matter decomposition.

Rehabilitation of Coal Mine Affected areas through Agroforestry Interventions

After various surveys conducted in Ramgarh and Dhanbad District of Jharkhand, Phusri Village, a Phusri coal mine affected area in Ramgarh district of Jharkhand was selected. The trial was laid out in the selected site to develop an agroforestry model for rehabilitation of the unutilized land. In this trial, an Agri-horti-silvi-pastural model is being developed involving *Aegle marmelos, Artocarpus heterophyllus, Citrus limon, Dalbergia latifolia, Mangifera indica, Melia azedarach, Pongamia pinnata, Psidium guajava, Punica granatum, Swietenia mahogany, Tectona grandis* and *Dendrocalamus asper*. The data on initial soil properties of the selected site have been presented in Table 28.

Phytosociology of Weeds Associated with Important Agricultural Crops under Eastern Plateau and Hill region of India

Phytosociological study on weeds under different crop-weed associations in hill and plateau conditions indicated species richness ranging from

Table 28. Soil nutrient status of selected coal mine affected area (Phusri village)

Soil depth (cm)	pH	EC (mS)	Organic C (%)	N (Kg/ha)	P_2O_5 (Kg/ha)	K_2O (Kg/ha)
0-15	3.40±1.16	0.03±0.02	1.55±0.09	132.13±66.11	28.31±16.81	145.60±33.60
15-30	3.61±1.33	0.09±0.06	0.86±0.08	114.99±68.81	14.78±2.33	265.07±101.63
30-45	4.05±1.47	0.06±0.05	0.75±0.05	68.57±44.18	12.31±3.72	231.47±168.50
45-60	4.87±0.69	0.09±0.04	0.94±0.23	91.99±67.02	16.86±9.70	253.87±36.00

8 (Black gram and Groundnut) to 29 (Fallow land). The Shannon's diversity index value of weeds was found to be comparatively and significantly higher at Fallow land (0.99) and significantly lower in case of Rice bean (0.49), Groundnut (0.49) and Paddy (0.40) fields. Lower Shannon's diversity index at some sites could be explained as dominance of few species.

In most of the agricultural field (*viz.*, rice bean, paddy, finger millets and fallow land), the weed '*Brachiaria deflexa*' was found to be the dominant species. On the other hand, *Dactyloctenium aegyptium* was found dominant in Elephant foot yam field, *Portulaca oleracea* in Cow pea field, *Cyperus rotundus* in Black gram field, *Eleutheranthera ruderalis* in brinjal field, *Spilanthes paniculata* in vegetable soybean field and *Lepidium sativum* in groundnut field, respectively (Fig. 79).

Sustainable and Resilient Farming System Intensification in the Eastern Gangetic Plains (SRFSI)

The Eastern Gangetic Plains (EGP) has the potential to become a major contributor to South Asian regional food security, but rice and wheat productivity remain low and diversification is limited because of poorly developed markets, sparse agricultural knowledge and service networks, and inadequate development of available water resources and sustainable production practices. Labour shortages are becoming more acute. These factors lead to smallholder vulnerability to climate and market risks that limit farmer and private sector investments in productivity-enhancing technologies. However, there is variation across the EGP: in some parts water policy and agricultural technologies have increased crop yields, although the sustainability of present rates of groundwater use is a concern. The SRFSI addresses two research questions: would farm management practices based on the principles of conservation agriculture (CA) and the efficient use of water resources provide a foundation for increasing smallholder crop productivity and resilience; and would institutional innovations that strengthen adaptive capacity and link farmers to markets and support services enable both women and men farmers to continue to innovate in the face of climate and economic change.

The SRFSI project was implemented in five nodes of Madhubani district in Bihar. Performance of rice under three methods of establishment methods (Zero-till direct seeded, unpuddled transplanting and puddled transplanting) was evaluated in each node. Zero-till direct seeded rice (ZTDSR) yield in three villages (Mauahi, Korahia & Khairi) under mid-July seeded condition was better than the traditional transplanted rice. Yield of unpudled transplanted rice (UPTR) was more than ZTDSR in two villages (Sukhet & Nanaur). UPTR produced more yield than the traditional transplanted rice in three villages (Mauahi, Korahia & Sukhet) (Fig. 80). Sushk Samrat and Bengali Mansoori produced the highest yield (4.2 to 4.45 t/ha) under all three methods of rice establishment (Table 29).

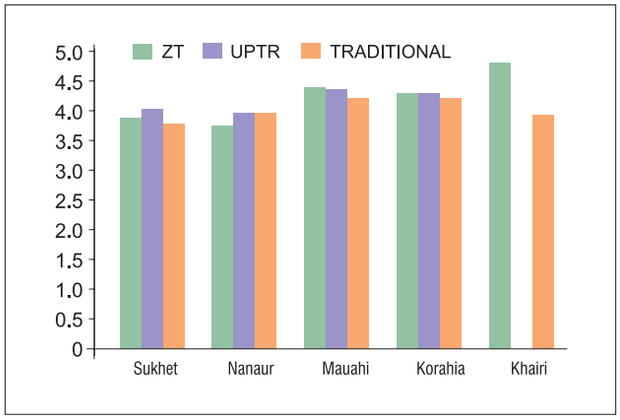


Fig. 80. Paddy yield under different establishment conditions (q/ha) during 2015 in different nodes of Madhubani district

Brachiaria deflexa

Eleutheranthera ruderalis

Lepidium sativum

Fig. 79. Dominant weeds in different crops

Table 29. Performance of different rice varieties in Madhubani during 2015 under different establishment methods (t/ha)

Rice Varieties	Yield (t/ha)		
	ZT	UPTR	Traditional
Rajendra Mansuri	4.00	4.04	3.85
Bengali Mansoori	4.45	4.41	4.25
Susk Samrat	4.43	4.44	4.21
Prabhat	3.47	3.58	3.79
Sahbhagi	3.82	3.74	3.62
Rajendra Bhagwati	4.25	4.21	3.96
Abhishek	3.52	3.94	3.82

Agricultural vulnerability studies revealed that except in Khairi, agricultural vulnerability in other four villages (Korahia, Sukhet, Nanore and Mauahi) was medium and the agricultural vulnerability index (AVI) varied from 0.36 to 0.48; that reveals that one should adopt technologies, crops and strategies which can minimize risk from adverse climatic, social and biological factors. Agricultural vulnerability was low in Khairi. Mauahi was more affected by climatic factors (climatic index 0.51) as it has lesser irrigation facilities. Korahia had maximum biological index score (0.65) and was more affected by biotic factors, like insect, diseases and weeds etc. and hence more care is needed for selection of crops and varieties those are resistant to insect and diseases. Further, adequate crop management practice should be adopted to minimize the risk of biotic factors. Korahia village was socially more vulnerable due to poor availability of credit, manpower, machinery and quality inputs needed for good agricultural production. Hence, establishment of 'Farmers Resource Centre' or promotion of custom hiring services through farmers club or by rural youth in the vicinity of these villages may be an important intervening option to minimize social vulnerability.

15. *Livestock and Fisheries*

LIVESTOCK

Buffalo Improvement

The project aims at improving the performance of non-descript buffaloes by Murrah buffaloes in terms of its production and reproduction traits. The total herd strength of the buffaloes increased to 58 with 30 breedable buffaloes (Fig. 81), 12 heifers, 15 calves (Fig. 82) and 1 teaser bull (Fig. 83). Test semen doses from 6 different bulls provided by CIRB, Hisar were used for inseminating the available breedable buffaloes. The average lactation yield, lactation length, service period and inter-calving period of the herd during the year 2015-16 were found to be 1778.53 ± 4.89 kg, 338.15 ± 3.89 days, 163.55 ± 6.78 days and 398.21±2.51 days, respectively.

The project registered the herd average and wet average as high as 5.41 kg and 8.26 kg for the year. Average peak yield was recorded at 10.28 kg milk per day and the individual peak yield was observed to be 20.2 kg of milk per day. Conception rate and calving rate for the year 2015-16 were 54.6 and 50.7%, respectively on total insemination basis. Calf mortality rate in the herd reduced to a minimum of 3.45 per cent.

Rigorous follow up of reproductive cycle of buffaloes, permitting the animals for wallowing a minimum of 5 hrs during summer, and usage of teaser bull have made significant improvement in the conception rate and calving rate of the buffaloes. Calves are dewormed every month up to 6 months and large animals are dewormed twice in a year. Vaccination against FMD, HS and BQ was carried out for all buffaloes above 4 months of age.

Buffaloes were offered a total of 52.3 tonnes of balanced pelleted concentrate feed for the year 2015-16. The animals were fed with jowar and maize green fodder during summer and monsoon season, and berseem and oat during winters. Paddy and wheat straw was also feed as a part of dry fodder requirement. In order to fulfil the mineral supplementation, the mineral mixture @ 50 g per day was offered to the large animals and also for needy animals. Besides, the animals were provided with timely treatment on necessity basis.

Fig. 81. Murrah buffaloes in the paddock

Fig. 82. Murrah heifers inside the shed implantation

Fig. 83. Teaser bull for detecting silent estrum

Characterization of Red Purnea cattle

A field study was undertaken in Araria, Purnea and Katihar districts of Bihar covering 60 villages in 12 blocks to characterize the distinct features of Red Purnea cattle. Results revealed that a total of 37.7 per cent of households in these districts possesses Purnea cattle. Purnea cattle existed mainly in two coat varieties *viz.* grey and red. Animals with grey coat colour constituted 47 per cent whereas the red coat colour variety constituted for 32 per cent. Rest of the animals had different shades of coat colours including black, brown etc (Fig. 84).

Fig. 84. Purnea cattle with varying coat colour

Though the Purnea cattle were reported to be reared for milking purpose, the milk yield was found to be low (5 to 6 kg/day). It was also noticed that these cattle were offered only dry fodder, apart from little green grasses based on availability. The lactation yield and lactation length were found to be 658.77 ± 5.87 kg and 183.81 ± 8.77 days, respectively. Males of Purnea cattle were aggressively used for agricultural operations and pulling loads. The study revealed that a pair of bullocks, on an average, worked for 7.34 ± 0.24 hrs in a day and took 6.08 ± 0.23 hrs to plough one acre of land.The body measurement of adult Purnea cattle has been recorded in its breeding tract in Table 30**.**

Table 30. Average body measurements for adult Purnea cattle (cm) in breeding tract

District	Length	Height	Girth
Araria	111.56±0.38 (86.5 to 122.0)	112.23±0.28 (84.0 to 125)	128.13±0.31 (100.0 to 152.5)
Purnea	114.21±0.35 (82.0 to 130.5)	114.56±0.26 (87.0 to 132.5)	134.07±0.32 (107.5 to 160.5)
Katihar	110.33±0.37 (81.5 to 120.5)	109.87±0.27 (78.5 to 125.0)	127.12±0.32 (102.0 to 148.0)

Evaluation of Area Specific Mineral Mixture "Swarna Min"

Area specific mineral mixture for Bihar "Swarna Min" was evaluated on 15 lactating crossbred cows with average milk yield of 8.52 kg/day. The animals were divided into 3 groups and supplemented Swarna Min @ 50 g/day (Gr-1), commercially available mineral mixture @ 50 g/day (Gr-2) and no supplementation (Control). All the experimental cows were fed concentrate mixture, wheat straw and green grass as per the standard feeding schedule. It was observed that the yield of milk was recorded 14.1% higher in Gr-I than the control, however, the yield was 4.8% higher than the cows in Gr-2 which were supplemented with commercial available mineral mixture (Table 31).

Table 31. Comparative milk yield of crossbred cows supplemented with Swarna Min and commercial mineral mixture

Parameters	Gr-I (Swarna Min)	Gr-2 (Commercial Mineral Mix)	Gr-3 (Control)
Milk yield (kg/day)	9.75 ± 0.31	8.90 ± 0.26	8.52 ± 0.11
Milk fat (%)	3.80	3.65	3.26

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

Assessing nutritive value and economics of baby corn (*Zea mays*) fodder compared to QPM and hybrid maize during winter season

A study was undertaken to assess the nutritive value of baby corn fodder. The economics of its production was compared to QPM and hybrid maize fodder to enable the farmers to have a better economic option for food-feed crop. Three maize varieties (hybrid maize, QPM var. PEMM-5 and baby corn var. VL-1) were taken for the study (Fig. 85). Maximum green fodder and DM yields were recorded in hybrid maize at 100 days of crop duration during Rabi season (Table 32). Highest CP and EE content was observed in QPM fodder. The CF, TA and GE values were almost similar in all the three varieties of maize fodder. Nutritive values of three varieties of maize fodder were evaluated in heifers.

Fig. 85. Baby corn, QPM and hybrid maize cultivation in experiemental farm

Table 32. Productive performance of different maize cultivars with chemical composition

Particulars	Hybrid maize	QPM (var. PEMM-5)	Baby corn (var. VL-1)
Fodder yield (t/ha)	58.67^{c}±1.33	24.67^{b}±0.33	19.17^{a}±0.44
Dry matter yield (t/ha)	7.59^{b}±0.17	4.13^{a}±0.06	3.73^{a}±0.08
CP%	8.65	10.56	9.65
CF%	19.73	20.24	20.17
DMI (kg/100kg B.Wt.)	2.13^{a}±0.05	2.59^{b}±0.06	2.23^{a}±0.14
DMD (%)	66.60±2.13	69.19±1.31	62.07±2.80
CFD (%)	65.53^{a}±2.95	75.35^{b}±0.61	63.98^{a}±1.73
CPD (%)	46.07^{a}±1.27	52.38^{b}±1.99	44.18^{a}±2.08
DCP (%)	3.99^{a}±0.16	5.53^{b}±0.21	4.26^{a}±0.20
DE (Kcal/kg DM)	2414±99	2712±52	2375±97
Benefit: cost ratio	2.19	0.92	2.63

* CP- crude protein ; CF- crude fiber; DMI- dry matter intake; DMD- dry matter digestibility ; CFD- crude fiber digestibility; CPD- crude protein digestibility; DCP- digestible crude protein; DE- digestible energy

Significantly higher DMI in heifers fed on QPM fodder was observed with the highest digestibility of CF and CP that exhibited in more DCP value than other maize varieties. Maximum DMD was recorded in heifers fed on QPM than normal hybrid and baby corn maize. The cost: benefit ratio of baby corn production was found higher than hybrid maize with the lowest value in QPM fodder. The study indicate that baby corn fodder, after harvesting of cobs, has similar chemical composition and nutritive value as hybrid maize fodder with higher economic returns as dual purpose crop.

Productivity of various fodder crops and their nutritive values

Multi-cut sorghum (var. MP Chari) and cow pea (var. Bundel-2) were sown during *kharif* season (Fig. 86a) after preparation of land by applying FYM @ 5 t/ha and DAP @ 60 kg/ha. The plot was left over for 45 days after harvesting forages and was ploughed after adding DAP @ 30 kg/ha. *rabi* forage crops *viz.* annual rye, berseem (var. Wardan) and oat (var. JHO-822) were sown (Fig. 87). The forage productivity along with their dry matter (DM), crude protein (CP) contents and nutritive values are presented in Table 33.

Fig. 86. *Kharif* forage crop

Fig. 87. ***Rabi*** forage crop

Table 33. Forage productivity and nutrients content

Fodder crops	Cum. Forage yield (t/ha)	Av. DM (%)	Av. CP (g/100 g DM	DCP (%)	DE (Kcal/ kg DM)
Kharif Forage Crops					
Multicut sorghum (2 cuts)	75.25	19.85	8.75	3.85	2380
Cow pea (var. Bundel-2) at 75d	25.66	13.55	14.50	9.42	2840
Rabi Forage Crops					
Berseem (5 cuts)	55.85	13.09	19.31	14.30	3020
Annual Rye (5 cuts)	61.20	13.07	17.12	13.25	3290
Oat (2 cuts)	28.33	13.62	11.49	7.60	3210

Cumulative maximum fodder yield was recorded in multi-cut sorghum during rainy season. The biomass yield of cow pea var., Bundel-2 was recorded at one third of sorghum, however, it produced almost double amount of digestible crude protein (DCP) than sorghum. During winter season, maximum forage yield of 61.20 t/ha was recorded in annual rye followed by berseem and oat with sufficient amount of DCP and Digestible energy (DE) values. Thus, considering forage yield and nutritive value, it is recommended to grow cereal and legume forages together in both the season for balanced feeding to livestock.

Seed production of fodder crops

A study was conducted to assess total biomass yield by recording forage, straw and seeds production of annual rye, berseem, oat and wheat (Fig. 88). The oat was harvested at 60 days after sowing and subsequently provided irrigation and urea @ 40 kg/ha as top dressing. The second cut of fodder from 50% area was taken at 105 days and remaining area was left for seed production. However, four cuts were collected in berseem and annual rye. In both the fodder, 50% area of sub-plots was kept for seed production. Irrigation was provided at every cutting of fodder followed by top dressing with urea @ 40 kg/ha. However, wheat was harvested from 50% area on 70 days of crop duration at 12cm base height. Irrigation was provided just after harvesting with subsequent application of urea @ 40 kg/ha. The wheat plant further grew and harvested at 150 days of crop duration and dry roughage and seed yield were calculated.

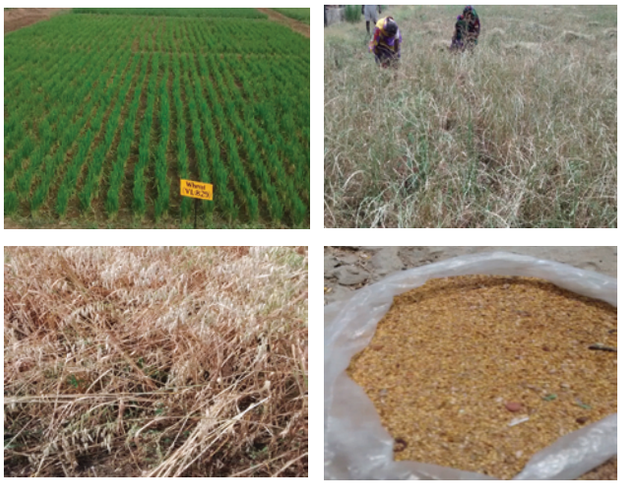


Fig. 88. Seed production from different forage crops

The highest total biomass yield was recorded from all the forage crops used for dual purpose (Table 34). The minimum forage yield of 7.20 t/ha was recorded from wheat due to single cut but it contained CP 17.46%, DCP 12.70% and DE 3085 Kcal/kg DM, which are comparable to other legume forage crops like berseem and annual rye. Therefore, it is suggested that farmers can produce seeds for their own use with equal total dry forage production.

Table 34. Performance indicators of various fodder varieties for production of total biomass and seed

Attributes	Cropping period (days)	Fodder DM yield (t/ha)	Straw yield (t/ha)	Seed yield (t/ha)	Total biomass yield (t/ha)
Annual Rye					
Fodder only	140	8.00	—	—	8.0
Fodder & seed	165	6.40	2.83	0.41	9.64
Berseem var. Wardan					
Fodder only	165	7.31	—	—	7.31
Fodder & seed	200	5.85	2.57	0.30	8.72
Oat var. JHO-822					
Fodder only	105	3.86	—	—	3.86
Fodder & seed	150	1.70	3.84	1.75	7.29
Wheat var. VL-829					
Fodder & seed	150	1.07	4.77	3.11	8.95
Seed only	150	—	4.54	3.30	7.84

Perennial forage production

An experiment was also conducted to assess the forage yield from perennial napier var. CO3 grown on bunds (Fig. 89). One metre wide bund was prepared and FYM (@ 5 t/ha and DAP 60 kg /ha) was added. Two rootslips were planted on bunds with plant to plant distance of 50 cm during July. Total cummulative forage yield of 182.1 t/ha

Fig. 89. Napier fodder production on bund

was recorded with average DM and CP content of 15.09 8.92 per cent, respectively (Table 35).

Table 35. Fodder yield from Napier

Particulars	Ist cut at 60d	IInd cut at 115d	IIIrd cut at 170d	Av. Cum. perfor-mance
Forage yield (t/ha)	60.40 ±0.49	76.33 ±1.45	45.33 ±0.88	182.06 ±0.87
DM (%)	12.65	17.43	15.20	15.09
No. of tillers	40±2.51	55±3.05	--	50±5.50

Considering the present productivity, farmers can obtain almost 10-12 t green fodder per annum (4-5 cutting) using bunds (area 400m^2). The study revealed that the bund area in one acre land is sufficient to produce 12 t green fodder per year which is sufficient to maintain two adult cattle by providing 30 kg green fodder per day.

Broom cultivation on buds: A study was conducted to evaluate possibility of Broom (*Thysanolaena maxima*) production on bunds under hot and subtropical humid weather condition of Bihar. The root slips were transplanted on bunds in the month of July, 2015 and fodder was harvested after 240 days in the month of Februray, 2016 (Fig. 90). The plant growth was promising and total 55 tillers/plant were recorded that yielded 1.20 kg green forage, 2.24 kg dry reed and 0.80 kg dry flower per plant. Looking at the production potentiality, it can be grown in waste and upland area of Bihar to mitigate forage deficit up to some extent and at the same time the flower may be sold for domestic use and reed can be utilized as thatch material.

Fig. 90. Broom fodder production on bund

Management of Heat Stress in Buffalo

Rectal temperature, respiration rate, blood profile and hormone level (Cortisol, T_3 and T_4) were measured in summer season to study the effect of heat stress in Murrah buffalo. Rectal temperature and respiration rate was measured fortnightly both in morning and evening when ambient temperature was above 35^{o}C. Mean rectal temperature varied from 100.3±0.47^{o}F in morning to 100.4±0.49^{o}F in evening and mean respiration rate was 14.9±0.9. Blood sample from 22 buffalo in summer season showed Total erythrocyte count (TEC), Total leukocyte count (TLC), Differential leukocyte count (DLC), Haemoglobin percentage PCV and MCV under normal range. Cortisol, T3 and T4 level of Murrah buffalo were measured with the help of ELISA based kit (Monobind Inc., USA). Serum cortisol, T3 and T4 level were 5.34±0.24 ng/ml, 1.92±0.14 ng/ml and 32.25±2.3 ng/ml, respectively in summer which were higher than the winter season.

Nutritional Interventions

Effect of sodium bicarbonate supplementation on milk yield in buffalo

Sodium bicarbonate feeding is beneficial in lactating buffalo due to its buffering capacity in the rumen as it maintains a normal rumen environment by lowering the incidence of acidosis effectively, which is commonly occurring during hot weather. For the study, 8 lactating buffalo (454.6 ± 28.3 kg b.wt, 3-4 months lactation length, 2-3 parity) were selected and divided into two groups. Group 1 was fed standard diet (wheat straw, concentrate and sorghum fodder) and buffaloes in Group 2 were fed standard diet along with supplementation of sodium bicarbonate @ 30 g/day dividing into equal doses in the morning and afternoon. The trial was conducted during summer (mean temperature

42.3°C and RH 56.8%). The buffaloes in group 2 yielded higher milk (7.33 ± 0.5 kg) over Group 1 (6.85 ± 0.4 kg). The fat percentage was also found slightly higher in milk with sodium bicarbonate supplement (6.28 ± 0.2 vs 6.2± 0.03).

Effect of roughage to concentrate ratio on growth of buffalo calves

To study the effect of roughage: concentrate ratio in buffalo calves, 12 calves (197-331 kg body weight, 6-8 months age) were selected and divided into 3 groups in RBD. Group 1 was fed wheat straw and concentrate at the ratio of 1:3 on DM basis while Group 2 and 3 were fed at the ratio of 1:1 and 3:1, respectively, for 3 months in summer. The calves in group 2 attained higher body weight growth (556 g/day) than group 1 (527 g/day) and group 3 (472 g/day). The digestibility of DM and OM was also found higher in group 2 followed by group 1 and 3.

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

Young crossbred male (N=14) were selected for experiment and divided into two groups on the basis of feed efficiency. For differential expression study skeletal muscle tissue was collected from each animal and mRNA was isolated. cDNA was synthesized by using oligo dT primer. Primer for amplification of UCP2 and UCP3 gene was designed and their differential expression was studied by real time PCR. Real time PCR protocol was standardized. Primers for both UCP2 and UCP3 gene showed amplification at annealing temperature of 55°C. Specificity of primers were studied by melting curve analysis (Fig. 91). Analysis of real time PCR data revealed that UCP 2 gene is down regulated and UCP 3 gene is up-regulated in feed efficient animal. The study revealed that expression of UCP gene act is an indicator to identify feed efficient cattle.

Development of herb-based calf-care mix for the production of disease-free calf

Under this project, 436 livestock holdings were surveyed in different districts of Bihar (Patna; Katihar, Araria, Purnea) and West Bengal (North Dinajpur; South 24 Parganas; Bardhaman; East Midnapur; Purulia). In the survey, 910 calves were selected for data recording comprising 33.41 % males and 66.59% females. Base on the information collected via questionnaire, 45.64 % of the farmers observed major calf diseases (Fig. 92a) in last one year and 29.82% farmers reported calf mortality in the same period. Among the dead calves, 59.23% were females. Calf mortality was higher in December and January months. Age at first calving of cattle was 47.21± 10.64 months and age at puberty was 37.45 ± 10.80 months in the surveyed livestock holdings.

Fig. 92a. Scabies in a buffalo calf

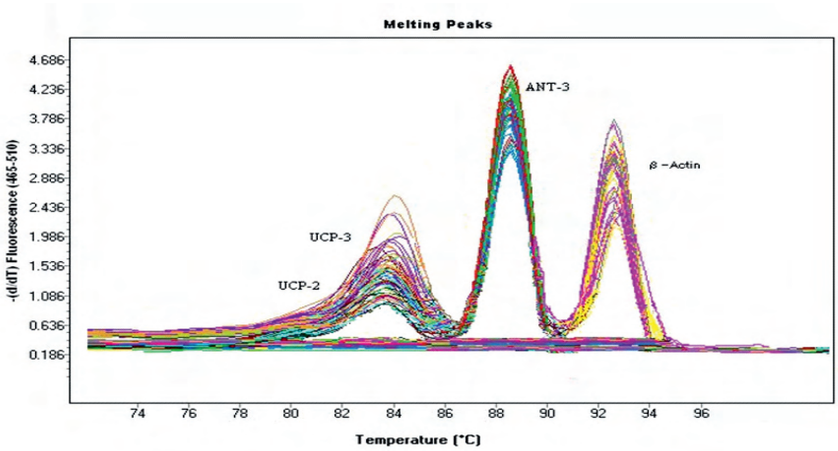


Fig. 91. Melting curve analysis of primers for UCP2 and UCP3 gene

The calf-care mix was prepared with 11 herbal ingredients. Experimental calves (14 nos) were selected from institute farm and divided into two groups-, viz., control (6 nos) and treatment (8 nos) groups. Calf care mixture was fed to experimental group daily (Fig. 92b). Blood samples were collected from both the groups before and after the treatments. Serum and blood samples were analyzed for LFT and KFT. Biochemically, there was no toxic changes observed in any of the parameters. Weight gain and regain and lustre of coat observed in all experimental animals. However, was non-significant elevation in total protein, albumin and total bilirubin observed in treatment group.

Fig. 92b. Calf-care mix is administered to a calf

Isolation and Morphological Characterization of ***Fusarium*** species from Degnala like Disease Affected Region

Different locations in Patna and Vaishali districts of Bihar were surveyed and cases of Degnala like diseases in cattle and buffaloes were recorded. Some animals were found to be severely affected and showed complete sloughing of hoof (Fig. 93) whereas, some were showing mild clinical symptoms.

Fig. 93. Animal with complete sloughing of hoof

The paddy straw, fed to the diseased animals were collected and processed for isolation of fungus. The potato dextrose agar media used for isolation of fungus, recovered three isolates showing characteristics growth of *Fusarium* species. Pure cultures of *Fusarium* species were obtained by sub-culturing on potato dextrose agar after incubation at 25°C for 4 days. The cultural appearances (colony colour and pigmentations) were observed on potato dextrose agar (PDA).The cultures were fast growing as well as cottony to flat and spreading. The color of the thallus varied from whitish to yellow, pink and reddish shades (Fig. 94.) which may be due to difference in species.

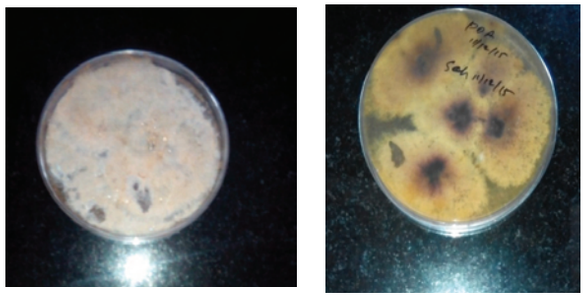


Fig. 94. Characteristics growth of fusarium on potato dextrose agar

Growth performance of crossbred (T&D) pigs fed sweet potato as a replacement of maize

An experiment was conducted to test the efficacy of replacement of maize feed with boiled sweet potato for T & D crossbred pig (Fig. 95). The trial was conducted with at 90 days age with average body weight of 30 kg. Experiment consisted of four treatments *viz.* replacement of maize with boiled sweet potato *(Ipomoea batatas)* (BSP) at the rate of T_1 (0%, Control), T_2 (20%), T_3 (40%) and T_4 (60%), respectively. The feed was offered twice

Fig. 95. Experimental pigs

daily @ 2.0 kg/pig/day on dry matter basis with half of the quantity in the morning and half in the evening. During 60 days trial all the groups showed significant difference in body weight. The maximum weight gain with increasing level of sweet potato up to 60% may be due to maximum availability of digestible carbohydrate in diet along with protein. It may be inferred from the experiment that boiled sweet potato is better option for replacement of maize and up to 60% may be incorporated in pig feed to achieve maximum weight gain.

Growth and Production Performance of Divyayan Red Poultry bird at Ranchi

An experiment with phytase enzyme was carried out and supplementation with phytase @ 20 g/100 kg of feed was provided to experimental group of birds and a diet without phytase enzyme was given to control group. Higher average growth rate of 15.36% was recorded in phytase supplemented birds (25.95 g/day) than control group (22.50 g/day), which indicated that phytase enzyme supplementation in ration of poultry birds has a beneficial effect on growth performance (Fig. 96).

Fig. 96. Divyayan red poultry birds

Multiplication and Production Profiling of Improved Poultry Germplasm under Backyard Rearing

Improved chicken variety *viz.* Vanaraja and Grampriya were reared under deep litter system (Fig. 97a & b). It was observed that upto 28th week of age, egg production was slightly higher in Gramapriya than Vanaraja bird, however, mortality was lower in Vanaraja than Grampriya. There was negligible effect of summer temperature and humidity on egg quality in both the birds. The mortality rate was found to be less and thus this breed can survive better in the environmental condition of eastern region with good production potential (Table 36).

Fig. 97a. Parent Stock of Vanaraja above and Gramapriya below in Deep Litter rearing System

Fig. 97b. Vanaraja in california cage system

Table 36. Production performance of F1 generation of Vanaraja and Grampriya bird

Hatchability %	Vanaraja	Gramapriya
Total egg set basis	70.75	70
Fertile egg set basis	86.14	87.5
Day old chicks body weight (g)	36.5±1.40	32.00±0.58
Body wt. upto 28th week of age (g)	2222.3± 74.81	1379.14± 20.86
Mortality % up to 28 weeks	Less than 1% (0.90±0.43)	Less than 5% (4.35±0.86)
Age at first lay (in days) & egg wt. (g)	140 & 36.46 ± 0.22	133 & 37.34 ± 2.12
Average body weight at first lay (g)	1601.3±46.86	1344.86±45.15
Egg production (egg /bird) when THI ranges from 81.16±0.64 to 85.45±0.28		
up to 28 weeks of age	20.59±0.04	22.40±0.03
Average Egg production (Hen day basis) %		
up to 28 weeks of age	34.32±3.61	37.33±3.25
Colour of Egg	Creamish white to light brown	light brown to brown

Characterization and Evaluation of Duck Germplasm in Odisha

A survey was conducted in Cuttack, Baleswar, Puri and Maurbhanj districts of Odisha to study the different duck production systems and to differentiate the phenotypic characteristics of ducks in different provinces. The average flock size was almost equal in Cuttack and Baleswar (9-10 birds/flock) whereas in Maurbhanj and Puri it varied from 20-30 birds/flock. Morphometric measurement on adult body weight, body length, bill length, beak width, shank length, wing length, head length, neck length and head width, in Drake/male and Duck/female has been presented in Table 37.

Table 37. Morphometric characteristics of indigenous ducks in Odisha

Traits	Drake	Duck
Body weight (kg)	1.80±0.02	1.41±0.02
Body length (cm)	42.69±0.55	41.30±0.29
Bill length (cm)	6.11±0.02	5.60±0.04
Bill width (cm)	3.70±0.04	3.46±0.03
Shank length (cm)	6.21±0.03	5.89±0.03
Wing length (cm)	42.73±0.34	39.99±0.22
Head length (cm)	9.47±0.15	7.99±0.10
Neck length (cm)	12.42±0.21	10.32±0.05
Head width (cm)	3.41±0.05	2.98±0.03

Body carriage and bill shape of drake ducks were found to be slightly upright and horizontal, respectively. Head colour were greenish black in 55% of drake where as it was black to brownish shed in remaining drake. The head colour were brown and white mixed in 75% of duck whereas it varied from black to white in remaining ducks. The shank colour in drake varied from yellow (44.4%) to orange (55.5%). Similarly, in case of duck also shank colour varied from yellow (40.5%) to orange (59.5%) (Fig. 98).

Evaluation of nutraceuticals as supportive therapy for subclinical mastitis in periurban cattle

Milk samples collected from Eastern UP were analyzed. Maximum prevalence of subclinical mastitis (SCM) was observed from Varanasi (37.5%), followed by Gajipur (35.29%), Ballia (27.78%) and Azamgarh (8.33%). The prevalence of subclinical mastitis was 27.27% animal wise and 8.18% udder wise in the peri-urban cattle of Eastern Uttar Pradesh. The pattern of incidence of SCM teat wise was maximum in left fore followed by right fore and right hind and least in left hind. Technology modification has been attempted by preparing California mastitis test (CMT) reagent using locally available ingredients. Bacterial isolates obtained were subjected to *in vitro* antibiotic sensitivity testing by disc diffusion method against 6 commercially available antimicrobial discs and evaluated based on standard inhibition provided. About 100 g dried powder of curry leave and 30 g dried powder of Methi seed was provided for 10 days as supportive therapy. Clinical trial of *Murraya koenigii* (curry plant) leaf and *Trigonella foenum-graecum* (Fenugreek/Methi) seeds were made in available seven sub-clinically affected cattle of Institute farm. Pre and post blood samples has been collected and serum samples stored for further analysis. Few animals were made available for clinical trial in Institute animal farm.

Fig. 98. Desi Duck germplasm of Odisha

FISHERIES

Integrated Fish Farming Models to Improve upon the Fish Productivity

Six integrated farming system models were developed and the fish productivity was compared with control (without integration). It was observed that cattle-fish resulted into highest productivity of 4.50 t/ha, followed by poultry-fish integration. The data also releaved that the fish rearing with concentrate feed was able to increase a fish yield only by 760 kg/ha as compared to productivity of cattle-fish integration. Resource poor farmers' of the region could therefore, adopt these technologies of integrated fish farming (Fig. 99).

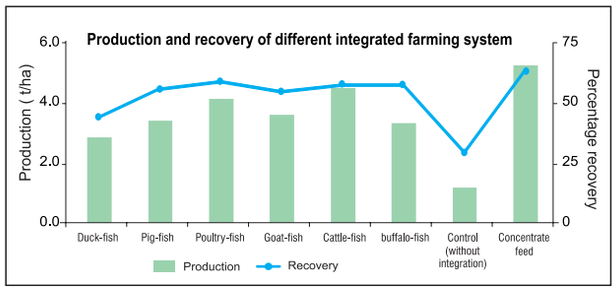


Fig. 99. Fish productivity under different fish integrated system

Optimization of Production Efficiency in Livestock – Fish Integrated Farming System

The study on integrated fish farming was carried out on cattle-fish, buffalo-fish, goat-fish, poultry-fish, pig- fish, duck - fish and a control in the institute fish farm. No feeding was given to any of the treatments except one pond with supplementary feeding. Nutrient sequestration, water quality, plankton density and microbial load in fish pond have been estimated (Fig. 100).

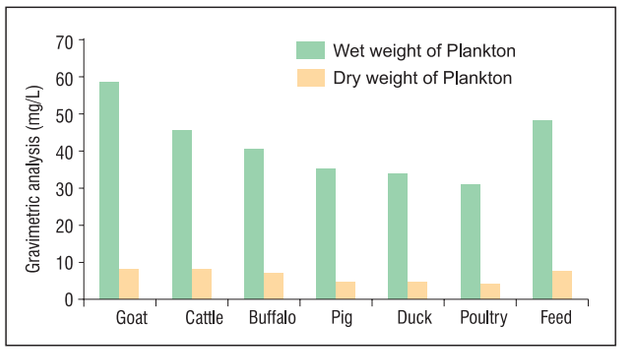


Fig. 100. Plankton concentration in different livestock based fish farming system

Study of fish food organisms/plankton

Higher concentration of plankton population was observed in Goat-fish (58.54 mg/l) followed by Cattle-fish (45.44 mg/l) and Buffalo-fish (40.56 mg/l) integrated system. Plankton density in poultry and duck was relatively less. It might be due to direct consumption of dung by the fish. From the preliminary study, three groups of zooplankton have been identified like rotifer, copepods and cladocerans among which *Diaphanosoma* sp. (Fig. 101) was most dominant species in pig-fish integrated system. Fig. 102-103 represents different fish food organisms collected from livestock based integrations. Fig. 104 shows different types of rotifers found under different integration system. Rotifers are the best fish food organism especially when fishes are in younger age. Similarly, Cladoceran are also found abundantly in the integrated fish farming system. Availability of these fish food organisms indicate healthy environment for the fishes to grow.

Fig. 101. ***Diaphanosoma*** sp.

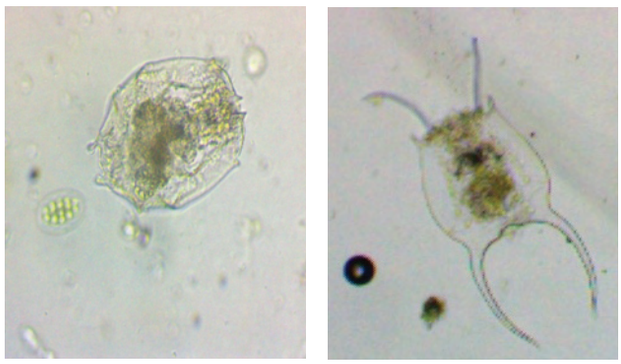


Fig. 102. Rotifer collected from integrated fish farming

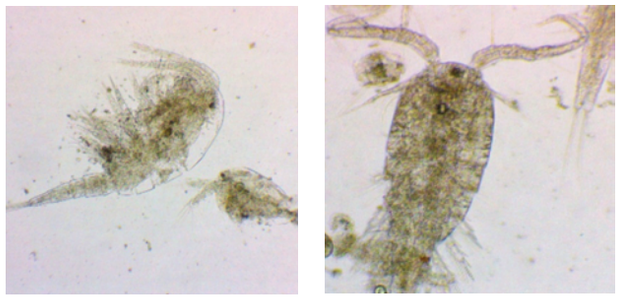


Fig. 103. Copepod integrated fish farming

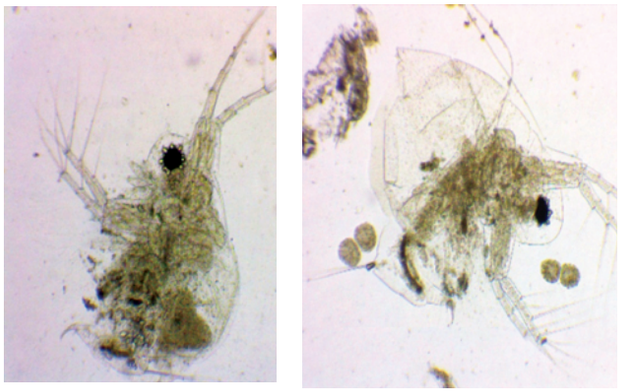


Fig. 104. Cladoceran integrated fish farming

Primary productivity

Primary productivity and water quality parameters are crucial for optimum fish production. Fig 105 illustrated the primary productivity of water under different integration. Gross primary productivity (GPP) and Net primary productivity (NPP) was highest in cattle-fish integration (0.34 g C/m^3/hr) followed by the poultry fish integration (0.32 g C/m^3/hr) and goat-fish (0.28 C/m^3/hr). This might be the reason for highest production of fish from cattle-fish integration, followed by poultry integration.

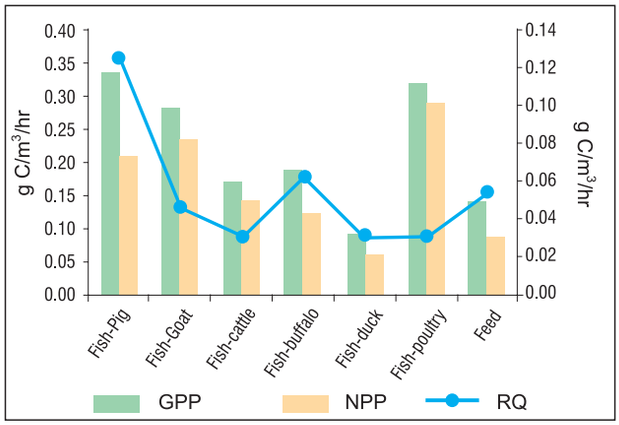


Fig. 105. GPP, NPP and RQ in different livestock based fish farming systems

Respiration quotient (RQ) was highest in pig-fish and rest of the integration showed almost similar results. Water quality parameters in different livestock based fish farming system are given in Table 38. From the study it was found that pH of water in all the integration have not changed significantly. Oxygen level was maintained between 4 to 5 ppm. Maximum oxygen level was recorded in the duck-fish integration. Alkalinity and hardness were within the acceptable limit in all the integrations.

Table 38. Water quality parameters under different integration

Integration	pH	DO (ppm)	Alkalinity (ppm)	Hardness (ppm)
Fish-goat	7.68±0.12	4.45±0.19	173.17±4.96	183.50±4.89
Fish-cattle	7.37±0.21	4.70±0.15	183.67±2.63	190.67±3.98
Fish-buffalo	7.55±0.13	4.02±0.13	196.83±2.44	177.67±2.30
Fish-pig	7.42±0.18	5.10±0.32	181.33±3.98	157.17±1.96
Fish-duck	7.35±0.17	6.35±0.33	183.50±1.52	171.00±2.44
Fish-poultry	7.43±0.22	4.37±0.53	199.17±3.33	177.50±3.94
Feed based	7.38±0.22	4.68±0.53	174.83±1.49	163.33±2.62

Microbial assessment

Microbial population have significant role for basic production and decomposition process in aquatic ecosystem. Fig. 106 illustrates the total coliform (x 10^3 cfu/ml) bacteria in water of different livestock fish integrated farming systems. Initial study of Total Coliform Count (TCC) was observed to be highest in buffalo-fish (2.25X10^{3}CFU/ml), and lowest in poultry-fish (0.25X10^3 CFU/ml) integrated system. The bacterial count estimated was in the order as fish-buffalo > fish-pig > fish-cattle > fish-duck and fish-goat > fish-poultry. In the present study the mean bacterial load was found to be notably lower than the recommended public health and standard value of 5.0 x 10^5 CFU/ml accepted by many countries.

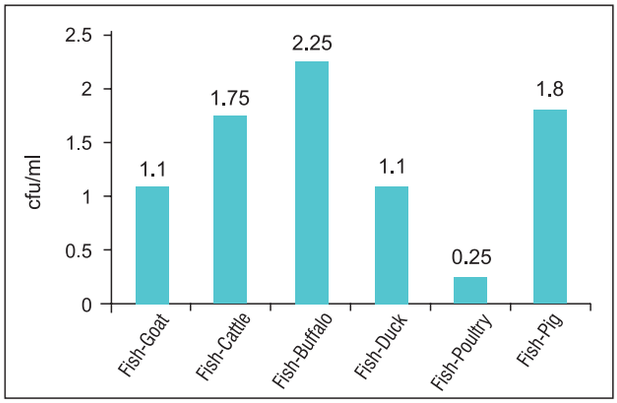


Fig. 106. Total coliform (x 10^3) load in water bodies of integrated fish farming systems

Haematological study

Haematological indices are important parameters for the evaluation of fish physiological status under different environment. Blood parameters like RBCs, WBCs, Haemoglobin (HB) and erythrocyte indices (Fig. 107) were estimated under different

Fig. 107. Blood collection from fish

integrated systems and found optimum for fish health (Table 39).

Table 39. Haematological parameters of fishes under different integration

Integration	Species	RBC (10^6/ mm^3)	WBC (10^3/ mm^3)	HB (gm/ dL)	PCV (Packed Cell Volume) (%)
Cattle-fish	Catla	1.83	20.65	7.08	27.00
	Rohu	1.40	18.90	6.24	23.80
	Mrigal	1.58	19.30	7.74	26.80
Goat-fish	Catla	2.70	19.27	9.19	27.00
	Rohu	1.87	20.99	6.86	23.80
	Mrigal	1.48	21.04	6.27	26.80
Buffalo-fish	Catla	2.00	23.92	7.58	27.00
	Rohu	1.48	23.26	6.62	23.80
	Mrigal	1.28	21.40	6.74	26.80
Duck- fish	Catla	1.29	19.86	5.82	27.00
	Rohu	1.15	24.88	6.62	23.80
	Mrigal	1.28	21.20	6.40	26.80
Pig-fish	Catla	1.21	21.40	6.68	27.00
	Rohu	1.19	17.96	6.98	23.80
	Mrigal	1.18	21.11	6.30	26.80

Fish production under different integrated farming system

Buffallo magur integration

Successful culture of *Clarias batrachus* (Magur) was carried out in buffalo wallowing pond. The fishes were stocked @ 30000/ha with 75% survival rate. The average body weight of *Clarias batrachus* varied from 100-120 g with a highest body weight of 495 g and total yield was obtained 2.5 t/ha without feeding for a culture period of 7 months (Fig. 108).

Fig. 108. Magur procured from wallowing pond

Fish Seed Production

Successful seed production of Indian Major Carps *viz.* Catla, Rohu and Mrigal was carried out in the portable carp hatchery of ICAR-RCER, Patna. Healthy matured brooders were separated and fed with protein rich feed (3-5% of body weight) for 3-4 months prior to breeding trial for getting superior offsprings. Brooders were maintained in 1:1 ratio and inducing agent Wova-FH @ 0.3 ml and 0.5 ml per kg body weight was given for male and female brooder, respectively (Fig. 109). Throughout the programme water hardness and other parameters were maintained optimum. The unfertilized eggs were discarded to protect from fungal attack in the hatching pool. A total of 2 lakh eggs were recovered from Rohu out of which 1.4 lakh egg were fertilized and produced 0.5 lakh healthy spawn. From Catla 1.5 lakh eggs were recovered with 60% fertilization which produced 0.28 lakh healthy spawn. From mrigal 1.2 lakh eggs were recovered showing 60% fertilization which produced around 0.27 lakh healthy spawn from the incubation tank.

Fig. 109. Hormone administration in fish during breeding

16. *Solar Energy Application*

Solar Photovoltaic Aerator for Fishpond

In view of immense solar energy potential in Eastern region of India, a spray type solar aerator was developed and evaluated for dissolved oxygen concentration in a fish pond of size 20 x 30 x 1.5 m at Patna (Fig. 109). It was designed with one horse power DC surface pump and 900 Wp solar panel. It sprays less oxygenated pondwater high into the air through perforated pipe. This aerator not only increases the dissolved oxygen concentration of pond water, but also breaks the thermal stratifications which obstruct inter mixing of more oxygenated top layers of pond water with the low oxygenated sub-surface layers.

Fig. 109. Solar aerator to improve dissolved oxygen concentration in fish pond

The inter mixing of top saturated layers with low oxygenated sub-surface water layers facilitates increase in dissolved oxygen concentration of sub surface layers. If this aerator was operated for 6 to 7 hrs in a day, then an increase of 20-22% in oxygen concentration in sub-surface layer (0.5 m from surface) and 40-50% increase in deeper layer (1.0 m from surface), were observed compared to the controlled conditions, i.e., 4.24 and 3.37 ppm, respectively (Fig. 110 & 111). However, no significant difference in dissolved oxygen concentration was observed in surface layers due to the fact that the top layer is always at higher concentration (Fig. 112).

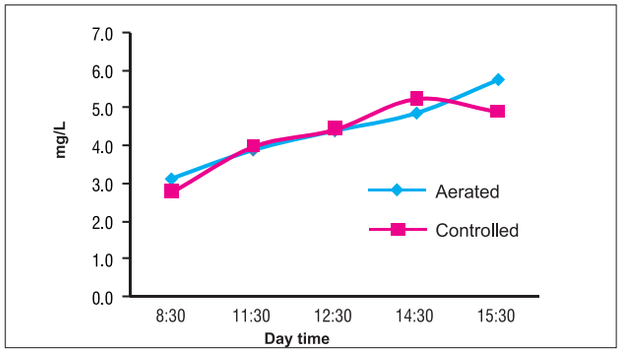


Fig. 110. Variation in dissolved oxygen level of subsurface (0.5 m) pondwater at different time

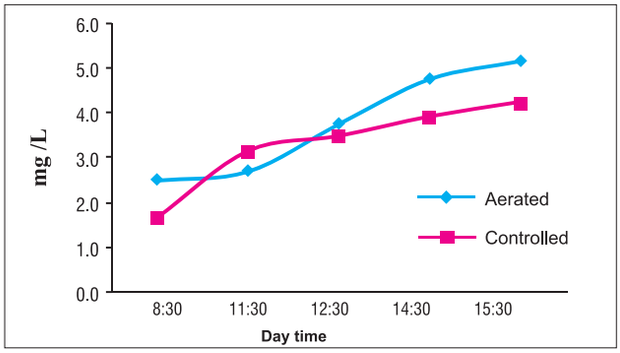


Fig. 111. Variation in dissolved oxygen level of subsurface (1.0 m) pondwater at different time

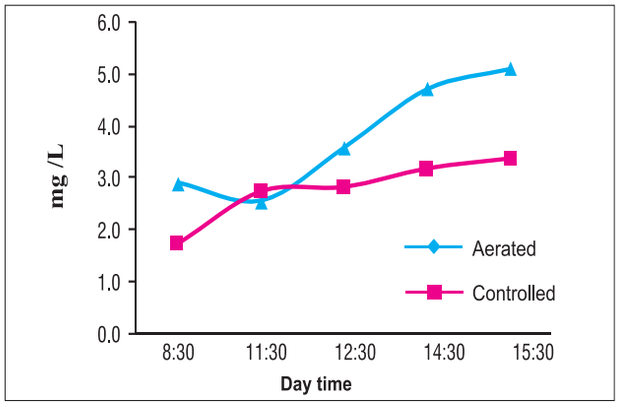


Fig. 112. Variation in dissolved oxygen level of top layer (0.0 m) of pond water at different time

Solar Photovoltaic System for Animal Shed Cleaning

Solar photovoltaic watering system was designed and installed. It can supply water to medium and large herds, based on the fact that Eastern region has good potential of solar radiation, i.e., 6.4 - 4.3 kWh/m^2/day with 250 - 300 bright sunny days per year (Fig. 113). The system consists of a 1 horse power dc motor pump, energized by 900 Wp solar panel. This system lifts water from the pond and supplies to the neighboring animal sheds (situated within 50 m radius). The water is supplied at a discharge rate of 5000-6000 lph when operated from 8.00 am to 2.30 pm during day time at relatively high pressure (Fig. 114).

Fig. 113. Solar photovoltaic system for animal shed

Fig. 114. Cleaning of animal shed through solar photovoltaic system

Solar Photovoltaic System for Groundwater Pumping and Operating Pressurised Irrigation System

A photovoltaic system for ground water pumping comprising of a DC or AC submersible pump to lift ground water into a grounded tank and a DC surface pump that delivers water out of tank to the fields for irrigation, was evaluated at Patna where a 2 horse power centrifugal pump energized by 1400Wp solar panel was used as delivery system. The static delivery head versus discharge and delivery head versus solar irradiance of this pump is shown in Fig. 115 & 116, respectively. Interpretation of the two graphs shows that, the system could operate pressured irrigation system successfully round the year, if the required operating pressure range from 1.1–1.5 kg/cm^2 between 9.00 to 14.30 hr. However, if this system is operated by 1800 Wp solar panel then offers pressure ranged from 1.3–1.8 kg/cm^2 on a bright sun shine day in Eastern region of India, where solar radiation intensity is ranged from 650-900 W/m^2 during aforesaid day time band. This system was successfully tested in guava orchard intercropped with vegetable at experimental farm of the Institute.

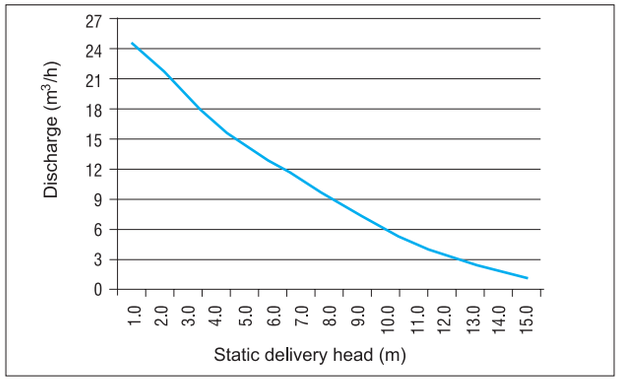


Fig. 115. Static delivery head vs. discharge curve of delivery unit

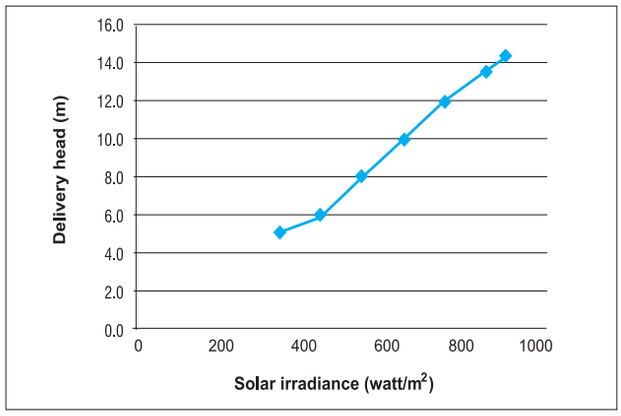


Fig. 116. Static delivery head of delivery pump at different intensity of solar irradiance

17. *Transfer of Technology*

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

To address the dynamics of economic, social and institutional development across eastern states, data were collected from Jharkhand and Bihar under ICAR-ICRISAT project during 2010-11 to 2014-15. Results indicated a positive relationship between farm size and productivity. The higher productivity of various crops on upper category of households was mainly due to the use of modern seed and fertilizers and ownership of water resources. Poor access to working capital to procure quality seeds, fertilizers and water resources for timely and adequate irrigation to crops were major constraints for realizing higher crop productivity on tiny land holdings. The results also reflected the prevalence of poverty and lack of working capital for crop production in area of infrastructure and non- existence of rural non-farm activities.

The changing employment and livelihood pattern of labour households during the last four years showed clear evidence of transition of labour force from farm to non-farm sector. There was an increase in employment for male in both farm and non- farm sectors, but increase was higher in non-farm sector than in farm sector. Women employment in farm sector declined from 69 days in 2010 to 41 days in 2013, whereas there was an increase in their employment in non- farm sector. The role of non-farm sector in providing rural employment has increased and strategy to increase non- farm employment may be one of potential pathways for alleviating poverty in Bihar.

Both farm and non-farm sectors witnessed increase in wages of labours during last four years, but the increase was much higher (65%) in non-farm sector than in farm sector (15%). Wages in farm sector is not only low, but also it does not provide regular employment, whereas wages in non-farm sector is higher and employment is more regular. Wage determinant analysis revealed that a healthy, educated and land owning adult male labour is likely to get higher wages.

Non-farm sector emerged as a major source for providing employment and generating income on labour households. Income through farming constituted about 8 to 12 per cent of total income on labour households. Remittances emerged as the second most important source of income on labour households because migration for gainful employment is one of the important strategies for maintaining livelihood in Bihar, particularly of economically most deprived households.

Institutional credit flow is low in Bihar and agricultural labour households have much less access to institutional sources of credit. They depend on non – institutional credit sources for meeting their consumption and production credit need.

Various programmes for welfare and development of the weaker sections are implemented by different government departments. But labour households have more access to social security schemes and project targeted to poor households (BPL families) than programmes launched for benefits of both poor and non-poor households. However, programmes like MNREGA, IAY, KCC and SHG were not implemented in the villages under study.

While analyzing determinants of income in Jharkhand, it was observed that education, size of household and share of non-farm income and adoption of high yielding varieties exerted significant influence on income of households. It was mainly due to fact that educated persons might have got more remunerative engagements, larger family size means larger number of workers, labours employed in non-farm activities get higher wages and adoption of high yielding varieties helps in getting higher productivity of crops.

Growth and Instability in Production of Principal Crops in Bihar

The project was initiated in 2014 to study the growth and instability in production of principal foodgrain crops in Bihar. For this, thirty years secondary data since 1982 on area, production and yield were collected. It was observed that the area under rice and pulses *vis-a-vis* total foodgrains is continuously decreasing in Bihar (Table 40). However, in case of rice and total food grains, the decrease in area has been counter balanced by the increase in yield and therefore, the total production of foodgrains has increased continuously over the last 30 years. But in case of pulses, although the yield has increased, it is not sufficient enough to counter balance the decrease in area under pulses and consequently, the total production of pulses has decreased over the years.

Table 40. Compound annual growth rate of principal crops in Bihar (%)

Crop	Particulars	1983 to 1992	1993 to 2002	2003 to 2012	1983 to 2012
Rice	Area	– 0.33	– 0.99	– 0.70	– 0.51
	Production	– 0.91	– 0.63	2.40	0.29
	Yield	– 0.59	0.37	3.12	0.81
Wheat	Area	1.02	1.01	0.81	0.60
	Production	2.55	0.80	7.94	1.97
	Yield	1.52	– 0.21	7.07	1.36
Pulses	Area	– 11.69	– 1.54	– 3.44	– 2.19
	Production	– 10.58	– 0.19	– 0.02	– 1.59
	Yield	1.26	1.37	3.54	0.61
Foodgrains	Area	– 0.79	– 0.23	– 0.35	– 0.34
	Production	0.63	0.57	4.88	1.17
	Yield	1.43	0.80	5.25	1.51

LEWA irrigation system modified and demonstrated in farmers' fields

Most parts of Bihar has experienced 5 annual deficit rainfall years in last decade. As a result, farmers are not able to irrigate their fields sufficiently through conventional methods of irrigation (irrigation efficiencies ranges up to 40 %) like check basin, border and furrow due to scarce water resource available on the ground surface or below ground level. Further, small and scattered land holdings and high energy requirement limit the conventional pressurized irrigation systems like sprinkler. Aiming to cater to the need of such farmers, modified LEWA irrigation system was designed and developed. Modified variant of LEWA device has higher structural strength due to its threading system. All the components were made of poly-propylene except the two washers which were made of Teflon. Modified LEWA device with new design (Fig. 117) has reduced leakage from it up to 90% at an operating pressure of 0.4 to 0.8 kg/cm^2.

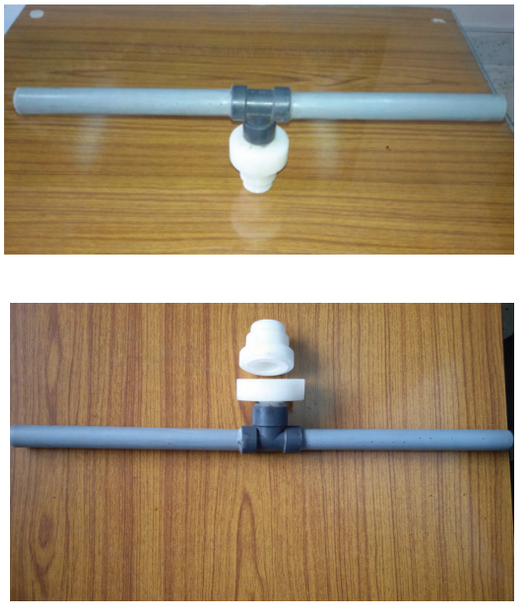


Fig. 117. Front and side view of modified LEWA device

After a satisfactory lab testing report of modified LEWA irrigation system, it has been demonstrated in vegetable crops of tribal dominant Karar village through KVKs (Fig. 118).

Fig. 118. Demonstration of modified LEWA irrigation system in brinjal at Karar village, Kaimur district, Bihar

False Smut Management in Rice

Efficacy of new fungicides against false smut in rice (Fig. 119) was evaluated in Buxar (Bihar). Trifloxystrobin 25% + tebuconazole 50% @ 200 g/ha or propiconazole 25 EC @ 500 ml / ha with first spray at booting stage and second at an interval of 14 days was found most effective. Similarly, seed treatment with carbendazim@ 1g/kg seed and spray@ (0.1%) at before flowering and copper oxychloride @ 1.5 kg/ha spray significantly reduced its incidence compared with the control.

Fig. 119. False smut disease in rice

Rice-fallow Management in Eastern Plateau and Hill region

This project is being implemented in Saraitoli village near Ranchi, Jharkhand to develop farming system models under Rice-fallows. In this model of 0.32 ha having components like paddy, vegetables like potato & tomato, lac, goat and cows, farmers could obtain a net return of Rs 48,460 per year with B:C ratio of 7.45. In another farming system model of 0.42 ha, five combinations of paddy + lac + fishery + goat; Paddy +Vegetables + Lac + Duckry + Goat + Buffalo; Paddy + Vegetables + Lac+ Goat+ Cow + Poultry; and Paddy + Vegetables + Lac + Poultry + Cow were developed. These farming systems yielded a net profit of ₹ 88,770 (B:C ratio 7.39); ₹ 63,400 (B:C ratio 5.04); ₹ 85,909 (B:C ratio 7.81) and ₹ 65,090 (B:C ratio 3.32) respectively, per year. In farming system models of 1.25 ha, three farming system combinations, *viz*., Paddy + Vegetables + Lac + Poultry; Paddy + Vegetables (potato & tomato) + Lac + Poultry and Paddy + Vegetables + Lac + Goat + Buffalo were developed.

These models yielded a net return of ₹ 1,02,000 (B:C ratio 4.34); ₹ 1,08,440 (B:C ratio 5.96) and ₹ 80,700.00 (B:C ratio 7.34) respectively per year.

Impact of Enhanced Water Availability

Strengthening of water resources under the project like Check Dam, Pucca Ring Wells and provision of electric pump resulted in ensuring life saving irrigation to the paddy in water deficit areas. A total of 8 numbers of farmers could irrigate their crop (10-12 irrigations) by using the water from Pucca Ring Wells covering an area of 6.3 acres and 11 farmers could irrigate their paddy (6-10 numbers of irrigation) using the water from the Check Dam constructed on Doranda river. The productivity of irrigated paddy var 'Tez' ranged between 4.8-6.4 t/ha, whereas productivity of unirrigated crop ranged from 1.0-1.5 t/ha. Apart from this, another 58 number of farmers covering an area of 32.8 acres could provide life saving irrigation to their crop by pumping the water stored in the check dam.

Due to the availability of 2.0 hp electric pumps, the farmers could increase their area under vegetable in the rice-fallow system by pumping of water from Swarnarekha river flowing adjacent to the village (Fig. 120). There was increase in area under different vegetables and thereby in income due mainly to access to irrigation water (Table 41).

Fig. 120. Irrigation water : a boon for increasing agricultural productivity

Table. 41. Impact of availability of irrigation source on vegetable cultivation

Before availability of pump for irrigation				After availability of pump for irrigation		
Name of the farmer	Crops cultivated	Area (Acre)	Income (₹)	Crops cultivated	Area (Acre)	Income (₹ in lakh)
Mr Robert Ekka	Cucumber, Tomato, Bottle Gourd, Chilli	0.5-0.6	40,000 -50,000/-	Cucumber, Tomato, Capsicum, Cauliflower, Cabbage, Bitter gourd, Brinjal, Chilli, Water melon, Onion, Garden peas, Radish	3.0	1.60
Mr Bablu Kacchhap	Brinjal, Tomato, Chilli, Cucumber Bottle gourd	0.4-0.5	40,000-50,000/-	Brinjal, Tomato, Chilli, Capsicum, Cauliflower, Cabbage, Cucumber, Bottle gourd, Onion	2.5	1.40
Mr Anil Kachhap	Cucumber, Cauliflower, Cabbage	0.35-0.4	25,000-30,000/-	Cucumber, Cauliflower, Cabbage, Tomato, Sponge gourd, French Bean, Okra, Water Melon, French bean	2.0	1.00
Mr Sohrai Kachhap	Cauliflower, Cabbage,	0.5	40,000-45,000/-	Cauliflower, Cabbage, Tomato, Sponge gourd, Brinjal, Radish, Wheat	1.5	1.00
Mr Komal Kachhap	Garden Pea, Brinjal, Chilli	0.5-0.6	45,000-50,000/-	Garden Pea, Brinjal, Chilli, Cucumber, Tomato, Cabbage, Cauliflower, Potato, Onion, Turnip, Radish	3.0	1.50
Mr Sumeet Kachhap	Cauliflower, Cabbage, Garden Pea	0.4-0.5	40,000-60,000/-	Cauliflower, Cabbage, Brinjal, Chilli, Garden pea, Tomato, Cucumber, Water melon, Bitter gourd, Wheat	3.0	1.50
Mr Govind Kachhap	Cucumber, Bottle gourd, tomato	0.4	35,000-40,000/-	Cucumber, Bottle gourd, Cauliflower, Cabbage, Garden pea, Potato, Radish, Wheat	2.0	1.40
Mr Sushil Lakra	Cucumber, Cabbage, Cauliflower	0.5	50,000/-	Cucumber, Tomato, Garden pea, Cauliflower, Cabbage, Bitter gourd, Okra, Capsicum, Chilli	3.0	1.50

Impact of Technology Demonstration on Improved Vegetable Production in Rice-fallow System

Technology demonstration on improved varieties of vegetables and plastic mulch was demonstrated in five farmers' fields. The income from vegetable cultivation ranged between ₹ 5600/- per 0.05 ha to ₹ 19280/- per 0.42 ha (Table 42). The yield of bottle gourd was markedly low due to heavy incidence of *Fusarium* wilt. Watermelon was found to be the most profitable crop due to its premium price in the market.

Impact of technology demonstration on multi-tier cropping system

Mr. Robert Ekka has planted fruit based multitier cropping system with mango as main crop and guava as filler crop in an area of 0.4 ha. During the first year, brinjal cv Swarna Pratibha was grown in an area of 0.75 acre as intercrop. During December, 2014 to July, 2015 the farmer could earn ₹ 76400/- from the brinjal crop. During August,

Fig. 121. Transforming barren land into productive asset through water availability

Table 42. Income from improved vegetable production practices in rice-fallow system

Name of the farmer	Total Area (ha)	Technology demonstrated	Period	Yield		Income (₹)
Smt Priti Kachhap	0.10	Off season cultivation of bottle gourd	January-April, 2015	cv Swarna Sneha	185 kg per 0.10 ha	3600
Sri Munna Kachhap	0.20	Improved variety of Bottle Gourd raised on portray and grown on plastic mulch	February-April 2015	cv Swarna Sneha	162 kg per 0.20 ha	3200
	0.12	Improved variety of cowpea on plastic mulch	July-October, 2015	cv Swarna Mukut	286 kg per 0.12 ha	3800
	0.10	Improved variety of Capsicum raised on portray and grown on plastic mulch	October-February, 2015	cv Swarna Atulya	312 kg per 0.10 ha	12280
					Total	19280
Smt Pratima Kachhap	0.10	Off season cultivation of bottle gourd	Dec 2014 - March 2015	cv Swarna Sneha	122 kg per 0.10 ha	1840
	0.05	Improved variety of cowpea grown on plastic mulch	February-May, 2015	cv Swarna Mukut	380 kg per 0.05 ha	4400
	0.10	Improved variety of Sponge Gourd raised on portray and grown on plastic mulch	July-October, 2015	cv Swarna Prabha	815 kg per 0.10 ha	8500
					Total	14740
Sri Sushil Kachhap	0.12	Improved variety of Water Melon raised on portray and grown on plastic mulch	February-May 2015	cv Kiran 2	625 kg per 0.12 ha	12300
	0.10	Off season cultivation of Bottle Gourd	Dec 2014-February, 2015	cv Swarna Sneha	75 kg per 0.10 ha	1120
	0.05	Improved variety of cowpea grown on plastic mulch	February to May, 2015	cv Swarna Mukut	560 kg per 0.10 ha	5500
					Total	18920
Mr Budhua Kachhap	0.05	Improved variety of Sponge Gourd + French bean grown on plastic mulch	July-September, 2015	Sponge Gourd cv Swarna Prabha	320 kg per 0.05 ha	3800
				French Bean cv Swarna Lata	125 kg per 0.05 ha	1800
					Total	5600

2015 to February, 2016, French bean was grown as intercrop from which an income of ₹ 65000/- was obtained. Due to the irrigation and fertilization of the intercrops, significant increase in the growth of the fruit trees has been observed. A total of 86 kg of guava was harvested during the second year of establishment.

Demonstration of Oyster Mushroom Production by Tribal Women Farmer

Production of oyster mushroom was demonstrated in households of 20 tribal women in Sagbehri village under Dumka block and 20 tribal women in Karela village under Jama block in Dumka district of Jharkhand (Fig. 122). In Sagbehri village, the total harvest of mushroom was 350.3 kg from 349 kg paddy straw with an average

Fig. 122. Oyster mushroom production in Karela village in Jama block

yield of 1.0 kg per kg of paddy straw. The total income of the group was ₹ 46575/- at sale price of ₹ 120-150/- per kg of mushroom. In Karela village, the total harvest of mushroom was 172.5 kg from 166 kg paddy straw with an average yield of 1.03 kg per kg of paddy straw. The total income of the group was ₹ 25875/- at sale price of ₹ 150/- per kg of mushroom.

Mera Gaon Mera Gaurav

Under MeraGaonMera Gaurav programme, ten teams, each comprising of 4-6 scientists, was formed to develop a group of selected villages in a radius of 50-100 km from Patna, Ranchi and Darbhanga as model villages. A total of 46 villages in Patna, Ranchi and Darbhanga district have been adopted and the technologies disseminated are depicted below (Table 43).

Table 43. Technologies demonstrated at village level

Technology	Numbers of villages
Integrate farming system	12
Improved animal husbandry practices	10
Resource conservation techniques	8
Composite fish culture	5
Integrated fish farming	5
Soil water management including green energy	5
Seed multiplication & climate change	10
Management of aquatic crops and its value addition	4
Off season nursery raising of vegetable seedling in portrays	10
Low poly tunnel cultivation of cucurbits for early cropping	10
Good agriculture practice for winter vegetable crops	10
Use of *trichoderma* for Soil borne disease management	5
Mushroom cultivation	10
Awareness programmes on pest management practices	10
Use of drip irrigation for increasing of water efficiency use	5
Soil fertility management	5
Seed treatment	5
Pest and disease management in vegetables	10

Training Programme on Ornamental Fish Culture and its Management

A five days training programme on ornamental fish culture and its management was conducted at ICAR-RCER, Patna from 8-12 March, 2015 (Fig. 123). The programme encompass various topics like scope, challenges, breeding, rearing, diseases and management of ornamental fishes. Twenty eight women trainees from Samastipur district of Bihar participated in the training programme. They were also made aware of the schemes and financial assistance made by the Government for smooth and successful fisheries activities.

Fig. 123. Women participation in training programme on ornamental fish culture

Workshop on Real Time Mango Pest Dynamics

The Annual Review-cum-Workshop on Real Time Mango Pest Surveillance" under NICRA project was organized at ICAR-Research Complex for Eastern Region, Ranchi on 13-14th September, 2015 (Fig. 124). In the programme, PI and Co-PIs from all the centres of of NICRA project on "Mango pest" (ICARRCER RC, Ranchi; IIHR, Bangalore; CISH, Lucknow; FRS, Sagareddy; AES, Paria; RFRS, Vengurla and NCIPM, New Delhi) participated in workshop.

Fig. 124. Participants interacting during review meeting

Meso-Level Animal Health Interventions and Evaluating Economic Losses from Animal Diseases

For meso-level health interventions several animal health camps cum diagnostic cum Gosthies were organized. The first-hand disease informations were collected from the villagers and impact of diseases on economics was assessed. Around 120 animals were given general health care, vaccination (FMD) and deworming in Darhaut village of Jehanabad district (Fig. 125). Few specific cases were treated which included mastitis, urinary tract infection, manage, conjunctivitis, ill-thrift and repeat breeding. Another camp was organized at Kurwa village of Jehanadbad district (Fig. 126). Around 150 cows and buffaloes were given general health care and reproductive health care. Vaccination and deworming was carried out in all animals. Specific cases of abortion, suspected brucellosis and mastitis and suspected IBR were also investigated. Distribution of folder on subclinical mastitis and advisory were provided to farmers and technology of CMT and herbal ointment was sensitized.

Fig. 125. Animal health camp at Darhaut village

Fig. 126. Animal health camp at Jatiput Purva

Serological Epidemiology of Major Viral Pathogen of Caprine in Bihar

All the four zones of Bihar was covered for screening of major viral pathogen. More than 500 vaccination was provided to all the goats where epidemiological study was conducted. Gaya and Jehanbad district showed 30.90 and 37.77% sero positivity of PPR, 16.66 and 15.5% for BT and 2.22% for CAE, respectively (Fig. 127).

Fig. 127. Vaccination programme in goat in Gaya district

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

Farmers-scientist interaction organized

Farmers-scientist interaction was organized in the selected villages i.e. Karai and Raunia on 17th Oct., 2015 and 19th Oct., 2015, respectively in which more than 100 farmers participated (Table 44).

Table 44. Training programme conducted by Regional Research Centre, Ranchi

Topic	Sponsored by	Duration	No. of Participants
Commercial cultivation of vegetable crop through drip irrigation system	NABARD, Ranchi	15-16 January, 2015	23
Commercial cultivation of vegetable crop through drip irrigation system	NABARD Ranchi	22-23 January, 2015	23
Seasonal /off-seasonal vegetable cultivation	SIRD, Ranchi	16-20 February, 2015	30
Seasonal /off-seasonal vegetable cultivation	ATMA, Deoghar	9-13 March, 2015	22
Seasonal /off-seasonal vegetable cultivation	ATMA, Purnia	17-21 March, 2015	19
Dendrobium, mushroom and protected cultivation of vegetable crop	NHM, Ranchi	25-27 March, 2015	22

Plant propagation and cultivation of papaya	DHO, Nalanda	06-09 May,2015	22
Mushroom spawn production and its management	JSPL, Patratu Ramgargh	11-15 May, 2015	23
Seasonal /off-seasonal vegetable cultivation	Reliance Foundation, Deoghar	04-06 November, 2015	25

Details of registration of varieties and material transfer agreement etc. is depicted below :

Table 45. Annual maintenance of registration of PPV & FRA registered varieties

Name of variety/ Crop	Registration Number	Certificate Number
Swarna Shree (Brinjal)	REG/2012/106	196 of 2014
Swarna Mani (Brinjal)	REG/2012/107	189 of 2014
Swarna Pratibha (Brinjal)	REG/2012/108	192 of 2014
Swarna Shymali (Brinjal)	REG/2012/109	188 of 2014

Table 46. Certificate of registration obtained under PPV & FRA

Name of variety/ Crop	Registration Number	Certificate Number
Swarna Shobha (Brinjal)	REG/2012/105	235 of 2015
Swarna Naveen (Tomato)	REG/2012/382	169 of 2015

Table 47. IC number registration from NBPGR

Crop	Released variety	IC Number	Date of registration
Amaranth	HAMTH-15 (Swarna Raktim)	IC616623	01-02-2016
Chilli	HC-50 (Swarna Praphulya)	IC616624	01-02-2016
	HC-25 (Swarna Tejawai)	IC616625	01-02-2016
Bitter gourd	HABG-30 (Swarna Yamini)	IC 616626	01-02-2016
Ridge gourd (Satputia)	HASS-1 (Swarna Sawani)	IC617193	01-03-2016
Faba bean	HAVFB-41 (Swarna Safal)	IC617240	08-03-2016

Table 48. Farmers variety Application filed

Farmer's name and Address	Date	Crop
Suphal Mahato & Group of Silli Village, Sidha bagan,Goradih village, Po: Goradih , Silli, Ranchi, Jharkhand	28-10-2015	Brinjal

Table 49. Material Transfer Agreement

Host institute/ Provider of the Material	Recipient of the Material & Address	Material/ Plant variety	Date
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	Dr. K. Mamocha Singh, College of Post Graduate Studies Central Agriculture University, Umiam, Meghalaya - 793103	Tomato varieties: Swarna Anmol, Swarna Kanchan, Swarna Ratan, Swarna Sampada (F1) Swarna Lalima; Brinjal variety: Swarna Shyamali	06/10/2015
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	Dr. S. S. Kushwah, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior, College of Horticulture, Mandsaur (MP) – 458001	Capsicum var. Swarna Atulya (Seed)	11/09/2015
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	Jai Prakash Singh Designation: Sr Scientist (Fruit Science) Organization/ Institute/ University Address: Division of F&HT, IARI, New Delhi	Mango cultivars Illaichi, Husn-e-Ara & Kesington	29.06.2015

Linkages

Besides having linkages with leading ICAR institutions, SAUs and State Govt. of various eastern states, the details of other linkages is depicted below:

International Collaborations

Research areas	Collaborating institutes
Conservation Agriculture	CIMMYT
Climate resilient cropping systems	CIMMYT
Improving water use for dry season agriculture	CIMMYT
Sustainable and resilient farming system intensification for EIGP	CIMMYT
Development of submergence tolerance rice varieties for flood plain and flood prone areas of eastern region	IRRI

Development of drought tolerance rice varieties for eastern region	IRRI
Restoration of degraded lands, water congested areas and carbon sequestration	World Agroforestry Centre
Developing suitable pulse varieties of lentil, grass pea and pigeonpeafor drought tolerance in eastern states	ICARDA
Small ruminants improvement and production system	ILRI

Other Collaborations

Research areas	Collaborating institutes/ Regional Centres
Integrated Farming System	IVRI RC, Kolkata; CSWCRTI, Koraput; IARI RS, Pusa (Bihar); CIFRI; CPRS RS, Patna and NBSS&LUP
Tribal Farming System	CSWCRTI, Koraput, Odisha, and NBSS&LUP
Quality brood management, fish seed, enclosure culture and wetland rehabilitation	CIFA; CIFRI; CRRI; NRC (Pig); AAU and CTCRI
Livestock & Avian Production System	IVRI; NRC (Pig); NDRI; AAU; UBKV; BAU (Bihar); BAU (Ranchi) and CARI
Seed production of agri-horti crops including production technology	DSR, Mau; IARI RS, Pusa; BISA (CIMMYT) Pusa; CRRI; BAU (Bihar & Ranchi); RAU, Pusa; IIVR; CTCRI; CHES; NRC, Litchi; CSISA; DMR; CPRS-RS, Patna & UBKV.

Education and Training of Staff Undertaken in India/ Abroad

Dr. Tarkeshwar Kumar attended the training programme on Competency Development for Human Resource Development at NAARM, Hyderabad during 10-12 February, 2016.

Awards

A team of scientists of the institute received award from President of India for original book writing on "Samekit Krishi Pranali ek Vrihad Drishtikon" under the Rajiv Gandhi National Award Scheme on Gyan Vigyan for the year 2013 on 14th September, 2015 at "Vigyan Bhawan, New Delhi (Fig. 128).

Fig. 128. Dr. Sanjeev Kumar, receiving the award from the President of India

18. *Krishi Vigyan Kendra*

KRISHI VIGYAN KENDRA, BUXAR

Extension of irrigation area through construction of retention wall-cum-drainage in adopted village Kukurah under NICRA

Two retention wall-cum-drainage structures were constructed in adopted village Kukurah to check the surface run off and canal water to the river Ganga (Fig. 129). It was able to ensure irrigation in 133 ha area and thereby benefitting 97 farmers. The farmers were able to save the cost of more than 800 litre of diesel (worth ₹ 41,600/-) which was otherwise required to lift underground water.

The productivity of paddy was recorded to be 4.46 and 4.18 t/ha of MTU 7029 & BPT 5204, respectively as compared to 3.0-3.5 t/ha before construction of the structures.

Cluster Demonstration on Oilseeds and Pulses under NMOOP

Cluster Demonstration on oilseeds and pulse crops was conducted during *rabi* 2015 (Fig. 130). All the demonstrations were conducted in cluster approach, emphasizing on rice-fallow areas. Farmers were advised to adopt good agronomic practices, balanced fertilization and follow IPM practices to reduce the cost of cultivation and also to get better economic returns. Farmers were also

Before construction

After construction of retention wall-cum-drainage
(Dimension: 15′ X 5′ X 1.25′)

Before construction

After construction

Fig. 129. Extension of irrigation area through construction of retention wall-cum-drainage

Fig. 130. Cluster demonstration of oilseeds and pulses under NMOOP in district Buxar

Fig. 131. Oilseeds and pulses demo cafeteria at KVK farm, Buxar under NMOOP

trained for seed production and primary processing. The details of crop, variety, area, beneficiaries and demo sites are given in Table 50. KVK has also developed the cafeteria of each crop at their farm to popularize the varieties of pulses and oilseed among the farmers of Buxar (Fig. 131).

Table 50. Details of demonstrations

Name of demonstration	Area (ha)	Beneficiaries (Nos.)	Place of demonstration
Improved Lentil Lentil Var. Pusa Masoor-5	30	95	Dhananjaypur, Pawani, Damgouli, Dalsagar, Badkagaon etc.
Chickpea Var. GNG 1581	34	139	Dhananjaypur, Bocsa, Damgauli, Geruabandh, Bishrampur, Bigna etc.
Improved field pea var. Prakash	25	104	Chunni, Padari, Manjhwari, Mhila, Darahpur etc.
Mustard (RGN 48)	20	69	Gosaipur, Pakri, Khakharhi, Milki, Khathrai etc.

Demonstration of standard beehive

Apiculture is a profitable intervention, particularly for small and marginal and even landless farmers. Keeping this fact in view, KVK, Buxar demonstrated 24 units (beehive) of standard Beehives along with Honeybee *Apis mellifera*. Demonstrations were made in Dharmagar, Rasen and Pandepatti villages in Buxar. The rural youth has made 127 units (beehive) from 24 units and earning about ₹ 1.25 to 1.50 lakh per annum.

Training programmes organized

Following trainings were conducted for rural youths and farmers :

Table 51. Training programmes for rural youths

Topic	Date	Total no. of beneficiaries
Mushroom production: A source of income generation	5-9 January, 2015	10
Production of technology of vermi compost	13-17 January, 2015	18
Production technology of cole crop	14-17 January, 2015	20
Seed production technology of lentil and chick pea	15-16 January, 2015	22
Seed production techniques of wheat and gram	16-20 February, 2015	15
Livestock production	26-28 March, 2015	18
Integrated Farming System	26- 30 October, 2015	20

Table 52. Training programmes for external functionaries

Topic	Total beneficiaries
IPM in vegetable & vegetable based cropping system	20
Seed Production of Paddy	20
Crop residue management for sustainable soil health	20
Microbial control and their Application in Plant Protection	20
Seed production techniques of Rabi cereal crops	20

Table 53. Vocational training programme

Topic	Total beneficiaries
Mushroom production: A source of Income generation	10

Table 54. On-campus training programmes for practicing farmers

Topic	Date	Total no. of beneficiaries
Mushroom production: A source of income generation	5-9 January, 2015	10
IPM in *Rabi* vegetable	12-15 February, 2015	20
IPM in summer vegetable (4 days)	3-6, November, 2015	22

Table 55. Off-campus training programmes for practicing farmers

Topic	Date	Total no. of beneficiaries
Resource Conservation technology for Wheat	3 January, 2015	20
Production technology of quality planting materials of vegetable crop	3 January, 2015	20
Quality seed production on Wheat	3 January, 2015	20
Mastitis in dairy cows	5-6 January, 2015	25
Seed production technology for rabi oil seed	5-6 January, 2015	22
Resource Conservation for pulses production	8-9 January, 2015	20
Control of parasitic diseases in dairy animals	8-9 January, 2015	23
Quality seed production of onion	13-14 January, 2015	22
Quality seed production for wheat	13-14 January, 2015	20
Hay making	13-14 January, 2015	23
Microbial pesticide and their use in plant protection	14-17 January, 2015	20
Production technology of cole crops	14-17 January, 2015	20
Production technology of berseem and oat	15 January, 2015	20
Production technology of berseem and oat	15 January, 2015	20
Silage making	16-17 January, 2015	22
Production technology of onion	16 -17 January, 2015	20
Quality seed production of wheat	19 January, 2015	20
Weed management in rabi season pulses	22 -23 January, 2015	20
Seed production technology of potato	22-23 January, 2015	20
Improved Management techniques for rice nursery production	28-29 August, 2015	20
Production techniques of Direct Seeded Rice	9 September, 2015	20
Water management in summer vegetable by (Mulch, FIRBS, MIS)	9 September, 2015	20
Integrated Crop Production technology for pigeon pea	9 September, 2015	20
Production technology of cole crops at Dalsagar	10-11 September, 2015	20
Pruning and training of guava orchard at Boxar	16-17 September, 2015	20
Nursery Management at Boxa	16 September, 2015	20
Crop residue management for sustainable soil health	18 September, 2015	32
Production technology of capsicum at Pawani	18 September, 2015	20
Seed production of Pigeon Pea at Pawani	18-19 September, 2015	25
Layout & Management of Orchard at Kusrupa	21-22 September, 2015	22
Layout & Management of Orchard at Pawani	21 September, 2015	20

Topic	Date	Total no. of beneficiaries
Control measures of storage insect & at Dhanajaypur	22 September, 2015	20
IPM in Rice Nursery at Kochadhi	23 September, 2015	20
Quality Seed production of Paddy at Kusurapa	23 September, 2015	20
Method & importance of Deep summer ploughing	23 September, 2015	22
Cultivation of Papaya & Banana	23 September, 2015	20
Layout & Management of Orchards	24-25 September, 2015	20
INM in rice	29 September, 2015	23
Management of disease and insect pest by cultural practices at Boxa	29 September, 2015	20
Seed production of Bajara at Dalsagar	29 September, 2015	23
Integrated crop management for sustainable rice production	29-30 September, 2015	20
Seed Production technique of Maize at JaishreeRam	30 September, 2015	26
Management of disease and insect through soil solarisation	12 October, 2015	20
Method of bunding and its importance	13 October, 2015	26
Seed production technology of Okra	26-27 October, 2015	21
Role of Conservation Agriculture Technologies in Rice – Wheat system	16 November, 2015	100
Crop production techniques of Perl millets & Sorghum	2-3 November, 2015	20
Rain water harvesting method and their role in life saving irrigation	10-12 November, 2015	25
Integrated crop management on pigeon pea	2 December, 2015	20
Management of young orchard	14 December, 2015	20
Rejuvenation of oild citus plant	16-17 December, 2015	20
Application of bio fertilizer in cereal and pulses.	22 December, 2015	22
Protection and management of Turmeric	29 December, 2015	20

Table 56. Front line demonstrations

Topic	Area (ha)	Total no. of beneficiaries	Place
Demonstration of improved varieties of Green Gram var. HUM-12 & SML 668 sponsored by Dist Agril. Deptt Buxar	54.0	152	Pawani, Lalganj, Dafadihari, Bijhora,Barri, Kukurha, Geruabandh etc
Demonstration of improved var. of Okra crop sponsored by District Agril Deptt Buxar	18.5	78	Barri, Bocsa, Dalsagar, Kwariya, Hukha, Uttampur, Nayabhojpur, Jigna, Koirpurwa
Demonstration of Kuroiler (nos.)	500	34	Hukha,Lalganj, Chousa
Demonstration of semi scented and fine Rice var Rjendra Sweta in district Buxar	20 ha	53	Rahathua, Kukurha, Lalganj, Pawani
Demonstration of Rhizobium Culture on yield of Lentil	4.15	24	Pawni, Surandha, Majhariya and Mukunddera
Demonstration of Mustard Var. HD2851	0.20	02	Kukurha
Demonstration of micronutrient on summer vegetable Cowpea. Var Kashi Kanchan (Sponsored by ATMA, Buxar	4.50	33	Kesth, Naya Bhojpur, Govind pur, Dullapur
Demonstration of Pigeon pea Var IPA 203	2.5	10	Balwa, Chhotka Dhakaich
Demonstration of Pigionpea Var Narendra Arhar -2	2.5	10	Raghunathpur, Baijnathpur, Sondhila
FLD on Hybrid Bajara JKBH 676	6.0	37	Pawani, Chunni, Kukurha
Demonstration of Oat	2.0	22	Kukurha
Demonstration of wheat (var. HD 2967)	5.0	20	Mahadah, Sohanipatti, ikati, Koirderwa, Gosaipur
Role of Rhizobium culture on yield of Chickpea. Var. JAKI 9218	3.0	13	Dhansoi, Rampur dera, Mahda, Kathrai
Demonstration of Oyster mushroom on crop residues of wheat and paddy straw.	20 kg spawn	09	Buxar, Kamarpur, Nenuadh, Harpur, Dulahpur & Kukurha

Demonstration of European Honey bee Apis mellifera with super and brood chamber among rural youth to develop entrepreneurship and generating self-employment.	24 Unit	05	Dharmagar, Pandepatti, Rasen,

Table 57. On-farm trials

Topic	Area (ha)	Total no. of beneficiaries	Place
Effect of chemical weed management on growth and yield of Direct Seeded Rice	1.0	10	Mahdah, Jagdishpur, Bocsa
Effect of micro nutrients zinc on Rice- Wheat cropping System	1.0	10	Kukurha, Surondha
Assessment of chemical fungicides for the management of False Smut Ustilaginoideavirens in Rice	01	04	Jagdishpur, Bishrampur
Assessment of new strain of Trichoderma against wilt disease in lentil	1.0	04	Pawani, Badkagaon
Effect of chemical weed management practices on growth and yield of zero till sown wheat	1.0	08	Mahdah, Jagdishpur, Bocsa
Effect of Nutrient management practice on yield attributing character and yield of lentil	01	12	Pawani, Kukurha
Effect of Nutrient Management practices on yield and yield attributes characteristics of lentil	1.0	10	Bharchakia, jagdishpur, Pawni and Turk Purawa
Effect of nutrient management (through nutrient expert) on yield of wheat.	01	10	Kukurha, Mahdah
Assessment of suitable wheat cultivar in late sown condition in Buxar district.	0.6	8	Pawani, Chousa, Kulhariya
Optimization of seed rate and nitrogen scheduling in dry Direct Seeded Rice	1.0	5	Bocsa, Jagdishpur, Hukha, Pawani
Optimization of potassium (K) supply in transplanted Rice through different K management practices	1.0	5	Bocsa, Jagdishpur, Hukha, Pawani

Table 58. Station Trials

Topic	Area	No. of Replication	Place
Optimization of seed rate and nitrogen scheduling in dry Direct Seeded Rice	1.0	5	KVK farm
Optimization of potassium (K) supply in transplanted Rice through different K management practices	1.0	5	KVK farm
Participatory Varietal Selection (PVS) trial (DSR & Transplanted)	0.5	3	KVK farm
Harvest plus Multi environmental Trial	0.25	3	KVK farm

Seed Production Chain

KVK is also producing foundation, certified and truthfully labelled seeds of various crop varieties as depicted in Table 59.

Table 59. Seed production (tonnes) programme

Crop	Variety	Quantity
Paddy (Foundation seed)	Rajendra Shweta	6.0
	Rajendra Kasturi	2.0
	MTU 7029	15.0
	BPT 5204	8.0
Wheat (Foundation seed)	HD 2967	3.0
Chickpea (Certified seed)	Pusa 256	1.3
Mustard (Truthfully labelled)	Pusa Mustard 28	0.2

Kisan Gosthi

One day Kisan Goshthi was organized by KVK, Buxar on 2nd September, 2015. Hon'ble Member of Parliament, Shri Ashwini Kumar Choubey inaugurated the programme (Fig. 132). Five hundred farmers, Block Agriculture Officer, Agriculture Coordinators, Kisan Salahkar and other line department officers participated in the programme. Hon'ble MP addressed the issue of increasing population, decreasing land availability and the challenges to feed the large population in the current scenario of climate change. He also suggested that the challenges can be tackled with the inclusion of new technologies, quality inputs, judicious and needful use of pesticides etc. Inclusion of income generating activities, vocational training to generate self-employment among rural youths through the KVK is equally important.

Fig. 132. Hon'ble MP, Shri Ashwini Kumar Choubey inaugurated the kisan goshti

World Soil Health Day-cum-*Rabi* Kisan Gosthi

World Soil Health Day-cum-*Rabi* Kisan Gosthi was organized on 5th December, 2015 at KVK, Buxar (Fig. 133). Shri Ashwani Kumar Choubey, Hon'ble Member of Parliament of Buxar constituency was the chief Guest on this occasion. Altogether, 250 Soil health cards were distributed to the practicing farmers of the district in continuation of nationwide soil health card distribution programme. A total of 300 progressive farmers of the district participated and interacted with Subject matter specialist as to how to keep their soil, animal and crop healthy and more profitable with climate resilient agriculture.

Fig. 133. Distribution of soil health card to the progressive farmers by chief guest

Kharif Kisan Gosthi

A kisan gosthi was organized on 2nd September, 2015 at KVK, Buxar. Sri Ashwani Kumar Chaubey, Hon'ble Member of Parliament of Buxar Constituency was the chief guest of the function. Subject Matter Specialists of KVK, Buxar interacted with more than 400 farmer participants on *kharif* crop as well as contingent crop. The farmers were benefited by enhancing their knowledge about gradual climate change and their effect on outbreak of diseases and insect pests in *kharif* season. 10 Progressive farmers were felicitated in the function by the Hon'ble MP (Fig. 134).

Fig. 134. Chief guest interacting with women farmers of Buxar

Krishak Chaupal

Three kisan chaupal were organized in district Buxar to combat the seasonal best management practices of *kharif* and *rabi* crops at village level

Fig. 135. Krishi chaupal at Buxar

along with the MP of district Buxar. SMSs of KVK, Buxar interacted with more than 100 progressive farmers on various crop management practices.

KVK Farm visit by school children under "ARYA"

Under an ambitious programme of ICAR "ARYA", KVK, Buxar arranged a visit of school students of intermediate levels at its farm to popularize the agricultural technology and its impact on Indian economy, where 65% of population are dependent on agriculture. The SMSs interacted with the students and laid emphasis on Attraction of Rural Youth in Agricultural Research Services and employment in the agricultural and allied sector.

Fig. 136. Students interacting with SMS of KVK, Buxar

Animal Health camp

KVK, Buxar organized an animal health camp at adopted village Kukurah under NICRA Project in coordination with department of Animal Husbandry, Buxar (Fig. 137). Health of 150 animals was checked and complementary medicine, vaccine, deworming tablet/bolus were recommended to the animals in supervision of Touring Veterinary officer, Buxar. Altogether, 52 farmers benefited from the animal health camp.

Fig. 137. Animal health camp organized at Kukurah village, Buxar

Participation of KVK in Sansad Adarsh Gram (Baluan) Yojana

The scientsts of KVK, buxar visited Baluwan village adopted by the Hon'ble MP, Rajya Sabha Sri Vashisht Narayan Singh. The KVK made an effort towards creating an awareness on replacement of old varieties of various crops by improved one and seed treatment in pulses for better return through imparting a training programme (Fig. 138). Frontline demonstrations of okra (5 ha), sponge gourd (10 ha) and bottle gourd (7 ha) was carried out covering 40 beneficiaries.

Fig. 138. SMSs of KVK with farmers in Sansad Adarsh Gram Yojana at Baluan (Buxar)

Krishi Vigyna Kendra, Ramgarh

KVK Ramgarh was established on 27th August 2014. Its activities were started with the existing staff of the Regional Centre, Ranchi. However, some of the SMS joined the KVK during August-September, 2015. The brief activities taken up thereafter are depicted below :

Trainings

The KVK, Ramgarh organized 10 on-campus and 17 off-campus trainings on various aspects of crop production and management *viz*. mulching in vegetable cultivation, disease management, pulse production, sugarcane production, agroforestry, mushroom production, soil sampling, etc. in which more than 800 farmers were trained. Besides, cluster demonstrations were also organized in chickpea on 72 farmers' fields in Sarla Kala, Nimi, Talatand, Hafua and Kovad villages covering an area of 20 ha.

Table 60. On-campus trainings organized

Topics	No. of courses	No of beneficiaries
Early cucurbitaceous vegetable cultivation by mulching and poly tunnel method	5	131
Cultivation technology (Lay out, plantation method) for horticulture crops	3	67
Disease management of Cucurbits in rabi season	2	48

Table 61. Off-campus training organized

Topics	No. of training	No of beneficiaries
Importance of SHG and clusters for farm woman	2	65
Pulse production technology under rainfed area	5	167
Pest and disease management of kharif season crops	4	148
Importance of agroforestry intervention	2	57
Package and practices of sugarcane cultivation	2	63
Disease and pest management of Sugarcane crops	2	49

Table. 62. Trainings organized for extention functioneries

Topics	Total
Mushroom production technology: An opportunity of employment for youth	35
Soil sampling and its importance	65

Table 63. Cluster demonstration

Crop	Area in ha	No of farmers	Village
Chickpea	20	72	Sarla kala, Nimi, Talatand, Hafua, Kovad

World Soil Day Celebration

Soil health cards were distributed during the occasion to 275 beneficiaries of Sarla, Kala, Murudeah, Aura villages by Hon'ble Union Minister for Agriculture and Farmers' Welfare, Govt. of India (Fig. 139)

Fig. 139. Soil health card distribution by the chief guest during world soil day celebration

Scientific Advisory Committee Meeting

The 1st Scientific Advisory Committee Meeting of KVK, Ramgarh was held on 11th January, 2016 at KVK, Ramgarh under the Chairmanship of Director, ICAR Research Complex for Eastern Region, Patna. The meeting was also attended by Director, IINRG, Namkum, Dr Shivendra Kumar, Former Head, ICAR RCER, RC, Ranchi, Dr A. K. Singh, Head, ICAR RCER, RC, Ranchi, Dr S.K. Roy, Principal Scientist, ICAR-ATARI, Kolkata, Dr R.K. Singh, Head, KVK, Hazaribagh, scientists from ICAR RCER, Research Centre, Ranchi, Central Rainfed Upland Rice Research Station, Hazaribagh, Central Tasar Research and Training Institute, Nagri, SMS from KVK, Ramgarh and KVK, Buxar, Officials from Department of Agriculture, Govt. of Jharkhand, Prasar Bharati, Govt. of India, NABARD, representatives from NGOs and progressive farmers.

Fig. 140. Scientific advisory committee meeting at KVK, Ramgarh

19. *Major Events*

Interface Meeting for Contingency Planning of *Kharif*, 2015 in Jharkhand

The Interface meeting on "Enhancing the preparedness of agricultural contingencies in kharif 2015 for Jharkhand" was jointly organized by ICAR RCER, Patna, ICAR-CRIDA, Hyderabad, and Department of Agriculture, Government of Jharkhand on 22nd June, 2015 at Ranchi under the chairmanship of Dr. Nitin Madan Kulkarni, Secretary, Department of Agriculture, Govt. of Jharkhand (Fig. 141). The Chairman stressed upon the need for crop diversification towards drought tolerant crops *viz.*, millets, pulses, oilseeds, maize, etc. and called upon the KVKs and ZRS to intensify seed multiplication programme of these drought tolerant crops.

During the deliberations, the benefits of technologies like community nursery, rainwater harvesting in plastic lined Dobha, increasing the height of field bund, farm implements like chisel plough and mould board plough, mulching with polythene sheet, etc for minimizing the impact of deficit rainfall or delayed monsoon were discussed in detail. Suggestion was made for constituting a task force comprising representatives from ICAR institutes in Jharkhand, Department of Agriculture, Govt. of Jharkhand under the Chairmanship of Secretary, Agriculture, Govt. of Jharkhand to apprise the policy makers regarding the status of monsoon, area coverage in different districts at fortnightly interval.

Fig. 141. Interface meeting for contingency planning of ***kharif*** 2015 at Ranchi

87th ICAR Foundation Day and 9th KVK National Conference

The ICAR 87th Foundation Day Award Ceremony and 9th National KVK Conference was organized by the ICAR-RCER, Patna. The programme was inaugurated by Hon'ble Prime Minister Shri Narendra Modi on 25th July, 2015 at Patna (Fig. 142). He called upon agricultural scientists and planners to work towards bringing about Second Green Revolution with new vision, dimensions and objectives to address the agricultural challenges in this modern era. He reiterated that second green revolution will begin from the land of eastern India which has immense potential in terms of natural resources and willing farmers to take up experiments in fields. Emphasizing on the lab-to-land initiative, he urged agricultural scientists to make farmers their fellow travellers in development and refinement of farm technolo-

Fig. 142. ICAR 87th Foundation Day Award Ceremony and 9th National KVK Conference held at Patna.

gies. Adoption of villages by teams of scientists can bring significant changes in the life of farmers by enhancing productivity. Prime Minister also suggested developing linkages with architecture experts in designing of agricultural infrastructure like canals, storage structures and other facilities so that benefits of new advances can reach to the farmers. He also suggested refining and revalidating traditional knowledge abundantly available in villages particularly with regard to value addition of agricultural products. He urged agricultural scientists to blend their knowledge with potential of farmers to enhance farm productivity per hectare. Prime Minister launched ICAR schemes Farmer First, ARYA, Student Ready and Mera Gaon Mera Gaurav and conferred awards to outstanding SAUs/ICAR institutions (Fig. 143).

Fig. 143. Outsanding university award conferred on Vice-Chancellor, AAU Jorhat, Dr. K.M. Bujarbaruah

On 26th July 2015, Shri Radha Mohan Singh, Union Minister of Agriculture inaugurated the National Conference of KVKs as the Chief Guest (Fig. 144). He highlighted the basic aims of initiating four schemes namely, Farmer First; Attracting and Retaining Youth in Agriculture (ARYA); Mera Gaon Mera Gaurav and Student Ready and asked for timely implementation of these schemes to enhance lab to land process. He also conferred eight awards on the best performing KVKs which include national and zonal awards.

Fig. 144. Address by Hon'ble Union Minister of Agriculture and Farmers' Welfare to the delegates in National Conference of KVKs

Inauguration of Administrative-cum-Laboratory Building of KVK, Buxar

Inaugural function of administrative-cum-laboratory buildings of KVK, Buxar was held on 19th August, 2015 in the Town hall, Buxar, Bihar. Sri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, GOI, was the Chief Guest of the programme (Fig. 145). Other dignitaries like Dr. A.K. Singh, DDG (Ext.), ICAR; Prof (Smt) Dr. Sukhada Pandey, Hon'ble MLA Buxar, Dr. A. K. Singh, Director, ATARI, Kolkata and Dr. B.P. Bhatt, Director ICAR-RCER, Patna were also present in the inaugural function. The Chief Guest said that the KVK will cater the needs of the farmers in production of high value crops. Farmers' can also take benefits of residential training, soil testing laboratory, mushroom spawn, etc.

Fig. 145. Inauguration of adminstration-cum-laboratory building of KVK, Buxar

About 1500 farmers participated in the programme. Ten farmers were felicitated for their contribution to IFS, conservation agriculture, fisheries, dairying, mushroom production, bee keeping, fruit processing and preservation, and vermicomposting. Chief guest of the function also felicitated some of the progressive farmers during the funtion (Fig. 146).

Fig. 146. Felicitation of progressive farmers by Hon'ble Union Minister of Agriculture and Farmers' Welfare

Foundation Stone of NRC on Integrated Farming Laid-down

The foundation stone of NRC on IF was laid down by Shri Radha Mohan Singh, Union Agriculture and Farmers Welfare Minister, GOI, on 21st Aug., 2015 at Pipra Kothi, East Champaran, Bihar (Fig. 147). The mandate of the Institute is to conduct research on the development of location specific integrated farming system models for diverse agro-ecological conditions, especially flood and wetland situation with emphasis on rice, sugarcane and banana which require more water. Progressive farmers and entrepreneurs from the region including seven women farmers who excelled in cultivation of mushroom, banana cultivation and rice production were felicitated during the programme.

Fig. 147. Foundation stone laying ceremony of NRC on IF

Stakeholders Meeting of NRC on Integrated Farming System

To finalize the mandates and objectives of newly developed NRC on Integrated farming, one day stakeholders meeting was held on on 17th Sept., 2015 at ICAR-RCER, Patna under the Chairmanship of Shri Vijoy Prakash, Agricultural Production Commissioner, Govt. of Bihar (Fig. 148). Directors and scientists of different ICAR institutes, SAUs, and KVKs of eastern region participated in the meeting. Since one ICAR institute on farming system research (IIFSR) already exist at Modipuram, it was emphasized that the newly developed institute should work on the lowland and wet land ecology in order to avoid duplicacy of research.

Fig. 148. Stakholder meeting of NRC-IF

हिंदी चेतना माह एवं राजभाषा वार्षिक प्रतिवेदन

राजभाषा हिंदी के प्रागामी प्रयोग से सम्बंधित चारों तिमाही की तिमाही प्रतिवेदन, समय पर निदेशक एवं सदस्य सचिव, राजभाषा कार्यान्वयन समिति, कृषि भवन, नई दिल्ली को प्रेषित की गयी। 14 सितम्बर से 13 अक्टूबर 2015 के दौरान "हिंदी चेतना मास–2015" का सफल आयोजन किया गया, जिसमें विभिन्न वर्गों के कर्मचारियों के लिए कुल 17 प्रतियोगिताओ एवं कार्यक्रमों आयोजन किया गया। इस दौरान विभिन्न विद्यालय के बच्चो के लिए निबंध, वाद विवाद एवं स्वरचित कविता पाठ जैसी लोकप्रिय प्रतियोगिताओं का भी आयोजन किया गया। इसके अतिरिक्त अनुसंधान केन्द्र रांची में भी हिंदी कार्यशाला का आयोजन किया गया। जिसमें 'वैज्ञानिक कार्यालयों में हिंदी का प्रतिगामी प्रयोग' एवं 'पत्रकारिता में हिंदी का प्रयोग' विषयों पर व्याख्यान आयोजित किए गए (चित्र 149)।

चित्र 149. मुख्यालय, पटना (ऊपर) एवं रांची केन्द्र (नीचे) में हिन्दी चेतना मास का आयोजन

Winter School on Water Productivity

A winter school on "Recent Advances in Enhancing Water Productivity in Hill and Plateau Region" was organised at the Ranchi Centre of the institute from September 25 - October 15, 2015. The major emphasis of the school was on increasing productivity of water resources to achieve more value and benefits from each drop of water used for crops, fish, forests and livestock, while maintaining or improving ecosystems. The winter school was structured to impart the knowledge on approaches to improve food security and livelihood improvement in the context of precise water use. Various aspects like basic concepts, methodologies, constraints and examples on improving water productivity drawn across various sub-domains of agriculture practised in the eastern plateau and hill region were covered during the course of the winter school. Twenty three participants from different agricultural universities (Anand, Bihar, Ranchi, Tamil Nadu), KVKs (Barh, Palamu, West Singhbhum, Darbhanga, Vaishali, Lohardaga), Zonal Research Stations (Darisai, Palamu) and ICAR institutes (IIAB, ICAR-NEH) participated in the winter school (Fig. 150).

Fig. 150. Participants of Winter School at RC, Ranchi

Workshop for Identifying the Production and Technological Gaps in Middle IGP Region

One-day workshop for identifying the production and technological gaps in middle IGP region was organized under the Chairmanship of Dr. J. S. Sandhu, DDG (Crop Science) on 7th Oct., 2015 at the ICAR RCER, Patna (Fig. 151). The meeting was attended by more than 100 participants from various ICAR institutes, SAUs, KVKs, NGOs, policy makers and farmers of the region. At the outset Dr.

Fig. 151. Interaction during identifying of technological gaps in middle IGP

B.P. Bhatt, Director, ICAR-RCER, Patna welcomed the participants of the Workshop. The Chairman Dr. J.S. Sandhu briefed participants the very purpose of organizing this workshop. He urged the participants to flag the technological, educational, marketing and policy gaps of the region so that a road map could be prepared to bridge these identified gaps. Farmers of different districts of middle IGP raised a number of problems related to production, processing, marketing and value addition of their produce (foodgrains, vegetables, milk, poultry, fish, animals, mushroom, etc).

Soil Health Card Distribution Ceremony

Soil health cards were distributed during the World Soil Day on 5th Dec. 2015 by the institute at its main campus, Patna as well as at regional centre, located in Ranchi. In this programme, large number of farmers participated from nearby villages. Shri Ram Kripal Yadav, Hon'ble Minister of Drinking Water and Sanitation, GOI graced the occasion as Chief Guest. Shri Sanjeev Chourasia, MLA, Digha attended the function as Guest of Honour (Fig. 152).

Fig. 152. Soil health card distribution to the beneficeries by the Chief Guest

The Chief Guest suggested farmers to apply fertilizers only after soil testing and according to the need of the crop. By doing so, it not only improves yield, but also the condition of the soil. During this programme soil health card was distributed to 250 farmers.

Livelihood Improvement of Rural Youth through Livestock and Poultry based Intervention

An ICAR sponsored short course on "Livelihood improvement of rural youth through livestock and poultry based interventions" was organized at ICAR Research Complex for Eastern Region, Patna during December 15-24, 2015. The Short course comprised 22 participants from 5 states covering 18 institutes including SAUs, KVKs and ICAR institutes. A total of 31 theory classes, 3 practical sessions and 01 field visit were organized during the course. The faculty consisted of 20 scientists from six divisions of ICAR RCER, Patna and six guest speakers.

'Jai Kishan—Jai Vigyan' Day 2015

ICAR Research Complex for Eastern Region, Patna celebrated 'Jai Kisan Jai Vigyan' Day on 25th of December, 2015 at Motihari, Bihar (Fig. 153), in the form of Scientist-Farmers Interaction-cum-Exhibition on the birth anniversary of former Prime Ministers Shri Atal Bihari Vajpayee and Late Shri Chaudhary Charan Singh, keeping in view their immense contribution for promoting use of science for the welfare of farmers. In his inaugural speech, Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture & Farmers' Welfare urged the farmers to adopt new technologies developed by the scientists for increasing agricultural productivity as a whole and nutritional security in particular. He also narrated different farmers friendly schemes launched by the Central Govt. and assured the farmers to launch New Crop Insurance Policy next year. He also urged the farmers to adopt integrated farming system technologies for increasing productivity. Hon'ble Minister stressed the need to develop climate resilient agricultural technologies. During the event, one bulletin and one leaflet published by ICAR-RCER were released by the Hon'ble Minister. The Minister conferred awards on seven farmers for their excellence in agriculture. Several local MLAs also graced the occasion. A farmers-

Fig. 153. Hon'ble Union Minister of Agriculture and Farmers' Welfare addressing to August gathering during the function

scientist interaction was also organized during the occasion to apprise the farmers regarding newer technologies developed by the ICAR, KVKs and SAUs. An exhibition was also organised to showcase and demonstratee the new technological advances for enhancing productivity and profitability of agriculture where different ICAR institutes, KVKs, NGOs, SAUs, National Seed Corporation, National Horticulture Board, IFFCO participated (Fig. 154). During the event more than six thousand farmers and entrepreneurs participated.

Fig. 154. Address by Hon'ble Union Minister of Agriculture and Farmers' interacting with the participants during the exhibition

The Hon'ble Agriculture Minister also inaugurated Motijheel Cleaning Programme under Swachh Bharat Mission of Govt. of India. Directorate of Weed Research, Jabalpur demonstrated their technologies to eradicate aquatic-weeds. Earlier, Dr. B.P. Bhatt, Director, ICAR Research Complex for Eastern Region welcomed the Hon'ble Union Minister of Agriculture & Farmers' Welfare, dignitaries and farmers.

Institute Foundation Day

Institute celebrated its 16th Foundation Day on February 22, 2016. Honb'le Union Minister of Agriculture and Farmer Welfare, Shri Radha Mohan Singh graced the occasion as the Chief Guest. Local MLA from Dihga Constituency, Sri Sanjeev Chaurasia was the Guest of Honor.

On this occasion, the Chief Guest also inaugurated the Farmers' Hostel of the Institute. In his address, the chief guest informed that the government had taken up massive drive to improve soil fertility and irrigation facilities in order to increase productivity of crops. The chief guest honoured 10 progressive farmers from the states of Assam, Bihar, Chhattisgarh, Jharkhand, West Bengal, Odisha and Eastern UP, besides giving best worker awards to 08 staff of ICAR RCER, Patna and press and media personnel. A book entitled *"Dutiya Harit Kranti Ki Oar Rashtra Ke Badhte Kadam"* compiled by Dr B. P. Bhatt, Director of the institute was also released by the Chief Guest and other dignitaries (Fig. 155).

Fig. 155. 16th Foundation Day ceremony of the Institute

The function was presided by Dr. A. K. Sikka, DDG (NRM), ICAR. He appreciated the institute for its remarkable work in the field of Integrated Farming System, Resource Conservation technologies and Wet Land Rehabilitation. Dr Sikka also falicitated 60 progressive farmers of eastern states who had excelled in the field of crops, livestock, horticulture and allied agricultural fields.

Earlier, Dr. B.P Bhatt, Director, ICAR RCER, Patna, welcomed the dignitaries and participating farmers of eastern region and narrated the progress made by the institute during last one year at research and development front.

Pashu Mela-cum-Kisan Vartalap held at Kotwa (East Champaran)

Pashu Mela-cum-Kisan Vartalap was held at Kotwa High School ground in East Champaran district of Bihar on March, 29-30, 2016 organised by ICAR Research Complex for Eastern Region, Patna in collaboration with Indian Veterinary Research Institute, Bareilly and Krishi Vigyan Kendra, Piprakothi (Motihari).

Fig. 156. Hon'ble Union Minister of Agriculture and Farmers' Welfare addressing to the gathering at Kotwa, East Champaran

Honb'le Union Minister of Agriculture and Farmers Welfare, Shri Radha Mohan Singh graced the occasion as Chief Guest. He emphasized that livestock is an important income generating enterprise in Indian agricultural economy and plays a multifaceted role in providing livelihood support of even landless farmers. He advised the farmers to adopt diversified farming in the sense that farmers need to think enterprises beyond dairy production. Fisheries, poultry, piggery and goat farming sectors provide good alternative options in social and economic development. Value addition of products can significantly improve the income and employment opportunities. He also emphasized the importance of indigenous breeds of cattle, buffalo, sheep and goat and their superiority over exotic breeds in climate change scenarios.

At its peak of the event, Yuvraj, the Champion Murrah bull, who had won several awards in many competitions at national level, also participated in the animal fair (Fig. 157). The bull had arrived from Kurukshetra, Haryana and was one of the major attractions in the event. Farmers were made to understand the value of bull in dairy production.

An animal health camp was also organized in which more than 500 livestock including cattle, buffalo, goat and horse were vaccinated and treated, and farmers were provided with advisory services on up-keeping of general health status of farm animals. An animal show was also organized. During the event, best animals were awarded.

Fig. 157. Hon'ble Union Minister of Agriculture and Farmers' Welfare interacting with owner of 'Yuvraj — the champion murrah bull' during the function

On 2nd day, Dr Sanjay Jaiswal, Hon'ble M.P., Betiah, graced the occasion as Chief Guest in concluding session of the event. Dr Jaiswal stressed on the role of animal in multifaceted functions of the farmers from food and nutrition to organic fertilizer, compost and natural gas production. He also urged the farmers to improve soil fertility by animal farming.

Altogether, 20 nos. of exhibition stalls related to animal health, production were displayed by, ICAR-NDRI, Karnal, IVRI –Eastern Regional Centre, Kolkata, ICAR-RCER, Patna, ICAR-CIRG, Makhdoom, ICAR-CIRB, Hisar, RAU, Pusa, 12 pharmaceuticals and feed manufacturing companies and NGOs.

Swachha Bharat Mission

Under the Swachha Bharat Mission Programme, the institute also organised the cleanliness drive programme in 2015. In this programme, all the staff of the institute actively participated in cleaning of the institute premises.

Research Management Programme

Research Advisory Committee (RAC) Meeting

XIIIth RAC meeting was held under the Chairmanship of Dr. D.P. Singh on 16-17th June, 2015 at ICAR-RCER, Patna (Fig. 158). Recommendations of the RAC are given below:

- Quantification of contribution of different components of integrated farming system models including makhana based IFS model.
- Impact of direct seeded & puddle rice in terms of yield, soil health, weed management, economics etc.

Fig. 158. Chairman, RAC interacting with scientists

- Design and evaluation of solar energy based pressurized irrigation system for improving water & energy use efficiency.
- Identification, collection and characterization of promising species of leafy vegetables.
- Weed management for aquatic crops like makhana and water chestnut.

Institute Research Council (IRC) Meeting

The Institute Research Council meeting was held under the chairmanship of Director, ICAR-RCER, during 09-10th July 2015 to review the ongoing projects and to discuss and approve new projects (Fig. 159). He emphasized that the scientists have to work for the livelihood upliftment and nutritional security of the small and marginal farmers by crop diversification including nutri-cereal crops like sorghum, pearl millet, maize, small/ minor millets and pulses in cropping system.

Fig. 159. Chairman, IRC interacting with scientists

20. *Seminar & Symposia*

Participation in Conference/Seminar/ Workshops/Symposia/Meetings

Chandran, P.C. Review meeting workshop for the project on "Network Project on Animal Genetic Resources – Characterization of Purnea Cattle" at ICAR-NBAGR, Karnal on 21st August, 2015.

Chandran, P.C. Review meeting workshop on the development in the "Network Project on Buffalo Improvement" at ICAR-CIRB, Hisar on 23 & 24 September, 2015.

Choudhary, A.K. National Conference on "Global research initiatives for sustainable agriculture and allies sciences (GRISAAS-2015)" organized at Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (Madhya Pradesh) during 12-13 December, 2015.

Das, Bikash and Mali, Santosh. Annual Review Workshop of NICRA project held at CMFRI, Kochi during 13-14th August, 2015.

Das, Bikash; Gutam Sridhar; Maurya, S.; Mali, Santosh and Chaudhary, J.S. "Annual Review-cum-Workshop on Real Time Mango Pest Surveillance" under NICRA project organized at ICAR-Research Complex for Eastern Region, Ranchi from 13-14th September, 2015.

Dayal, S. National Symposium on Policy Planning for Livelihood Security through Domestic Animal Biodiversity held at SKUAST-Jammu from 11-12 February, 2016. and presented paper(s) on Identification and characterization of Single Nucleotide Polymorphism of growth hormone gene in Black Bengal goat and Effect of growth hormone gene polymorphism on birth weight in local goat of Bihar.

Dhakar, Mahesh Kumar. 2nd Group Discussion Meeting of AICRP on Fruits held at MPUAT, Udaipur during 26th February to 1st March, 2015.

Dwivedi, S.K. 3rd International Plant Physiology Congress at JNU, New Delhi during 11-14 December, 2015 and presented paper on Comparative performance of wheat genotypes adjusting by sowing windows and moisture regimes in eastern Indo-gangetic plains.

Dwivedi, S.K. Short course on "Advanced technique for bio-remediation and management of salt affected soils" organized by CSSRI, RRS, Lucknow (U.P.) from 15-24 September, 2015.

Gupta, J.J. and Dey, A. XXIII International Grassland Congress of held at New Delhi from 20-24 November, 2015 and presented paper on Assessing nutritive value and economics of baby corn fodder (Zea mays) production compared to QPM and hybrid maize during winter season.

Gutam, Sridhar. 18th International Symposium on Electronic Theses and Dissertations - "Evolving Genre of ETDs for Knowledge Discovery" held at Jawaharlal Nehru University, New Delhi during 4-6th November, 2015.

Idris, M. 1st "All India group meeting of ANIP on vertebrate pest management "held at ICAR-Central Arid Zone Research Institute, Jodhpur-342004 from 15-17th October, 2015.

Jana, B.R. 3rd International Symposium on Under Utilized Plant Specices TNAU (KVK,AC&RI) Madurai 5-8th August 2015.

Kumar, Abhay and Chandra, N. Sixth Annual Review Meeting of the VDSA Project held at ICRISAT, Hyderabad during 2-3 April, 2015 and presented poster on Changing Livelihood Scenario: Village insight from Bihar state.

Kumar, Pankaj. XXXIII Annual Convention of Indian Society for Veterinary Medicine (ISVM) at Pookode, Kerela 22-24 January, 2015.

Kumar, Santosh. 50th Annual Rice Workshop, held at Indian Institute of Rice Research (ICAR-IIRR), Hyderabad during 11-15 April 2015.

Kumar, Santosh. Annual Review and planning workshop, Stress-Tolerant Rice for Africa and South Asia (STRASA Phase 3) held at NASC complex, New Delhi during 19-22, April, 2015.

Maurya, S. "33rd Group meeting All India Coordinated Research Project on Vegetable Crops" held at IIVR, Varanasi, UP during 21- 24th May, 2015.

Maurya, S. "XVII Annual Workshop of AICRP-Mushroom held at ICAR-DMR, Solan during 29-30th June, 2015.

Mishra, J.S. and Mali, S.S. Interaction meeting-cum-training programme for partners of CRP on Conservation Agriculture at CIAE, Bhopal during 29-30 January 2016.

Mishra, J.S. 25th Asia-Pacific Weed Science Society Conference at PJTSAU, Hyderabad during 13-16 October 2015.

Sangle, U.R. 6th International conference "Plant, pathogen and people"at New Delhi, India during 23-27 February, 2016 and presented a paper on Antagonistic properties of Trichoderma spp. Restricted due to *fusarium* sp.- A unique case.

Sarkar, Bikash. Workshop on Making Engineering Scientist Contribution more meaningful to stake holders and the Nation at NASC Complex, New Delhi on 13 April, 2015.

Sarma, Kamal. National seminar on "Fisheries and Aquaculture: Livelihood Security, Sustainability and Conservation" held at College of Fisheries (CAU), Lembucherra, Agartala, Tripura on 21-22 January, 2016 and presented paper on Livestock – fish integrated farming system an ideal proposition for farmers of Eastern Region.

Singh, Arun Kumar. 23rd Meeting of Central Sub committee on Crop standards and release of varieties for horticultural crops held at IIHR, Bengaluru on 7th April, 2015.

Singh, S.K. Mid-term review meeting under SRI-Tata Trust, Mumbai Project at Bhubaneswar on 17 January, 2016.

Thakur, Abhay Kumar. Workshop on "Making Engineering Scientists Contribution more meaningful to stake holders and the Nation" organized by Agricultural Engineering Division of ICAR at NASC Complex, New Delhi during 13-14 April, 2015.

Thakur, Abhay Kumar. 50th ISAE Annual Convention and Symposium on Agricultural Engineering in nation building: Contributions and Challenges, at College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, Odisha, India on 19-21 January, 2016.

21. *Training & Capacity Building*

Participation in Trainings (Category-wise)

Category-wise details of trainings attended by employees during 2015-16 is given below

Category	Total No. of Employees in-position	No. of trainings lanned for 2015-16 as per ATP	No. of employees undergone training during			% realization of trainings planned during 2015-16
			April-Sept., 2015	Oct., 2015-Mar., 2016	Total (Apr., 15 to Mar., 2016)	
Scientist	58	12	1	5	6	50
Technical	55	16	30	1	31	100
Administrative & Finance	24	5	0	1	1	20
SSS	79	6	0	40	40	100
Total	218	39	31	47	78	

Trainings Organized for various Categories of Employees

Training on improved techniques in nursery management for skilled supporting staff

Two days training of Skilled Supporting Staff was organized by ICAR-Research Complex for Eastern Region, Research Centre, Plandu, Ranchi during 30-31 March, 2016 on 'Improved Techniques in Nursery Management' (Fig. 160). The training programme was inaugurated by Dr. A. K. Singh, Head, ICAR-RCER, Research Centre. In his deliverance, he focused on equal opportunities and enhancement of work potential of the Skill Supporting staff especially on 'production of quality saplings using innovative and improved techniques in nursery'. Dr Bikash Das, delivered a lecture on 'Importance of quality plant saplings

Fig. 160. Training on improved techniques in nursery management

in establishment of orchard in Jharkhand' and he also discussed the recent development in establishment of new fruits and vegetable nursery and their management. Dr Sudarshan Maurya talked about nursery diseases and their management and emphasised on production of disease free saplings. Dr. Jaipal Singh Choadhary, delivered lecture on 'Insect-Pest management in nursery crop plants' and also discussed the homemade insecticides formulation for the management of insect and pest of saplings. Hands on training on hybrid seed production in Solanaceous and Cucurbitaceous crops was also provided. On second day, Dr. Mahesh Kumar Dhaker discussed on Nursery Management of Fruit crops and the potting mixture. Mr. Dhananjay Kumar, delivered lecture on production of quality nursery in vegetable crops usig pro-trays nursery raising technology. Certificates were also distributed to the trainees.

HRD fund allocation and utilization

RE 2015-16 for HRD			Actual Expenditure 2015-16 for HRD	% Utilization
Plan	Non plan	Total		
(Lakh Rs.)			(Lakh Rs.)	2015-16
2.28	0.00	2.28	2.28	100

22. Publications

Research Papers

Alam A.; Chadha, N.K.; Joshi, K.D.; Chakraborty, S.K.; Sawant, P.B.; Kumar, Tarkeshwar and Sharma, A.P. (2015). Maturation profile and fecundity of the exotic in the river Yamuna, India *Oreochromisniloticus*. *Journal of Environmental Biology,* **36**(4): 927-931.

Alam, A.; Chadha, N.K.; Joshi, K.D.; Chakraborty, S.K.; Sawant, B.P.; Kumar, Tarkeshwar; Srivastava, K.; Das, S.C.S and Sharma, A.P. (2015). Food and feeding ecology of the Non-native Nile Tilapia *Oreochromisniloticus* (Linnaeus, 1758) in the river Yamuna, India. *Proceeding of National Academy of Science, India, Sect. B Biol. Science,* **85**(1): 167-174.

Anoopraj, R.; Rajkhowa, T.K.; Cherian, S.; Arya, R.S.; Tomar, No.; Gupta, A.; Ray, P.K.; Somvanshi, R. and Saikumar, G. (2015). Genetic characterization and phylogenetic analysis of PCV2 isolates from India: Indications for emergence of natural inter-genotypic recombinants. *Infection Genetics and Evolution* **31**: 25-32.

Banerjee, Shipra; Sengupta, Shubhranshu and Das, Bikash (2015). Influence of pre and post harvest treatments on shelf life and fruit quality of mango cv. Amrapali. *Environment & Ecology*, **33**(4B): 1976-1978.

Bharti, P.K.; Dutt, T.; Patel, B.H.M.; Pandey, H.O.; Singh, M.; Gaur, G.K.; Kamal, Reena and Verma, K.K. (2016). Effect of weaning on milking behaviour and temperament of Murrah buffaloes. *Indian Journal of Animal Sciences,* **86**(2): 216-220.

Bhatt, B.P.; Rathore, S.S.; Lemtur, Monaro and Sarkar, B. (2016). Fuelwood energy pattern and biomass resources in Eastern Himalaya. *Renewable Energy,* **94**: 410-417.

Chakrabarti, Asit (2016). Traumatic esophagitis in a crossbred piglet- case study. *International Journal of Applied and Natural Sciences,* **5**(2): 69-70.

Chakrabarti, Asit (2016). Traumatic ventriculitis in deep litter system managed poultry birds- case study. *International Journal of Environment, Ecology, Family and Urban Studies,* **6**(2): 9-12.

Chakrabarti, Asit and Jha, B.K. (2016). Winter coccidiosis in a calf- A case report. *International Journal of Agricultural Science and Research,* **6**(1): 279-282.

Chakrabarti, Asit and Chandran, P.C. (2016). Foot disorders of goats (*Capra hircus*) in Bihar, India. *International Journal of Environment, Ecology, Family and Urban Studies,* **6**(1): 171-176.

Chakrabarti, Asit and Kumar, Pankaj (2016). Incidences of foot diseases of cattle in Bihar, India. *International Journal of Agricultural Science and Research,* **6**(1): 267-272.

Chandran, P.C.; Pandian, S.J.; Dey, A.; Kamal, Reena and Kumari, Rajni (2015). Production and reproduction performances of Diara buffaloes in the Gangetic basin of Bihar. *Indian Journal of Animal Sciences,* **85(7):** 770-773.

Choudhary, J.S.; Moanaro; Naaz, N. and Idris, M. (2015). Determination bio efficacy of insecticides against litchi stink bug *Tessaratoma javanica* (Thunberg) (Hemiptera: An emerging major pest of litchi *Litchi chinensis* Sonn. *Bio-scan,* **10**(1): 217-220.

Choudhary, J.S.; Naaz, N.; Prabhakar, C.S.; Rao, M. Srinivasa and Das, B. (2015). The mitochondrial genome of the peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae): complete DNA sequence, genome organization, and phylogenetic analysis with other tephritids using next generation DNA sequencing. *Gene*, http://dx.doi.org/10.1016/j.gene.2015.05.066.

Choudhary, J.S.; Prabhakar, C.S.; Moanaro and Maurya, S. (2015). New record of the litchi stink bug, *Tessaratoma javanica* (Thunberg) Egg Parasitoids and their natural control effect in litchi orchards from India. *Entomologia Generalis*, **35**(3): 187–197.

Das, Bikash (2015). Fruit characteristics of mango (*Mangifera indica*) germplasm conserved under Ranchi conditions. *Current Advances in Agricultural Sciences*, **7**(2): 133-138.

Desingu, P.A.; Ray, P.K.; Patel, B.H.M.; Singh, R.; Singh, R.K. and Saikumar, G. (2016). Pathogenic and genotypic characterization of a Japanese Encephalitis virus isolate associated with reproductive failure in an Indian pig herd. *PLOS ONE*, **11**(2): e0147611. *DOI:10.1371/journal. pone.0147611*.

Dhakar, M.K.; Singh, A.K.; Patel, V.B.; Singh, S.K.; Datta, S.P.; Kumar, R. and Khanna, M. (2015) Effect of different nitrogen sources and nitrification inhibitors on soil nitrogen distribution in Kinnow orchard. *Indian Journal of Horticulture*, **72**(2): 178-182.

Dwivedi, S.K. and Kumar, S. (2016). Effect of paclobutrzol on photosynthesis and expression of *pyroline-5-carboxylatesynthase* in contrasting wheat genotypes under water deficit stress condition. *Physiology and Molecular Biology of Plants, DOI 10.1007/ s12298-016-0343-5*.

Dwivedi, S.K.; Kumar, S.; Prakash, V.; Mondal, S. and Mishra, J.S. (2015). Influence of rising atmospheric CO_2 concentrations and temperature on morpho-physiological traits and yield of rice genotypes in sub humid climate of eastern India. *American Journal of Plant Sciences*, **6**: 2339-2349.

Dwivedi, S.K.; Kumar, S.; Singh S.K.; Prakash, V. and Arora, A. (2015). Improvement of photosynthetic machinery in wheat genotypes by application of plant growth regulator, Thiadiazuron (TDZ, synthetic cytokinin). *Environment and Ecology,* **34** (4): 1267-1272.

Elanchezhian, R.; Haris, A. A.; Kumar, S. and Singh, S.S. (2015). Positive impact of paclobutrazol on gas exchange, chlorophyll fluorescence and yield parameters under submergence stress in rice. *Indian Journal of Plant Physiology,* **20**(2): 111-115.

Gupta, J.J. and Baishya, S.K. (2015). Effect of phytase supplementation on growth performance of growing pigs fed on rice polish based diets. *Indian Journal of Animal Science,* **85**(10): 1120-1122.

Gupta, J.J. and Dey, A. (2015). Nutritive value of promising cereal forages with or without combination of leguminous forages in goat. *Indian Veterinary Journal,* **92**(7): 34-37.

Haris, A.A.; Chhabra, V.; Bhatt, B.P. and Sikka, A.K. (2015). Yield and duration of potato crop in Bihar under projected climate scenarios. *Journal of Agrometeorology,* **17**(1): 67-73.

Jan, Mustafa H.; Das, G.K.; Singh, J.; Khan, S.; Kumar, Pankaj; Singh, G.; Sarkar, M. and Pathak, M.C. (2015). Oxidative stress during cystic ovarian disease in water buffalo (*Bubalusbubalis*). *Indian Journal of Animal sciences,* **85**(4): 356-360.

Kamal, Reena; Dutt, T.; Patel, B.H.M.; Singh, G.; Chandran, P.C.; Dey, A. and Barari, S.K. (2016). Effect of shade materials on rectal temperature, respiration rate and body surface temperature of crossbred calves during rainy season. *Indian Journal of Animal Sciences,* **86**(1): 75–81.

Kamal, Reena; Dey, A.; Kumar, S.; Chandran, P.C. and Barari, S.K. (2015). Effects of feeding time of starter to finisher diet on growth performance and carcass characteristics of broiler chickens. *Indian Journal of Poultry Science,* **49**(1): 30-33.

Kamal, Reena; Dutt, T.; Patel, M.; Dey, A.; Chandran, P.C.; Bharti, P.K. and Barari, S.K. (2016). Behavioural, biochemical and hormonal responses of heat-stressed crossbred calves to different shade materials. *Journal of Applied Animal Research,* **44**(1): 347–354.

Kaswan, S.; Patel, B.H.M.; Singh, M.; Dutt, T.; Gaurg, G.K.; Kamal, Reena; Singh, G. A.S.U. (2016). Carcass traits of crossbred (Landrace × Desi) barrows reared with different floor space allowances under intensive system. *Indian Journal of Animal Sciences,* **86**(3): 335–340.

Kaushik, P.; Kumar, P. and Dayal, S. (2015). Male buffalo calf rearing: a mean to boost rural economy. *Indian Farming,* **64**(10): 41-42.

Kerketta, S.; Singh, M.; Patel, B.H.M.; Dutt, T.; Upadhyay, D.; Bharti, P.K.; Sahu, S.; Kamal, Reena (2015). Relationships between age, body measurements, testicular measurements and total ejaculation of semen in local goat of Rohilkhand region. *Small Ruminant Research,* **130**: 193-196.

Krishna, R.; Upadhyaya, A. and Roy, L.B. (2015). Comparison of Evapotranspiration rate for Pusa area of Bihar, by employing different methods through DSS. *Journal of Indian Water Resources Society*, **35**(4): 14-22.

Kumar, Ajay; Singh, S.K.; Kaushal, K.K.; Purushottam (2015). Effect of micro-irrigation on water productivity in system of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) intensification. *Indian Journal of Agricultural Sciences*, **85**(10): 1342-1348.

Kumar, Pankaj; Dayal, S.; Tiwari, R.; Sengupta, D.; Barari, S.K. and Dey, A. (2015). Vaginal prolapse in peri-partum primiparous Murrah buffalo complicated into endometritis and cystitis: A case report. *Buffalo Bulletin,* **34**(2):153-159.

Kumar, Pankaj; Dey, A.; Kumar, N. and Kumar, S. (2015). Management of respiratory distress and septicemia in male calves suffering from infectious respiratory disease. *IntasPolivet,* **16**(1): 118-121.

Kumar, S.; Dwivedi, S.K.; Haris, A. A.; Mondal, S.; Singh, S.K.; Mehta, P. and Singh, S.P. (2015). Response of yield and yield attributing traits of rice (*Oryza sativa* L.) genotypes grown under aerobic condition in eastern India. *Environment and Ecology*, **34**(1A): 271-275.

Kumar, S.; Dwivedi, S.K.; Singh, S.S.; Kumar, S.; Sundaram, P.K.; Shivani and Mall, A.K. (2015). Characterization of rice (*Oryza sativa* L.) genotypes on the basis of morphological and biochemical traits grown under aerobic situation in rainfed ecosystem. *Journal of Environmental Biology*, **36**(4): 999-1005.

Kumar, S.; Singh, S.S.; Dwivedi, S.K. and Kumar, S. (2015). Yield attributing physio-morphological trait response in rice (*Oryza sativa* L.) genotypes grown under aerobic situation in eastern Indo-Gangetic plain. *Indian Journal of Agricultural Sciences,* **85**(8): 1102-1108.

Kumar, U.; Bikash, Sarkar; Dey, A.; Sarma, Kamal and Bhatt, B.P. (2016). Energy use efficiency of oyster mushroom production in a selected Tribal village. *International Journal of Agriculture Sciences,* **8**(7): 1069-1071.

Kumar, Ujjwal; Sarkar, Bikash; Chaubey, R. and Bhatt, B.P. (2016). Agricultural Vulnerability Assessment: A Case of Madhubani district of Bihar, *Research Journal of Agricultural Sciences*, **7**(2): 372-374.

Kumari, Neelam; Srivastava, Piyush; Mehta, Sarita; Moanaro and Das, Bikash (2016). Allelopathic effects of some promising agro forestry tree species on different annual crops. *Ecology, Environment and Conservation*, **22**(1): 225-236.

Kumari, P.; Chandramoni; Singh, P.K.; Dey, A. and Sheetal, S.K. (2015). Effect of different dietary supplementation on nutrient balance and economics in Vanraja chicken. *Environment and Ecology*, **33**(3A): 1285-1288.

Kumari, R.; Dayal, S.; Kumar, S.; Lal, S.V.; Chakrabarti, A.; Barari, S.K. and Dey, A. (2015). Genetic polymorphism of bone morphogenetic protein receptor type–1 gene in Black Bengal goat and its association with litter size. *Indian Journal of Animal Sciences*, **85**(5): 469-471.

Kumari, R.R.; Lingaraju, M.C.; Gupta, G.; More, A.S.; Balaganur, V.; Kumar, D.; Kumar, Pankaj; Kumar, D.; Sharma, A.K.; Mishra, S.K. and Tandan, S.K. (2015). Effect of alcoholic extract of *Entadapursaetha* DC on Monosodium iodoacetate –induced Osteoarthritis pain in rats. *Indian Journal of Medical Research,* **141**(4): 454-462.

Mali, S.S.; Singh, D.K. (2015). Mapping spatial variability in crop evapotranspiration and defining spatial resolution units for crop water footprint assessment at river basin scale. *The Ecoscan,* **9**(1&2): 75-79.

Mali, S.S.; Singh, D.K.; Sarangi, A.; Khanna, M.; Parihar, S.S.; Das, D.K. (2015). Variability mapping of crop evapotranspiration for water footprint assessment at basin level. *Indian Journal of Soil Conservation,* **43**(1): 225-259.

Mali, S.S.; Singh, R.; Singh, A.K.; Meena, M. (2016). Influence of drip lateral placement depth and fertigation level on germination, yield and water-use efficiency of cucumber (*Cucumis sativus). Indian Journal of Agricultural Sciences*, **86**(2): 30-37.

Mishra, J.S. (2015). Weed management in millets: retrospect and prospects. *Indian Journal of Weed Science,* **47**(3): 246-253.

Mishra, J.S.; Hariprasanna, K.; Rao, S.S. and Patil, J.V. (2015). Biofortification of post-rainy sorghum (*Sorghum bicolor*) with zinc and iron through fertilization strategy. *Indian Journal of Agricultural Science,* **85**(5): 721-724.

Mishra, J.S.; Rao, S.S. and Patil, J.V. (2015). Response of grain sorghum (*Sorghum bicolor*) cultivars to weed competition in semi-arid tropical India. *Indian Journal of Agricultural Science,* **85**(5): 688-694.

Mishra, J.S.; Thakur, N.S.; Singh, P.; Kubsad, V.S.; Kalpana, R.; Ulse, U.N. and Nemade, S.M. (2015). Productivity, nutrient-use efficiency and economics of rainy-season grain sorghum (*Sorghum bicolor*) as influenced by fertility levels and cultivars. *Indian Journal of Agronomy,* **60**(1): 76-81.

Mukherjee, J.; Singh, S.S.; Kumar, S. and Idris, M. (2015). Radiation use efficiency and yield of wheat grown under elevated CO_2 and temperature in open top chamber at Patna, Bihar. *Journal of Agrometeorology,* **17**(2): 158-164.

Naik, S.K.; Das, B.; Kumar, S. and Bhatt, B.P. (2015). Evaluation of major and micronutrient status of acid soils of different mango orchards. *International Journal of Fruit Science*, **15**(1): 10-25.

Pandian, S.J.; Ray, P.K. and Chandran, P.C. (2014). Episiotomy for Management of Fetal Dystocia due to Goiter in a Doe. *Intas Polivet (2014)* **15** (II)*:* 351-352.

Pandian, S.J.; Ray, P.K.; Chandran, P.C.; Kumar, M. (2015). Seroprevalence of *Brucellaabortus* and *Leptospirahardjo* in cattle. *Veterinary World,* **8**(2): 217-220.

Pandian, S.J.; Subramanian, M.; Vijayakumar, G.; Balasubramaniam, G.A. and Sukumar, K. (2015). Epidemiological observations in carrion- mediated clusters of botulism in dairy cattle. *Indian Journal of Animal Sciences,* **85**(8): 865-866.

Pandian, S.J.; Subramanian, M.; Vijayakumar, G.; Balasubramaniam, G.A. and Sukumar, K. (2015). Therapeutic management of botulism in dairy cattle. *Veterinary World,* **8**(11): 1305-1309.

Parveen, S.; Choudhary, J.S.; Thomas, A. and Ramamurthy, V.V. (2015). Biology, morphology and DNA barcodes of *Tessaratoma javanica* (Thunberg) (Hemiptera: Tessaratomidae). *Zootaxa,* **3936**(2): 261–271.

Rahman, A. (2015). Low Energy Rotary Nozzle: An energy and water saving device for field crop irrigation. *Journal of Agricultural Science & Technology* **17**: 1071-1082.

Sahu, S.; Babu, L.K.; Karna, D.K.; Behera, K.; Kanungo, S.; Kamal, R. and Upadhyay, D. (2015). Effect of prepartum concentrate supplementation on blood biochemical profiles of pregnant Ganjam goat. *Indian Journal of Animal Research,* **49**(4): 487-490.

Sandhya, K.M.; Chakraborty, S.K.; Jaiswar, A.K.; Kumar, T. and Mohite, S. (2015). Morphometry and length-weight relationship of *Otolithescuvieri* (Trewavas, 1974) from Ratnagiri waters, Maharashtra, north-west coast of India. *Indian Journal of Fisheries,* **62**(4): 99-103.

Sarkar, B.; Sundaram, P.K.; Dey, A.; Kumar, U.; Sarma, K. and Bhatt, B.P. (2015). Traditional agricultural tools used by tribal farmers in eastern India. *Research Journal of Agricultural Sciences*, **6**(1): 215-219.

Sarkar, Bikash; Kumar U.; Chandra, N.; Mishra, J.S.and Bhatt, B.P. (2016). Performance evaluation of hand held crop cutter used in wheat and rice harvesting. *International Journal of Agriculture Sciences*, **8**(20): 1364-1365.

Sarkar, L.; Biswal, S.K.; Panigrahi, R.K.P. and Sarkar, Bikash (2015). Estimation of filtration potential of an effective biosand filter for removal of iron, turbidity from various sources of water. *Current World Environment*, **10**(2): 656-662.

Sarma, K.; Mohanty, S.; Dey, A.; Barari, S.K. and Bhatt, B.P. (2015). Prospects, status and challenges of aquaculture in the eastern region of India. *Fishing Chimes*, **35**(7): 24-33.

Sarma, Kamal; Pal, A.K.; George, G.; Baruah, K. (2015). Effect of sub-lethal concentration of endosulfan on lipid and fatty acid metabolism of spotted murrel, *Channapunctatus*. *Journal of Environmental Biology,* **36**: 451-454.

Sethi, M.; Agarwal, S.; Ray, P.K.; Anoopraj, R. and Saikumar, G. (2015). PCV-2 load in pre-weaned piglets affected with porcine circovirus2 associated disease. *Indian Journal of Animal Sciences,* **85**(7)*:* 701-704.

Sheery, P.M.; Kaushal, D.K.; Choudhary, B.K.; Sarma, K.; Mohanty, S.; Kumar, T. and Dey, A. (2016). Culture of *Macrobrachumrosenbergii*, Under Monoand Poly Culture System in Bihar. *Environment & Ecology* **34**(4C): 1922-1926.

Singh S.K.; Kumar, A. and Manibhushan (2015). Productivity and economics of mentha (*Mentha arvensis*) okra-potato cropping system as influenced by irrigation and fertility levels under drip irrigation. *Green Farming*, **6**(1): 114-116.

Singh, A.K. (2015). Swarna Suraksha: A new high yielding faba bean variety. *HortFlora Research Spectrum,* **4**(2):184.

Singh, A.K. and Bhatt, B.P. (2015). Late-sown lentil performance in response to foliar application of zinc. *Bangladesh Jornal of Botany,* **44**(1): 125-128.

Singh, A.K.; Islam, A.; Singh, S.R.; Upadhyaya, A, Rahman, A. and Sikka, A.K. (2015). Low Energy Water Application (LEWA) device: Concept and applications. *Journal of Soil & Water Conservation,* **14**(4): 344-351.

Singh, A.K.; Manibhushan; Chandra, Naresh and Bhakta, Narayan (2015). Extent and pattern of diversity in saffron germplasm of Indian Kashmir. *Bangladesh Journal of Botany*, **44**(4): 635-642.

Singh, A.K.; Pedapati, A. and Manibhushan (2015). Assessment of exchange of crop in view of change climate and International treaties. *Journal of Environmental Biology*, **36**(1): 309-317.

Singh, A.K.; Pan, R.S. and Bhavana, P. (2014). Genetic studies for quantitative traits and resistance to bacterial wilt in brinjal (*Solanum melongena* L.). *International Journal of Innovative Horticulture*, 3(2):73-72.

Singh, D; Gupta, A.K.; Singh, A.K.; Singh, A.K. and Kumar, S. (2015). Evaluation of field pea germplasm against rust disease caused by *Uromyces vicia*e fabae de bary in glass house and field conditions. *Bangladesh Journal of Botany,* **44**(3): 443-449.

Singh, H.S.; Sangeetha, G.; Srivastava, S.K.; Choudhary, J.S.; Srivastava, Kuldeep; Das, Bijan Kumar; Sahoo, Ajoy Kumar; Mishra, Debasis and Pattnaik, Sanghamitra (2014). Emerging pests of fruit crops, like mango, litchi, bael, tamarind, sweet orange, banana, papaya and guava in eastern India. *Journal of Applied Zoological Research* 25(2): 161-169

Singh, K.M.; Singh, R.K.P.; Kumar, Abhay; Kumar, A.; Meena, M.S. and Chahal, V.P. (2015). Implications of labour migration for rice production and household economy: Evidences from eastern India. *Indian Journal of Agricultural Sciences,* **85**(6): 768-72.

Singh, P. and Dwivedi, S.K. (2015). Effect of nursery nutrient management on plant survival, physiological traits and yield of rice (*Oryza sativa*) genotype Swarna-Sub1 under submerged rainfed lowland ecosystem. *Agricultural Research.* DOI 10.1007/s40003-015-0195-1, pp.1-8.

Singh, R.K.P.; Singh, K.M. and Abhay Kumar (2015). Agricultural Development in Bihar: Some Empirical Evidences. *Agricultural Situation in India,* Vol. **LXX** (12): 5-14.

Singh, R.K.P.; Singh, K.M.; Jha, A.K. and Kumar, Abhay (2015). A micro analysis of fodder production and marketing in Bihar. *Indian Journal of Animal Sciences,* **85**(12): 1379-1383.

Singh, Rashmi; Maurya, Sudarshan and Upadhyay, R.S. (2016). The improvement of competitive saprophytic capability of Trichoderma species through the use of chemical mutagens. *Brazilian Journal of Microbiology*, **47**: 10-17.

Singh, S.K.; Dey, A. and Meena, M.K. (2015). Effect of organic nutrient sources on forage yield in rainfed farming system. *Green Farming,* **6**(3): 569-572.

Upadhyaya, A. (2015). Bi-level Drainage System Design considering Upward Leakage from Semiimpermeable Barrier. *Irrigation and Drainage Systems Engineering*, **4**(4): 1-5. DOI: 10.4172/2168-9768.S1-004. OMICS International.

Upadhyaya, A. **(**2015). Social Protection and Agriculture: Breaking Cycle of Rural Poverty. An invited Paper presented and published in Proceedings of Seminar on Social Protection and Agriculture: Breaking the cycle of Rural Poverty by Bihar State Productivity Council, Patna, pp 16-30.

Upadhyaya, A. and Sikka, A.K. (2016). Concept of water, land and energy productivity in agriculture and pathways for improvement. *Irrigation and Drainage Systems Engineering,* B(1): 1-10. DOI: 10.4172/2168-9768.1000154. OMICS International.

Usharani, J.; Viswas, K.N.; Thomas, P.; Gupta, S.K.; Bhure, S.K.; Dandapat, P.; Agarwal, R.K. and Singh, V.P. (2015). Development of a recombinant flagellin based ELISA for the detection of *Clostridium chauvoei. Anaerobe,* **33**: 48-54.

Varma, R.; Choudhary, A.K.; Datta, Abhijit and Maurya, Sudarshan (2015). Antimicrobial potential of an animal peptide and some antibiotics against a dreaded soilborne phytopathogen *Ralstonia solanacearum*. *International Journal of Current Research*, **7**: 23015-23022.

23. *Personnel*

Division of Land and Water Management

Scientists

Dr. R.K. Singh, Pr. Scientist & Head
Dr. A. Upadhyaya Pr. Scientist
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)
Mr. Manibhushan, Scientist(SS) (Comp. App.)
Er. P.K. Sundaram , Scientist (FMPE) (Study leave)
Mr. Surjit Mondal, Scientist (Soil Science) (Study leave)

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. Shivani, 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)
Dr. Rakesh Kumar, Scientist (Agronomy)
Mr. Ved Prakash, Scientist (Agril. Meteorology)
Dr. Tshering Lhamu Bhutia, Scientist (Veg. Science)
Mr. Karnena Koteswara Rao, Scientist (Soil Science)

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.C. Chandran, Scientist (Animal Genetics and Breeding)
Dr. S. J. Pandian, Scientist. (Veterinary Medicine)
Dr. P. K. Ray, Scientist (Veterinary Pathology)
Mrs. Rajni Kumari, Scientist (Animal Biotechnology) (Study leave)
Dr. Pankaj Kumar, Scientist (Vet. Medicine)
Dr. Reena Kumari Kamal, Scientist (LPM)
Dr. Santosh Kumar Gupta, Scientist (Vet. Microbiology)
Ms. Snatashree Mohanty, Scientist (Fish Health)
Dr. Tarkeshwar Kumar, Scientist (Aquaculture)

Technical Officers

Dr. S. K. Barari, 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, Sr. Scientist

Technical Officers

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

Performance Monitoring & Evaluation Cell

Dr. Abhay Kumar, Pr. Scientist (Agril. Stat.) I/c PME Cell

Technical Officer

Mr. Sarfaraj Ahmad, Technical Officer (Computer)

ARIS Cell

Dr. R.C. Bharti, Pr. Scientist (Agril. Stat.) I/c ARIS

Technical Officer

Sh. Anil Kumar, Senior Technical Officer (T-6)

Farm Section

Mr. A.K. Khan, Farm Manager (T-9)
Mr. Hari Shankar, Technical Officer (T-7-8)
Mr. R.K. Tiwari, Technical Officer (T-5)
Mr. 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. P.R. Kumar, Sr. Scientist (Seed Technology)
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. S.S. Mali, Scientist (CWC)
Dr. (Mrs.) P. Bhavana, Scientist (Plant Breeding)
Dr. Jaipal Singh Choudhary, Scientist (Entomology)
Ms. Reshma Shinde, Scientist
Dr. P.K. Sarkar, Scientist (Agroforestry)
Dr. M.K. Dhakar, Scientist
Dr. Anuradha Srivastava Scientist (Food Technology)

Technical Officers

Sh. G.P. Singh, Asstt. Chief Tech. 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. M.K. Pandey, Technical Officer- Library (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)
Sh. Kishore Kumar, Technical Officer (Driver) (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. Thakur, Pr. Scientist (AS & PE)
Dr. A.K. Choudhary, Pr. Scientist (Plant Breeding)
Dr. I.S. Singh, Scientist (Soil Science)
Dr. B.R. Jana, Scientist (Horticulture)
Mr. N.K. Meena, Scientist (Soil Science)

ICAR RCER, Krishi Vigyan Kendra, Buxar

Subject Matter Specialist

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

Technical

Sh. Arif Parwez, Farm Manager (T-5)
Sh. Afroz Sultan, Programme Assistant (Lab. Tech.)/ T-5
Sh. Vikash Kumar, Programme Assistant (Computer)/T-5

ICAR RCER, Krishi Vigyan Kendra, Ramgarh

Subject Matter Specialist

Dr. Dushyant Kumar Raghav, SMS (Plant Protection),
Dr. Indrajeet, SMS (Ag. Extension),
Dr. Dharmjeet Kherwar, SMS (Agro Forestry/ Horticulture),

Technical

Shri Sunny Kumar, Farm Manager

Verma, N.; Singh, Surendra; Khan, Y.J.; Sushil, K. and Singh, A.K. (2015). Chickpea genetic resources to enhance production in changing climatic scenario. *Legume Research*, **38**(5): 710-713.

Vijayakumar, G.; Sivaraman, S.; Venkatesakumar, E.; Pandian, S.J. and Subramanian, M. (2014). Hypokalemia in Postparturient Animals and its Management -A Clinical Study in 18 Cows. *IntasPolivet*, **15**(II): 535-536.

Books

Bharati, R.C. and Singh, A.K. (2015). *Designing Agricultural Research* (Kindle Edition). Published by Satish serial Publication House Delhi, ASIN: B010AFLMIK.

Bharati, R.C. and Singh, A.K. (2015). *Elements of Agricultural Statistics* (Kindle Edition). Published by Satish serial Publication House Delhi, ASIN: B010BGZWIC.

Bhatt, B.P. (2015). *Dwitiye Harit Kranti ki aur Rashtra ke Badhte Kadam* (Hindi). Published by Satish Serial Publishing House, New Delhi, pp. 255.

Meena, M.S.; Singh, K.M. and Bhatt, B.P. (2015). *Water Management in Agriculture.* Published by Narendra Publishing House, Delhi, pp. 450.

Pathak, H.; Bhatt, B.P. and Gupta, S.K. (2015). *State of Indian Agriculture 'Water'*. Published by National Academy of Agricultural Sciences, New Delhi, pp. 102.

Book Chapters

Abdul Haris, A.; Bhatt, B.P. and Chhabra, Vandana (2015). Climate change impacts on field and horticultural crops with special reference to Bihar, possible adaptation strategies and mitigation options. In: Choudhary, M.L. et. al (eds.). *Climate Dynamics in Horticultural Science- Impact, Adaptation and Mitigation*. Published by Apple Academic Press, pp. 341-349.

Bhagwat, V.R.; Mishra, J.S. and Patil, J.V. (2015). Improving water-use efficiency through management of aquatic weeds. *In:* Meena, M.S. et al. (eds.): *Water Management in Agriculture.* Narendra Publishing House, New Delhi, pp.171-179.

Bhatt, B.P.; Islam, A.; Singh, K.M. and Meena, M.S. (2015). Water resources in eastern India. In: Meena, M.S. et. al. (eds.). *Water Management in Agriculture*. Published by Narendra Publishing House, Delhi, pp. 37-45.

Dhakar, M.K.; Sarolia, D.K.; Kaushik, R.A.; Kumawat, K.L.; Singh, S. and Singh, A.K. (2015). Mahua (*Madhuca longifolia* (Koenig) J.F. Macribide). *In*: Ghosh, S.N. (ed.): *Breeding of Underutilized Fruit Crops Part II*. Narendra Publishing House, New Delhi, pp. 305-325.

Dhakar, M.K.; Sarolia, D.K.; Soni, A.K. and Meena, C.P. (2015). Pilu (*Salvadora oleoides*). *In*: Ghosh, S.N. (ed.): *Breeding of Underutilized Fruit Crops Part II*. Narendra Publishing House, New Delhi, pp. 413-423.

Kumar, Sanjeev; Bhatt, B.P.; Dey, A.; Kumar Ujjwal; Chandra, N. and Shivani (2015). Sustainable integrated farming systems models for small farm holders of Bihar. In: Gangwar, B. et. al. (eds.). *Research in Farming Systems*. Published by Today & Tomorrow's Printers and Publishers, New Delhi, pp. 229-249.

Kumar, Sanjeev; Bhatt, B.P.; Dey, A.; Kumar, Ujjwal; Chandra, N. and Shivani (2015). Sustainable Integrated Farming System Models for small and marginal farm holders of Bihar. *In:* Gagwar, B. et al. (eds.): *Research in Farming Systems*. Todays & Tommorow's printers and Publishers, New Delhi, pp. 229-249.

Kumawat, K.L.; Sarolia, D.K.; Singh, V. and Dhakar, M.K. (2015). Timroo (*Diospyrosmelanoxylon* Roxb.). *In*: Ghosh, S.N. (ed.): *Breeding of Underutilized Fruit Crops Part II*. Narendra Publishing House, New Delhi, pp. 507-518.

Mishra, J.S. (2015). Pearl millet agronomy for higher productivity. *In:* Tonapi, Vilas A .and Patil, J.V. (eds.): *Millets: Ensuring Climate Resilience and Nutritional Security*. Daya Publishing House, New Delhi, India. ISBN: 978-93-5124-644-2, pp. 431-441.

Mishra, J.S. and Patil, J.V. (2015). Nutrient-use efficiency in Sorghum. *In:* Rakshit, A. Et al. (eds.): *Nutrient Use Efficiency: from Basics to Advances*. Springer. ISBN: 978-81-322-2168-5, pp. 297-315.

Rathore, S.S.; Prakash, B. and Bhatt, B.P. (2015). Agronomic interventions for sustaining the jhum cultivation in North East India. In: Gangwar, B. et. al. (eds.). *Research in Farming Systems*. Published by Today & Tomorrow's Printers and Publishers, New Delhi, pp. 489-516.

Sarma, K.; Dey, A. and Pal, A.K. (2015). Stress in Aquaculture. In: *Hand book of fisheries and aquaculture*. Published by College of Fisheries, AAU, Raha, Assam.

Singh, A.K.; Bhatt, B.P. and Singh, K.M. (2015). Efficient water management: Way forward to climate smart grain legumes production. In: Meena, M.S. et. al. (eds.). *Water Management in Agriculture*. Published by Narendra Publishing House, Delhi, pp. 243-260.

Training Manual Research/Technical Bulletins

Dwivedi, S.K.; Kumar, S.; Singh, S.S.; Mukherjee, J.; Haris, A.A.; Prakash, V. and Bhatt, B.P. (2015). Impact of elevated CO_2 and temperature on rice/wheat genotypes of Eastern India under predicted climate change scenario. Technical Bulletin No.: R-52/PAT-32. ICAR Research Complex for Eastern region, Patna, pp. 30.

Jha, B.K.; Mali, S.S.; Naik, S.K.; Singh, A.K. and Kumar, A. (2015). Optimal planting geometry and growth stage based fertigation in vegetable crops. Technical Bulletin No.: R-56/Ranchi-25. ICAR-RCER Research Centre Ranchi.

Kumar, A.; Bhatt, B.P.; Singh, R.K.P.; Singh, K.M.; Kumar, P.; Bharati, R.C. and Kumar, R. (2015). Dumarya (Jharkhand)- A village profile. Technical Bulletin No.: R58/Patna-34. ICAR Research Complex for Eastern Region and International Crop Research Institute for the Semi-Arid Tropics, pp. 32.

Kumar, Abhay; Bhatt, B.P.; Singh, R.K.P.; Singh, K.M.; Kumar, Pankaj; Chandra, N. and Kumar, Sanjay (2015). Durgapur (Jharkhand)- A Village Profile. Technical Bulletin. ICAR Research Complex for Eastern Region and International Crop Research Institute for the Semi-Arid Tropics, pp. 38.

Kumar, S.; Dwivedi, S.K.; Haris, A.A.; Singh, S.S.; Idris, M.; Sangle, U.R.; Mondal, S.; Kumar, S.; Singh, S.K.; Kumar, A. and Bhatt, B.P. (2015). Drought Tolerant rice for rainfed ecosystems of Eastern India. Technical Bulletin No.: R-51/PAT-31. ICAR Research Complex for Eastern region, Patna, pp. 37.

Kumar, Sanjeev; Shivani and Bhatt, B.P. (2015). Makka mein sashay prabandhan avum *rabi* makka utpadan ki nai taknik. Technical Bulletin No.: R-48/PAT-29. ICAR Research Complex for Eastern region, Patna, pp. 43.

Sanjeev, Kuma; Shivani, Kumar, Santosh and Bhatt, B.P. (2015). Recent advances in maize production technology. Technical Bulletin No.: R-49/PAT-30. ICAR Research Complex for Eastern region, Patna, pp. 32.

Extension Bulletin

Bhavna, P.; Singh, A.K.; Pan, R.S.; Naik, S.K.; Mourya, S.; Mali, S.S.; Choudhary, J.S.; Kumar, D. and Moanaro (2015). Poorvi Bharat me Baingan ki unnat kheti.. Prasar Pustika No.: E-123/Ranchi-43. ICAR-RCER, Patna.

Das, B.; Dhakar, M.K.; Mourya, S. and Shinde, R. (2015). Poorvi Bharat me Amrood ki vaigyanik kheti. Prasar pustika No.: E-131/Ranchi-51. ICAR-RCER, Patna.

Das, B.; Mehta, S. and Mali, S. (2015). Poorvi pathari kshetra me atiuchchaghanatva pranali dwara Amrood ke bag ki sthapna evam rakhrakhav. Prasar pustika No.: E-122/Ranchi-41. ICAR-RCER, Patna.

Das, B.; Sarkar, P.K., Maurya, S. and Choudhary, J.S. (2015). Poorvi Bharat me Kathahalki vaigyanik kheti. Prasar pustika No.: E-129/Ranchi-49. ICAR-RCER, Patna.

Das, B.; Singh, A.K. and Dhakar, M.K. (2015). Uparvaar bhoomi ke liye bahusthariya phasal pranali. Prasar pustika No.: E-130/Ranchi-50. ICAR-RCER, Patna.

Dhakar, M.K.; Das, B. and Choudhary, J.S. (2015). Poorvi Bharat me Goun phalon ki vaigyanik kheti. Prasar pustika No.: E-142/Ranchi-62. ICAR-RCER, Patna.

Jha, B.K.; Naik, S.K.; Maurya, S.; Choudhary, J.S. and Shinde, R. (2015). Sabjiyon ki jaivik kheti. Prasar pustika No.: E-128/Ranchi-48. ICAR-RCER, Patna.

Kumar, Ujjawal; Sarkar, Bikash; Sarma, Rajveer; Singh, S.K.; Prakash, Ved; Choubey, R. and Choudhury, A.K. (2015). Sunya jutai taknik dara gehun utpadan ki adhuniktam takniko. Prasar Pustika No.: E-149/PAT/77. ICAR RCER,Patna, pp.1-4.

Maurya, S. (2015). Oyster mushroom (Dheengri) utpadan taknik. Prasar Pustika No.: E-140/Ranchi-60. ICAR-RCER, Patna.

Maurya, S. and Shinde, R. (2015). Doodhiya mushroom ki utpadan taknik. Prasar Pustika No.: E-139/Ranchi-59. ICAR-RCER, Patna.

Maurya, S.; Choudhary, J.S. and Moanaro (2015). Poorvi Bharat me sabjiyo me samekit rog prabandhan. Prasar Pustika No.: E-127/ Ranchi-47. ICAR-RCER, Patna.

Maurya, S.; Choudhary, J.S. and Moanaro. (2015). Poorvi Bharat me shwet button mushroom (Khumb) ki kheti. Prasar pustika No.: E-143/Ranchi-63. ICAR-RCER, Patna.

Pan, R.S. and Singh, A.K. (2015). Poorvi pathari kshetra me French bean ki vaigyanik kheti. Prasar pustika No.: E-135/Ranchi-55. ICAR-RCER, Patna.

Pan, R.S.; Singh, A.K. and Shinde, R. (2015). Poorvi pathari kshetra me matar ki vaigyanik kheti. Prasar Pustika No.: E-134/Ranchi-54. ICAR-RCER, Patna.

Pan, R.S.; Singh, A.K.; Maurya, S. and Choudhary, J.S. (2015). Poorvi pathari kshetra me bodee ki vaigyanik kheti. Prasar Pustika No.: E-144/Ranchi-64. ICAR-RCER, Patna.

Pan, R.S.; Singh, R.; Kumar, S. and Sharma, J.P. (2015). Poorvi pathari kshetra me sem ki vaigyanik kheti. Prasar Pustika No.: E-136/ Ranchi-56. ICAR-RCER, Patna.

Singh, A.K.; Pan, R.S.; Bhavna, P.; Naik, S.K.; Mali, S.S.; Choudhary, J.S.; Kumar, D.; Singh, V.K. and Moanaro (2015). Poorvi Bharat me tamatar ki vaigyanik kheti. Prasar Pustika No.: E-132/Ranchi-52. ICAR-RCER, Patna.

Srivastava, A.; Das, B. and Dhakar, M.K. (2015). Lichee ke phalo ki turaiuprant prabandhan. Prasar Pustika No.-**E-137/Ranchi-57**. ICAR-RCER, Patna.

कुमार, पंकज, गुप्ता, जे.जे., कुमारी, रजनी राय, राम कृष्ण और दयाल, शंकर (2015). दुधारु गाय में लक्षणहीन थनैलाः निदान और रोकथाम। प्रसार पुस्तिका सं. ई–120/पटना/75

Popular articles

इदरीस, मुहम्मद एवं साग्ले, य. आर. (2015). मक्का में समेकित कीट प्रबन्धन, *अक्षय खेती* जून 2015 पेज 63–65.

Chakrabarti, Asit; Dayal, S.; Dey, A.; Bhatt, B.P. (2015). Broiler rabbit production-An alternative source of income. *Indian Farming*, **65**(9): 37-40.

Dwivedi, S.K., Kumar, S., Prakash, V. and Mishra, J.S. (2015). Adopting strategies for sustaining productivity of rice-wheat cropping system in Eastern Indo-Gangetic Plains. *Indian Farming*, **65**(6): 11-14.

Kumar, S.; Dwivedi, S.K.; Singh, S.S. and Sundaram, P.K. (2015). Aerobic rice growing rice successfully in water-shortage areas of Eastern India. *Indian Farming*, **64**(10): 10-12.

Kumar, Sanjeev; Bhatt, B.P.; Dwivedi, S.K. and Shivani. (2015). Family Farming: A mechanism to contribute towards Global Food Security. *Indian Farming*, **64**(12): 13-18.

साग्ले, यू.आर. और इदरीस, मुहम्मद (2015). धान में समेकित राग प्रबन्धन, *अक्षय खेती* जून 2015 पेज 60–62.

Mishra, J.S. (2015). Good agronomic practices for productivity enhancement in dryland crops. *Indian Farming*, **65**(4): 43-45.

Mishra, J.S. (2015). Integrated weed management in millets. *Indian Farming*, **65**(7): 76-80.

Prakash, V.; Singh, A.K.; Kumar, S. and Dwivedi, S.K. (2015). Effectiveness of cropping systems in mitigation of climate change through carbon sequestration. *Indian Farming*, **65**(1): 31-34.

राघव, दुष्यंत (2015). चूहों का कृषि में महत्व एवं निदान. *ईछू* **4**(1): 79-80.

e-Publications

Kumar, Pankaj; Pandian, S.J.; Kumari, R.R. and Kumar, M. (2015). Package and practices for livestock farmers: under supervision of a veterinarian. *E-publication*. http://poulvet.com/dairy/articles/livestock_farmers.php

Kumar, Pankaj; Roy, R.K.; Kumar, M.; Kumari, R.R.; Kumar, A. (2015). PPR control in goat: A guide for animal health service providers. *Vethelp India E journal*. http://www.vethelplineindia.co.in/ppr-control-in-goat-a-guide-for-animal-health-service-providers/

Kumari, R.R.; Kumar, M.; Kumar, S. and Kumar, Pankaj (2015). Rabies: Timely intervention can be protective. *E Publication*. http://www.poulvet.com/dog/articles/rabies.php

Majumdar, Koustab; Sengupta, Arunava and Jha, B.K. (2015). Social & livelihood matrix of rural Jharkhand- A case study. *LAP Lambert Academic Publishing, Germany*, pp1-102.

24. *Joining & Promotion*

New Joining

Scientific

Sh. Karnena Koteswara Rao Scientist (Soil Science) at ICAR-RCER, Patna w.e.f. 10.04.2015.

Dr. Priya Ranjan Kumar Sr. Scientist (Plant Breeding) at ICAR-RCER Research Centre Ranchi w.e.f. 25.05.2015.

Dr. Rakesh Kumar Scientist (Agronomy) at ICAR-RCER, Patna w.e.f. 10.11.2015.

Dr. R.K. Singh Head, DLWM at ICAR-RCER, Patna w.e.f. 29.02.2016.

Technical

Sh. Dhiraj Prakash, Technician (T-1) at ICAR-RCER Research Centre for Makhana, Darbhanga w.e.f. 10.04.2015.

Dr. Dushyant Kumar Raghav, SMS (Plant protection) at KVK, Ramgarh w.e.f. 17.08.2015.

Dr. Indrajeet, SMS (Agri. Extension) at KVK, Ramgarh w.e.f. 21.08.015.

Sh. Sunny Kumar, Farm manager (T-4) at KVK, Ramgarh w.e.f. 31.08.2015.

Dr. Dharamjeet Kherwar, SMS (Horticulture) at KVK, Ramgarh w.e.f. 08.12.2015.

Administration

Sh. Md. Sajid Mustaq, Assistant at ICAR-RCER, Patna w.e.f. 14.12.2015.

Sh. Vipul Raj, Administrative Officer at ICAR-RCER, Patna w.e.f. 21.12.2015.

Sh. Alok Kumar, Administrative Officer at ICAR-RCER, Patna w.e.f. 17.02.2016

Transfer (Outside)

Sh. M.K. Meena, Scientist transferred to ICAR-NDRI, Karnal w.e.f. 08.01.2016.

Dr. U.R. Sangle, Sr. Scientist transferred to ICAR- NRC on Pomegranate, Solapur w.e.f. 29.02.2016.

Dr. V.K. Gupta, Pr. Scientist transferred to ICAR-IISR Locknow w.e.f. 06.02.2016.

Dr. R.K. Roy, SMS, KVK, Buxar transferred to RAU KVK, Gopalganj w.e.f. 15.06.2015.

Joining from Study Leave

Dr. P.K. Ray, Scientist w.e.f. 11.02.2016

Promotions

Administration

Smt. Prabha Kumari promoted to Assistant Admin. Officer w.e.f. 28.12.2015.

Sh. Rakesh mani promoted to Assistant w.e.f. 31.12.2015.

Sh. Madan Paswan promoted to Assistant w.e.f. 31.12.2015.

Mr. Markanday Mishra, promoted to UDC w.e.f. 18.04.2015.

Technical

Smt. Anima Prabha, STA (Hindi) to TO (Hindi) w.e.f. 06.09.2012.

Sh. Suresh Chandra, Tech. Asstt. to Sr. Tech. Asstt. w.e.f. 10.07.2013.

Sh. Arif Parwez, FM (Sr. Tech. Asstt.) to FM (Tech. Officer) w.e.f. 30.03.014.

Sh. Ganga Ram, Technical Officer to Sr. Technical Officer w.e.f. 10.06.2014.

Sh.Vikash Kumar, Programme Asstt. (Computer/ T-4) to Programme Assistant (Computer/T-5) w.e.f. 17.08.2014.

Sh. Anil Kumar, Technical Officer to Sr. Technical Officer w.e.f. 08.09.2014.

Sh. Murari Maharaj, Technical Assitant (Driver) to Sr. Technical Assitant (Driver) w.e.f. 01.01.2015.

Sh. Akhilanand Ray, Technical Assitant (Driver) to Sr. Technical Assitant (Driver) w.e.f. 01.01.2015.

Sh. Chandradev Rai, Sr. Technical Assitant to Technical Officer w.e.f. 01.01.2015.
Sh. Chandrakant, Technical Officer to Sr. Technical Officer w.e.f. 01.07.2015.
Sh. Sarfaraj Ahmad, Sr. Technical Assitant to Technical Officer (Computer) w.e.f. 09.09.2015.
Sh. Vijay Kumar, Singh Sr. Technical Assitant to Technical Officer w.e.f. 15.06.2015.
Sh. Afroz Sultan, Sr. Technical Assitant to Technical Officer w.e.f. 13.08.2015.
Sh. Rajesh Kumar Rai, Technician (Driver) to Sr. Technician (Driver) w.e.f. 12.08.2015.
Sh. Sarfaraj Ahmad Khan, Technician (Driver) to Sr. Technician (Driver) w.e.f. 16.08.2015.

Skilled Supporting Staff

Shri Sunil Kumar SSS promoted to T-1 Lab Technician w.e.f. 9.3.2016.
Shri Subhash Kumar SSS promoted to T-1 Manager-cum-Chief Cook w.e.f. 9.3.2016.
Shri Manoj Kumar Singh SSS promoted to T-1 Lab Technician w.e.f. 9.3.2016.

Retirements

Technical

Sh. Ramashish Pandit, Technician (T-1) w.e.f. 31.05.2015.
Sh. Kishan Singh, Chief Technical Officer w.e.f. 30.11.2015.

Supporting

Sh. Etwa Toppo, SSS w.e.f. 24.04.2015.
Sh. Suresh Prasad, SSS w.e.f. 30.06.2015.
Sh. Etwa Kesariyar, SSS w.e.f. 31.08.2015.

24. *On-going Research Projects*

Theme wise Ongoing and New Institute Research Projects 2015-16

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 U. Kumar N. Chandra M. Idris S.Mondal	June 2010	Mar. 2016	PDFSR, AICRP (Externally funded)
1.2	ICAR-RCER/ RCM/ 2011/ **25(ii)**	Development of makhana based Integrated Farming System models for low land eco-system	I.S. Singh V.K. Gupta	July 2011	June 2016	ICAR RCER
1.3	ICAR-RCER/RC Ranchi/ 2011/ **25(iii)**	Development of location specific Integrated Farming System models for rainfed eco-system of Eastern Plateau Hill region	B.K. Jha Reshma Shinde S.S. Mali A. Chakrabarti	June 2011	May 2016	ICAR RCER
1.4	ICAR-RCER/ R.C Makhana/ 2014-15/ 157	Introduction of sweet flag and tuber vegetable crop under wetland ecosystem with makhana crop for north Bihar	V.K. Gupta B.R. Jana Rajvir Sharma	July 2014	June 2017	ICAR RCER
1.5	ICAR-RCER/ DLFM/ 2014/ 155	Optimization of production efficiency in livestock- fish integrated farming system	Kamal Sarma A.Dey S.Mondal S. J.Pandian S.K. Gupta Snatashree Mohanty Tarkeshwar Kumar	Aug. 2014	July 2017	ICAR RCER
1.6	ICAR-RCER/ DLFM/ 2014/ 143	Multiplication and production profiling of improved poultry germplasm under Backyard farming system	Reena Kumari Kamal P.C.Chandran S.J.Pandian	July 2014	June 2019	ICAR RCER
1.7	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 Extd. Dec. 2016	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
1.8	ICAR-RCER / R.C Ranchi / 2014/147	Development of multi-tier cropping system for rainfed uplands of eastern plateau and hills	Mahesh Kumar Dhakar Bikas Das Reshma Shinde	Sept. 2014	Sept. 2019	ICAR RCER
1.9	—	Integrated farming system for improvement of nutrition and livelihood of farm women	T.L. Bhutia Reena Kumari Kamal Snatashree Mohanty	2015	Dec. 2017	Externally funded
2. Resource Conservation Technology						
2.1	ICAR-RCER/ FF/CSISA-II/2013/36	Cereal Systems Initiative for South Asia (CSISA) phase II	J.S. Mishra Md. Idris Ajay Kumar S.K. Dwivedi U.R.Sangle S. Mondal	July 2013	Sep. 2015	CIMMYT
2.2	ICAR-RCER / DLWM /2012 / 130	Evaluation of vegetable varieties under different irrigation methods	Shivani A.K. Singh M. Idris T.L. Bhutia	Sept. 2013/ Initiated in 2014	Aug. 2017	ICAR RCER
2.3	—	Sustainable Resilient Farming System in intensification (SRFSI) in the Eastern Gangetic Plane	Ujjwal Kumar Rajvir sharma S.K. Singh Bikash Sarkar A.K. Chaudhary S. Mondal Ved Praksah	Oct. 2014	June 2018	CIMMYT
2.4	ICAR-RCER/ RC Ranchi / 2015/168	Evaluation of vegetable cropping sequences under drip irrigation with mulching in EPHR	B.K. Jha S.S. Mali S.K.Naik	Aug. 2015	July 2018	ICAR RCER
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)	Bikash Das J.S. Choudhary S. Maurya S. Gutam	Jan. 2011	Mar. 2016	NICRA (Externally funded)
3.2	ICAR-RCER / DLWM/2012/ **126**	Land suitability classification for different crops using remote sensing and GIS	Manibhushan S. 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 Santosh Kumar Ved Prakash	July 2014	June 2017	ICAR RCER
3.4	—	Management of high intensity rain events in flood prone region of middle IGP for kharif crops and low temperature in Boro rice in eastern IGP (NICRA)	J.S.Mishra Kamal Sarma U.Kumar Bikas Sarkar N.Bhakta Ved Prakash	July 2015		NICRA (Externally funded)

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
Theme 2. Genetic Resource Management and Improvement of Field, Horticultural and Aquatic crops						
4. Varietal Development						
4.1	ICAR RCER/ FF /2011/ 30	Evaluation and development of drought tolerant rice for Eastern region (STRASA Phase-III)	Santosh Kumar M. Idris U.R. Sangle N. Bhakta S. K. Dwivedi	April 2014	Feb. 2019	IRRI (Externally funded)
4.2	ICAR-RCER/ EF/IRRI/2012/33	Improved Rice based rainfed Agricultural System (IRRAS) in Bihar State, India	J. S. Mishra Santosh Kumar A. K. Singh S.K. Dwivedi S. Mondal N. Bhakta	July 2012	Sept. 2015	(Externally funded by IRRI)
4.3	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
4.4	ICAR-RCER / HARP/ 2001/ 03	Plant genetic resource and improvement of fruit and ornamental crops	Bikash Das M.K. Dhakar P.K. Sarkar S. Gutam	2001	Long term	ICAR RCER
4.5	ICAR-RCER/ RCR/2012/**132**	Collection, characterization and evaluation of potentials wild edibles including tuber crops	R.S. Pan Bikash Das Reshma Shinde Anuradha Srivastava	Apr. 2013	Mar. 2018	ICAR RCER
4.6	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
4.7	ICAR-RCER/ DCR/ 2014/142	Evaluation and identification of rice genotypes for tolerance to drought stress at different growth stages.	Santosh Kumar N. Bhakta S. K. Dwivedi	July 2014	June 2018	ICAR RCER
4.8	ICAR-RCER/ DCR/ 2014/160	Breeding for submergence tolerance in rice	N. Bhakta Santosh Kumar S. K. Dwivedi	July 2014	June 2018	ICAR RCER
4.9	ICAR RCER/RC Ranchi/2015/171	Improvement of seed quality of solanaceous and cucurbitaceous vegetables	P. R. Kumar	Aug. 2015	July 2019	ICAR RCER
4.10	ICAR RCER/RC Ranchi/2015/172	Genetic improvement for yield and biotic stress resistance in pigeonpea under eastern plateau and hill region	P. Bhavana S. Maurya P.R. Kumar J.S. Chaudhary	Aug 2015	June 2019	ICAR RCER
4.11	ICAR RCER/RC Ranchi/2015/174	Collection, evaluation and development of bacterial wilt resistant germplasm of brinjal	P. Bhavana S. Maurya	Agu. 2015	July. 2019	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
4.12	—	Evaluation of different genotypes of water chestnut	Rajvir Sharma	2015	2020	ICAR RCER
Theme- 3. Improved Production and Protection Technologies for Agri-Horti Crops						
5. Production Technologies						
5.1	ICAR-RCER/ DC/ 2011/ **104**	Evaluation of different production system for Carbon sequestration potential	S. Mondal S.K. Naik S. Maurya Shivani	July 2011	June 2017	ICAR RCER
5.2	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
5.3	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 N. Chandra T.L.Bhutia	2013	2016	ICAR RCER
5.4	ICAR RCER/ RCM Darbhanga/2014/ 158	Sustainable crop intensification through the development of suitable plant type in cool season pulses under rice-fallow and makhana-fallow cropping stystem in Eastern India	A.K.Choudhary I.S. Singh	July 2014	June 2017	ICAR RCER
5.5	ICAR RCER/ RCM Darbhanga/2014/ 159	Development of value-added product of makhana.	A.K. Thakur I.S. Singh	July 2014	June 2017	ICAR RCER
5.6	ICAR RCER/ RCM Darbhanga/2014/ 156	Response of integrated nutrient management on the production potential of makhana crop growing under field condition in northern Bihar.	I.S. Singh Rajvir Sharma	July 2014	June 2017	ICAR RCER
5.7	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 S.K. Naik S. Maurya P. Sarkar	Aug. 2014	July 2017	ICAR RCER
5.8	ICAR-RCER/ RC Ranchi/ 2014/154	Study on decomposition rate of different organic substrate and their nutrient release pattern	Reshma Shinde S. Maurya	July 2014	June 2017	ICAR RCER
5.9	ICAR-RCER/ RC - Ranchi/ 2014 / **152**	Nutritional characterization and value addition of potential underutilized leafy vegetables of Jharkhand	Anuradha Srivastava R.S. Pan	Sept. 2014	Sept 2017	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
5.10	—	Integrated Weed Management (i) Integrated weed management in makhana (ii) Integrated weed management in direct seeded rice (iii) Integrated weed management for hill and plateau region	Rajvir Sharma Sanjeev Kumar Pradeep Sarkar	2015	2020	ICAR RCER
6. Protection Technologies						
6.1	ICAR-RCER/ RC Ranchi/ 2012 / **131**	Survey and surveillance of pest complex and their natural enemies on selected horticultural crops	J.S. Choudhary S. Maurya	Jan. 2013	Dec. 2015	ICAR RCER
6.2	ICAR-RCER/ DCR/ 2011/ **105**	Management of wilt complex of lentil through bio-agents coupled with host resistance	U.R. Sangle Sanjeev Kumar	Nov. 2011	Oct. 2015	ICAR RCER
6.3	ICAR RCER/RC Ranchi/2015/170	Fruit flies (Tephritidae: diptera) diversity and their host plant determination from eastern region of India.	J.S. Choudhary Md. Idris Ram Kewal (Associate)	July 2015	June. 2018	ICAR RCER
6.4	ICAR RCER/RC Ranchi/2015/167	Development and evaluation of disease suppressive potting mixtures in vegetable crops.	S. Maurya	July 2015	June. 2018	ICAR RCER
6.5	ICAR RCER/RC Ranchi/2015/162	Phenological monitoring of selected horticultural fruit crops	S. Gutam	July 2015	June. 2018	ICAR RCER
Theme- 4. Integrated Land & Water Management						
7.0 Land & Water Management						
7.1	ICAR-RCER / DLWM/2014/	Development of bio-drainage in participatory mode under waterlogged area	S.K. Singh S.K. Dwivedi Ajay Kumar	July 2014	June 2022	ICAR RCER
7.2	ICAR-RCER/ RC Ranchi/ 2014/149	Participatory management of rice-fallow in eastern plateau and hill region	A. K. Singh S.K. Singh B.K. Jha Bikash Das R S Pan S. Mondal Ajay Kumar S.K. Naik Reshma Shinde P. Bhavana S.S.Mali	July 2014	June 2017	ICAR RCER
7.3	—	Evaluation of Conservation Agricultural (CA) practices under Rice-fallow system of Eastern Region	Dr. J. S. Mishra	2015	2017	ICAR-Platform Research on CA

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
7.4	ICAR-RCER / DLWM /2014/	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
7.5	ICAR-RCER / DLWM/2014/	Flood and drought mapping in Eastern region	Manibhushan A. Upadhyaya	Sept 2014	Aug. 2017	ICAR RCER
7.6	ICAR-RCER / DLWM/2014/	Optimization of water productivity of aerobic rice based cropping system	S.K. Singh Ajay Kumar	July 2014	June 2017	ICAR RCER
7.7	ICAR-RCER / DLWM/ 2014/	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 B. Sarkar Bikas Das	Aug. 2014	July, 2017	ICAR RCER
7.8	ICAR-RCER /RC Ranchi/ 2014/148	Evaluation of hydrological response of micro water sheds in eastern plateau and hill region	Santosh Mali S.K. Naik P.K.Sarkar	Jan. 2015	June 2018	ICAR RCER
7.9	ICAR-RCER /RC Ranchi/ 2014/150	Rehabilitation of coal mine affected area of Jharkhand through agroforestry interventions	Pradip Kumar Sarkar Santosh Mali Mahesh Kumar Dhakar	Sept. 2014	Aug. 2019	ICAR RCER
7.10	—	Genetic improvement for yield and biotic stress resistance in pigeonpea under eastern plateau and hill region	P. Bhavana S. Maurya P.R. kumar J.S. Chaudhary	July 2015	June 2019	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 S. Bandopadhyay	Apr. 2011	Mar. 2015 Extd Sept 2015	ICAR RCER
8.2	ICAR-RCER / DLFM / 2011/ 106	Formulation of area specific mineral mixture for Bihar based on Soil-plant-animal continuum	A. Dey J.J. Gupta S.K. Naik Pankaj Kumar	Aug. 2011	July 2015 ExtdJuly 2016	ICAR RCER
8.3	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	Jan. 2013	Dec. 2015	DBT (Externally funded)
8.4	ICARRCER/ DLFM/ EF/2011/ **31**	Buffalo improvement	P.C. Chandran A. Dey Pankaj Kumar	June 2012	Dec. 2016	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
8.5	ICAR-RCER/ DLFM/ 2013/ 135	Characterization of lesser known breeds of farm animals in Eastern India	P.C. Chandran Shanker Dayal Reena Kumari Kamal	July 2013	June 2017	ICAR RCER
8.6	ICAR-RCER/ DLFM/ 2014/141	Management of heat stress in buffalo	S. Dayal	Jan. 2015	Dec. 2018	ICAR RCER
8.7	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
8.8	ICAR-RCER/ DLFM/ 2014/146	Development of herb-based calf care mix for production of disease free calf.	S.J. Pandian Pankaj Kumar P.C. Chandran Arun Kumar Das, IVRI-ERS, Kolkata	Oct. 2014	Sept. 2017	ICAR RCER
8.9	ICAR-RCER/ DLFM/ 2014/	Network Project on Animal Genetic Resource: Characterization of Red Purnea cattle.	P.C.Chandran Pankaj Kumar S.J. Pandian Reena Kumari Kamal	July, 2014	June, 2016	NBAGR, Karnal
8.10	—	Meso level animal health interventions and evaluating economic losses from animal diseases	Pankaj Kumar	Aug 2015	Aug 2018	ICAR RCER
8.11	—	Isolation and characterization of Fusarium species responsible for Degnala like disease in animals	S.K. Gupta	Aug 2015	Aug 2018	ICAR RCER
8.12	—	Evaluation and characterization of duck germplasm in Eastern region.	Reena Kumari Kamal	Aug 2015	Aug 2018	ICAR RCER
8.13	—	Identification, documentation and quantification of non conventional feed resources in traditional swine husbandry practices	Asit Chakrabarty	July 2015	July 2018	ICAR RCER
8.14	ICAR-RCER/ DLFM/ 2012/ 122	Evaluation of nutraceuticals as supportive therapy for subclinical mastitis in peri-urban cattle	Pankaj Kumar J.J. Gupta S. Dayal	Feb. 2013	Jan. 2016	ICAR RCER
8.15	ICAR-RCER/ DLFM/ 2012/ 123	Serological epidemiology of major viral pathogen of caprine in Bihar	Pankaj Kumar P.C. Chandaran K.K. Rajak, IVRI	Mar. 2013	Mar. 2016	ICAR RCER
8.16	ICAR-RCER/ DLFM/ 2012/ 124	Health monitoring and disease surveillance of farm animals	Pankaj Kumar P.C. Chandran	Mar. 2013	Feb. 2016	ICAR RCER
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 Ujjwal Kumar	Jan. 2013	Dec. 2015	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp. Year	Funding agency
Theme- 6. Socio-Economics, Extension and Policy Research						
10.0 Socio-economic Research						
10.1	ICAR-RCER/ DSEE/ 2012/ 127	Technology out-scaling for sustainable food production and livelihood improvement	Ujjwal Kumar Kamal Sarma A. Dey	Sept. 2013	Aug. 2015 Extd. Aug. 2016	ICAR RCER
10.2	ICAR-RCER/ DSEE/ 2012/	Impact assessment of agricultural technologies in Eastern India	N. Chandra R.C. Bharati Abhay Kumar A.K. Singh (Ranchi)	Aug. 2014	July 2017	ICAR RCER
10.3	ICAR-RCER/ DSEE/ 2014/	Growth and instability in production of principal crops in Bihar	Abhay Kumar	July 2014	June 2017	ICAR RCER

Approved as Activities during IRC 2015

Sl.No	Title of Activities	PI
1	Effect of sowing time on wheat Performance In Eastern India	A.K. Singh
2	Effect of Auxin and Zinc on Performance of Late Sown Lentil	A.K. Singh
3	Evaluation of bio-agent to control wilt complex of lentil	U.R. Sangle
4	Development of mass production of mushroom spawn	U.R. Sangle
5	Maintenance breeding of released varieties/parental lines of hybrids of vegetables	P.R. Kumar
6	Studies on litter decomposition of litchi	S. Maurya
7	Mass multiplication of Trichoderma	S. Maurya
8	Recycling of locally available biomass and its effect on soil fertility improvement in EPHR	S.K. Naik
9	Evaluation and improvement of existing Backyard Poultry production system	Asit Chakrabarty

ANNEXURE - I

Results-Framework Document (RFD) for ICAR Research Complex for Eastern Region (2014 - 2015)

Results-Framework Document (RFD)
for
ICAR Research Complex for Eastern Region
(2014 - 2015)

Address: ICAR Parisar, P.O. B.V. College, Patna-800 014
Website ID: http://www.icarrcer.in

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 productivity and profitability.
- 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 productivity and profitability	60	Integrated farming system including wetland rehabilitation	IFS models developed/tested/ refined	No.	20	5	4	3	2	1
			Collection, conservation and evaluation of germplasm	Germplasm of agri-horti crops, animal breed and fish species collected, conserved and evaluated	No.	20	6	5	4	3	2
			Development of production technologies for different components	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	20	Transfer of technology	FLDs/OFTs conducted	No.	10	32	27	22	17	12
			Creation of awareness and knowledge	Training programmes organized	No.	10	72	60	48	36	24
*	Publication/Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	30	27	24	21	18
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30, June 2014	02, July 2014	04, July 2014	07, July 2014	09, July 2014
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20,2014	May 21, 2014
			Timely submission of Results for 2013-2014	On-time submission	Date	1	May 1 2014	May 2 2014	May 5 2014	May 6 2014	May 7 2014
*	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80
*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	Nov.2 2014	Nov.3 2014	Nov.4 2014	Nov.5 2014
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of Implementation	%	1	100	90	80	70	60
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80
			Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	2	100	90	80	70	60

Section 3: Trend Values of the Success Indicators

S. No.	Objectives	Actions	Success Indicators	Unit	Actual Value for FY 12/13	Actual Value for FY 13/14	Target Value for FY 14/15	Projected Value for FY 15/16	Projected Value for FY 16/17
1	To undertake strategic and adaptive research for efficient and integrated management of natural resources to enhance agricultural productivity and profitability	Integrated farming system including wetland rehabilitation	IFS models developed/ tested/ refined	No.	3	5	4	3	3
		Collection, conservation and evaluation of germplasm	Germplasm of agri-horti crops, animal breed and fish species collected, conserved and evaluated	No.	9	6	5	6	6
		Development of production technologies for different components	Technologies developed for enhancing input use efficiencies and improving livestock & fish production	No.	8	5	4	5	6
2	Human resource development and capacity building	Transfer of technology	FLDs/OFTs conducted	No.	23	25	27	30	30
		Creation of awareness and knowledge	Training programmes organized	No.	57	60	60	70	70
*	Publication/Documentation	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	24	38	27	30	30
		Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	-	-	02.07.2014	-	-
*	Fiscal resource management	Utilization of released plan fund	Plan fund utilized	%	100	100	96	96	96
*	Efficient Functioning of the RFD System	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	-	-	May 16, 2014	-	-
		Timely submission of Results for 2013-2014	On-time submission	Date	-	-	May 2, 2014	-	-
*	Enhanced Transparency / Improved Service delivery of Ministry/ Department	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	-	-	95	-	-
		Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	-	-	95	-	-
*	Administrative Reforms	Update organizational strategy to align with revised priorities	Date	Date	-	-	Nov.2, 2014	-	-
		Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC)	% of Implementation	%	-	-	90	-	-
		Implementation of agreed milestones for ISO 9001	% of implementation	%	-	-	95	-	-
		Implementation of milestones of approved Innovation Action Plans (IAPs)	% of implementation	%	-	-	90	-	-

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 farming 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 assessment 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 structured 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 structured 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

Annual (April 1, 2014 to March 31, 2015) Performance Evaluation Report in respect of RFD 2014-2015 of RSCs i.e. Institutes

Name of the Division: Natural Resource Management
Name of the Institution: ICAR-ICAR Research Complex for Eastern Region
RFD Nodal Officer of the RSC: Dr. Abhay Kumar

S.No.	Objective (s)	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achieve-ments	Performance		Per cent achievements against Target values of 90% Col.	Reasons for short-falls or excessive achievements, if applicable
							Excel-lent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weight-ed Score		
1.	To undertake strategic and adaptive research for efficient and integrated management of natural resources to enhance agricultural productivity and profit-ability	60	Integrated farming system including wetland rehabilitation	IFS models developed/ tested/ refined	No.	20	5	4	3	2	1	5	100	20.0	125.0	The target in 90% column is not the 10% deduction in actual target in numerical terms but it is simply a deliberate reduction by at least 1 by target proposed. That's why, if the target (90%) is reduced by 1, the actual achievements shows 125% of this column.
			Collection, conservation and evaluation of germplasm	Germplasm of agri-horti crops, animal breed and fish species collected, conserved and evaluated	No.	20	6	5	4	3	2	6	100	20.0	120.0	
			Development of production technologies for different compo-nents	Technologies developed for enhanc-ing input use efficiencies and improving live-stock & fish production	No.	20	5	4	3	2	1	5	100	20.0	125.0	
2.	Human resource development and capacity building	20	Transfer of tech-nology	FLDs/OFTs conducted	No.	10	32	27	22	17	12	52	100	10.0	192.6	20 FLD/OFTs were sponsored during kharif/ Rabi sea-son on different crops by Deptt. of Agriculture, & Animal Husband-ry, Govt. of Bihar and Jharkhand, ATMA and led to excess achieve-ments.

			Creation of awareness and knowledge	Training programmes organized	No.	10	72	60	48	36	24	77	100	10.0	128.3	5 excess training programmes were sponsored by different department of Govt. of Bihar & Jharkhand and led to excess achievements
*	Publication/ Documentation	5	Publication of the research articles in the journals having the NAAS rating of 6.0 and above	Research articles published	No.	3	30	27	24	21	18	30	100	3.0	111.1	-
			Timely publication of the Institute Annual Report (2013-2014)	Annual Report published	Date	2	30 June 2014	02 July 2014	04 July 2014	07 July 2014	09 July 2014	16 July 2014	100	2.0	-	-
*	Fiscal resource management	2	Utilization of released plan fund	Plan fund utilized	%	2	98	96	94	92	90	100	100	2.0	-	-
*	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD for 2014-2015 for Approval	On-time submission	Date	2	May 15, 2014	May 16, 2014	May 19, 2014	May 20, 2014	May 21, 2014	May 03, 2014	100	2.0	-	-
			Timely submission of Results for 2013-2014	On-time submission	Date	1	May 1, 2014	May 2, 2014	May 5, 2014	May 6, 2014	May 7, 2014		100	1.0	-	-
*	Enhanced Transparency / Improved Service delivery of Ministry/Department	3	Rating from Independent Audit of implementation of Citizens' / Clients' Charter (CCC)	Degree of implementation of commitments in CCC	%	2	100	95	90	85	80	100	100	2.0	-	-
			Independent Audit of implementation of Grievance Redress Management (GRM) system	Degree of success in implementing GRM	%	1	100	95	90	85	80	100	100	1.0	-	-

*	Administrative Reforms	7	Update organizational strategy to align with revised priorities	Date	Date	2	Nov.1 2014	Nov.2 2014	Nov.3 2014	Nov.4 2014		Oct. 31, 2014	100	2.0	-	-
			Implementation of agreed milestones of approved Mitigating Strategies for Reduction of potential risk of corruption (MSC).	% of Implementation	%	1	100	90	80	70	60	100	100	1.0	-	-
			Implementation of agreed milestones for ISO 9001	% of implementation	%	2	100	95	90	85	80	100	100	2.0	-	-
			Implementation of milestones of approved Innovation Action Plans (IAPs).	% of implementation	%	2	100	90	80	70	60	100	100	2.0	-	-

Total Composite Score: 100.0

Rating: Excellent

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

स्वच्छ भारत
एक कदम स्वच्छता की ओर