Annual Report
2017-18

भाकृअनुप
ICAR

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

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Preface

It is a great pleasure for me to present the 17th Annual Report of ICAR Research Complex for Eastern Region, Patna for the year 2017-18, highlighting the significant research achievements and activities of the Institute. The Institute undertakes multi-commodity and multi-disciplinary research to enhance the productivity of agricultural production systems, efficient management of available natural resources and dissemination of developed technologies in diverse agro-climatic zones of eastern region.

During the period under report, the research, extension and agricultural development activities continued to gain momentum. For achieving the goal of doubling farmers' income by 2022, efforts are being made to disseminate the technologies developed by the Institute to the farmers and other stake-holders. Further, emphasis has been given on management of fallow land, conservation agriculture, crop diversification, varietal development for stress tolerance, water productivity enhancement, ergonomic studies of farm tools, weed management, restoration of degraded lands, solar energy application in agriculture, etc. 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. Host-pest interaction and its dynamics in mango have been studied under climate change scenario in different states of eastern region.

To strengthen the plant genetic resource management, promising genotypes of different fruits like, mango, sapota, tamarind, jackfruit and improved lines of makhana, water chestnut, solanaceous vegetable and pulses like pigeonpea, lentil, chickpea and grass pea have been identified. In the field of agro-biodiversity conservation, several germplasm of tuber crops have been collected from Chhattisgarh, Jharkhand, Odisha and West Bengal. Besides, two Pulse Seed Hub for quality seed production of pulses have been created at Patna and Buxar. Characterization of lesser known farm animals and duck germplasm in eastern region is being done. Studies on improving the performance of non-descript buffalo by selecting genetically superior Murrah bulls has been undertaken. Cattle-fish integration has been found most suitable for improving fish productivity.

The institute has also been providing technological support to the farmers, extension workers and state officials through its extensive extension net work. A total of 148 training programmes, 50 Front Line Demonstrations, 45 On Farm Trials have been conducted for the farmers and the state government officials. Thirty seven villages of six districts of Bihar and Jharkhand were covered under *Mera Gaon Mera Gaurav* to make the farmers aware of improved technologies. During the period under report, the institute has published 122 nos. of research papers in the journal of national and international repute, 02 books, 28 book chapter, 01 training manual, 02 extension bulletins, and 33 popular articles. A Policy Document on 'Doubling Farmers' Income of Bihar by 2022' was also prepared.

I place on record my sincere gratitude to Dr. T. Mohapatra, Secretary DARE and Director General, ICAR for his unstinted guidance and support in executing the mandate of the Institute. The encouragement, valuable guidance and support rendered by Dr. K. Alagusundaram, DDG (NRM) is duly acknowledged. I express my gratefulness to Chairman and Members of Research Advisory Committee for critical assessment and improving the research programme. All Heads of the Divisions/Research Centres deserve appreciation for submitting their research findings in time. I also express my appreciation to the editorial team and other staff members of the Institute for their efforts and cooperation in bringing out this report.

(B.P. Bhatt)
Director
ICAR-RCER

Content

1. Executive Summary

- Twenty four rice genotypes were evaluated under dry direct-seeded condition for drought stress tolerance at various growth stages. Seven genotypes *viz*., IR84899-B-179-16-1-1-1 (Swarna Shreya), IR84898-B-168-24-1-1-1, IR84899-B-183-CRA-19-1, IR84894-143-CRA-17-1, IR83929-B-B-291-2-1-1-2, IR84899-B-182-3-1-1-2 and IR88964-24-2-1-4 with productivity range of 2.43-2.87 t/ha have been found promising for multi-stages drought stress condition compared to Sahbhagi Dhan (1.91t/ha) and IR 64 (0.857 t/ha) .
- Six genotypes *viz*., IR84899-B-179-16-1-1-1, IR84899 -B-179-13-1-1-1, IR84899-B-182-3-1-1-2, IR84898-B-168-24-1-1-1, IR84899-B-183-CRA-19-1 and IR83929-B-B-291-2-1-1-2 have been found promising for vegetative stage drought tolerance with productivity range of 3.36-3.93 t/ha compared to Sahbhagi Dhan (2.56 t/ha).
- Rice genotypes TP30495, TP30194 and TP30505 were found to have submergence tolerance for 21 days as compared to Swarna sub1 which was completely damaged.
- Sixteen genotypes were screened for cold tolerance at seedling stage during *boro* season. Only one genotype TP30752 (IRTON 103) was found to be highly cold tolerant.
- The maximum concentration zinc (38.8-40.4 mg/kg) in rice grain was recorded with soil application of zinc sulphate at 25 kg/ha + foliar spray (0.5% zinc sulfate) at 30 and 45 days after sowing.
- Chickpea genotypes 'DBGC 1' (2880 kg/ha) and 'DBGC 3' (2860 kg/ha) with 100 seed wt of 31 g and 24 g, respectively have been found promising for the North East Plain Zone. Similarly lentil genotype 'DBGL 135' with seed yield of 2184 kg/ha and grass pea genotype 'RCEGP 16-2' (1288 kg/ha) were found promising for this region.
- Significant effects of the treatments on basin enrichment were recorded in organic carbon in the soil. At 0-15 cm soil depth, mulching of Subabul resulted in significantly higher organic carbon content (0.73%) over control (0.48%) whereas at 15-30 cm soil depth, soil incorporation of rice bean biomass resulted in significantly higher organic carbon (0.70%) over control (0.39%).
- Shoot bending technique in guava increased the production of lateral new shoots by 6 times and flower emergence by 14 times over control.
- A total of 256 germplasm of tuber crops and wild edibles collected through survey in Jharkhand, Chhattisgarh, Nagaland, Odisha and West Bengal were multiplied in the field for characterization and evaluation.
- Colocasis lines ACC-118 and ACC 280, elephant foot yam ACC 136 and ACC 204, cassava line ACC 139, greater yam line ACC 113 and yam bean genotype HAYB-1 were found promising for yield, nutritional, anti-nutritional, and biotic stress traits..
- *Tricoderma asperellum* + vermicompost and consortial root dip showed minimum blackleg disease infested plant of cabbage.
- Of the 28 makhana germplasm evaluated at RC, Darbhanga, Superior Selection-1 with maximum yield of 6.13 t/ha and early maturing (3.75 months) was found promising for the wet land ecosystem of North Bihar.
- In Integrated farming System, maximum energy efficiency was recorded with crop + fish + poultry integrations.
- The highest system annual productivity (SREY) was recorded with maize cob-pigeonpea (22.41 t/ha) system followed by sorghum fodder-mustard-urdbean (15.97 t/ha) and soybean-maize (13.31 t/ha) systems.
- The highest water productivity of 6.23, 13.40 and 3.75 kg/m^3 was obtained in case of cabbage, cauliflower and broccoli, respectively under drip irrigation with polythene mulch in Eastern Plateau & Hill region.
- In rice-lentil-greengram cropping system, the productivity of lentil and greengram in ZT was on a par with CT. Irrigation scheduled at IW CPE raio (W3) produced significantly higher seed yield (1.28 t/ha) and water productivity (2.08 kg/m^3) in lentil as compared to W1 (0.97t/ha). In case of greengram, the highest seed yield (2.17/ha) was recorded with IW: CPE = 0.6.
- In rice-fallows, the productivity of chickpea, lentil and mustard was higher after puddle transplant

rice. However, linseed and safflower produced maximum after ZT-DSR. Higher seed yields of winter crops was recorded in 30% residues retention as compared to control.

- Lentil cv. Pusa Masoor 5 (1560 kg/ha), Vaibhav (1517 kg/ha) and DPL 15 (1507 kg/ha), and linseed cv. Uma (1209 kg/ha) were promising in rice fallows under zero tillage system.
- A long-term study on effect of CA practices in rice-wheat system revealed that in 8th year rice yield under DSR (conventional or zero till) declined significantly as compared to conventional puddle transplanted conditions due to heavy attack of rice mealy bug (5-8/plant) under scenario 4 (S4) due to severe infestation of grassy weeds like *Brachiaria* spp. Again puddling and transplanting of ZT field yielded maximum (7.97 t/ha) followed by UPTR (6.73 t/ha), CT DSR (4.5 t/ha), ZT DSR (3.58 t/ha).
- A spray type solar aerator was developed with 900Wp solar array and 750W induction motor pump and installed in fishpond of 30 m x 40 m with 1.5 m of water depth. For 6 to7 hours day time operation there was 23-28% increase in dissolved oxygen over the controlled value of 4.0 - 4.4 ppm in middle water layers. The fish weight increased to150-175 g compared to control (100 -125g) in one month period.
- An ergonomic study in SRI revealed that rolling marker recorded the lowest energy expenditure (4.71 kJ/s) and cardiac cost (5.62 beats/m^2) as compared to line marker. The rolling marker could save 19% drudgery and increased efficiency by 16%.
- In buffalo improvement programme, the average lactation yield, lactation length, service period and calving interval of Murrah buffaloes were recorded at 1486.25±10.82 kg, 276.44±5.34 days, 212.83±9.18 days and 487.18±5.88 days, respectively.
- Ghungroo, an indigenous breed of pig, was characterized in its home tract of Alipurduar district of West Bengal. The study indicated that the average body weights of Ghungroo pigs at 1, 3, 6, 9 and 12 months of ages were found to be 7.12±0.12 kg, 18.20±0.23 kg, 45.67±0.28 kg, 81.04±0.33 kg and 92.58±0.68 kg, respectively. The average litter size was 11.18 at birth and 10.56 during weaning. Age at sexual maturity was 11.36 months whereas interval between two parturition was 5.12 months.
- Lactation milk yield of Sahiwal cattle was recorded at 2400 kg with individual peak yield of 14.5 kg/d. Incidence of mastitis in Sahiwal cattle was recorded nil in comparison to crossbred (HF x deshi) cattle (14.7%).
- Under round the year fodder production programme, maximum annual fodder yield was recorded in multicut sorghum-berseem crop rotation (108.53 t/ha) that could sustain almost 15 adult cattle unit /ha round the year.
- Soil-plant-animal continuum studies revealed that crop residues and concentrate feed in Jharkhand were deficient in phosphorus (0.06 -0.25%). Zn was deficient in all kinds of feeds and fodder including tree leaves (18.1- 25.62 ppm).
- Carcass characteristics of different indigenous ducks collected from Bihar, Jharkhand, West Bengal and Odisha were evaluated and compared with Khaki Campbell ducks. The study revealed that body weight of Pekin ducks (1794.2± 45.52 g) at 150 d of age was significantly higher than Khaki Campbell (1319 ± 32.30 g) and all indigenous duck germplasm (1288.4 ± 14.6 g).
- Various integrated fish farming models showed the highest fish productivity in cattle-fish integration (5.05 t/ha) followed by pig-fish integration (3.97 t/ha) and buffalo-fish integration (3.57 t/ha).
- In integrated fish farming models, annual average plankton density was recorded to be the highest in fish-pig integration (1152.08 no./lit) follwed by fish-duck (830.21 no./lit.) and fish-poultry (741.67 no./lit.) integrations. The lowest plankton population was recorded in fish-cattle integration i.e 639.58 no./lit.
- Under the Pulse Seed Hub project, quality seed of around 11.3 t lentil (HUL 57, KLS 218), 2 t field pea (HUDP 15, Swarna Mukti), 41.3 t chickpea (Pusa 547, Shubhra), 2.5 t mung bean (Samrat, IPM 02-3, IPM 02-14) was produced. In addition, 3.4 t vegetable seed, 0.45 t makhana, 4.2 t mushroom spawn and 33000 nos. of quality planting materials of fruits and trees was also produced.
- During the period under report, the Institute published 122 nos of research papers in journals of national and international repute, 02 books, 28 book chapters, 02 technical extension bulletins, 01 training manual and 33 popular articles. A Policy Document on 'Doubling Farmers' Income of Bihar by 2022' was prepared.
- During the year 2017-18, thirty seven villages of six districts of Bihar and Jharkhand were covered under *Mera Gaon Mera Gaurav*, and 852 farmers were directly benefitted through various activities like training, demonstration, supply of quality planting materials, etc.
- Further, total of 148 training programmes, 50 Front Line Demonstration and 45 On Farm Trials have been conducted for the farmers and the State Government officials.

2. Introduction

Historical Perspective

The Eastern region comprises of plains of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha and West Bengal, representing 21.85% of the geographical area of the country and supporting 33.62% of country's population. In spite of the natural resource endowments in terms of fertile soils, water resources and solar radiation, the productivity and per capita income of the farmers in the Eastern region is very low due to erratic climate variations, population explosion, land degradation, small and scattered land holdings, lack of quality seed and planting materials, poor extension mechanism, etc. However, the Eastern region of the country holds promise for a Second Green Revolution, which can be accomplished through holistic management of land, water, crops, biomass, horticultural, livestock, fishery and human resources. Though Eastern region is rich in natural resources, its potential could not be harnessed in terms of improving agricultural productivity, poverty alleviation and livelihood improvement.

ICAR Research Complex for Eastern Region (ICAR-RCER), Patna came into existence on the 22nd February 2001 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. Geographically, the Institute is located at 25°35'30" N latitude, 85°05'03" E longitude, at an altitude 52 m above mean sea level.

The mandates of the Institute are:

- 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 are:

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

The complex has four divisions besides two research centres and two KVKs. The organizational setup of the complex is given in Fig. 2.1.

Finance

Summary of allocation and expenditure during the financial year 2017-2018 of the complex is presented below (Table 2.1).

Table 2.1. Financial allocation and expenditure during the year 2017-18 (Rs. in Lakhs)

Head of accounts	Budget allocation	Actual expenditure
Establishment charges	2051.50	2050.99
T.A.	22.50	22.27
HRD	3.50	2.57
Works	30.00	15.95
Other charges	1132.50	1026.40
Total	3240.00	3118.18

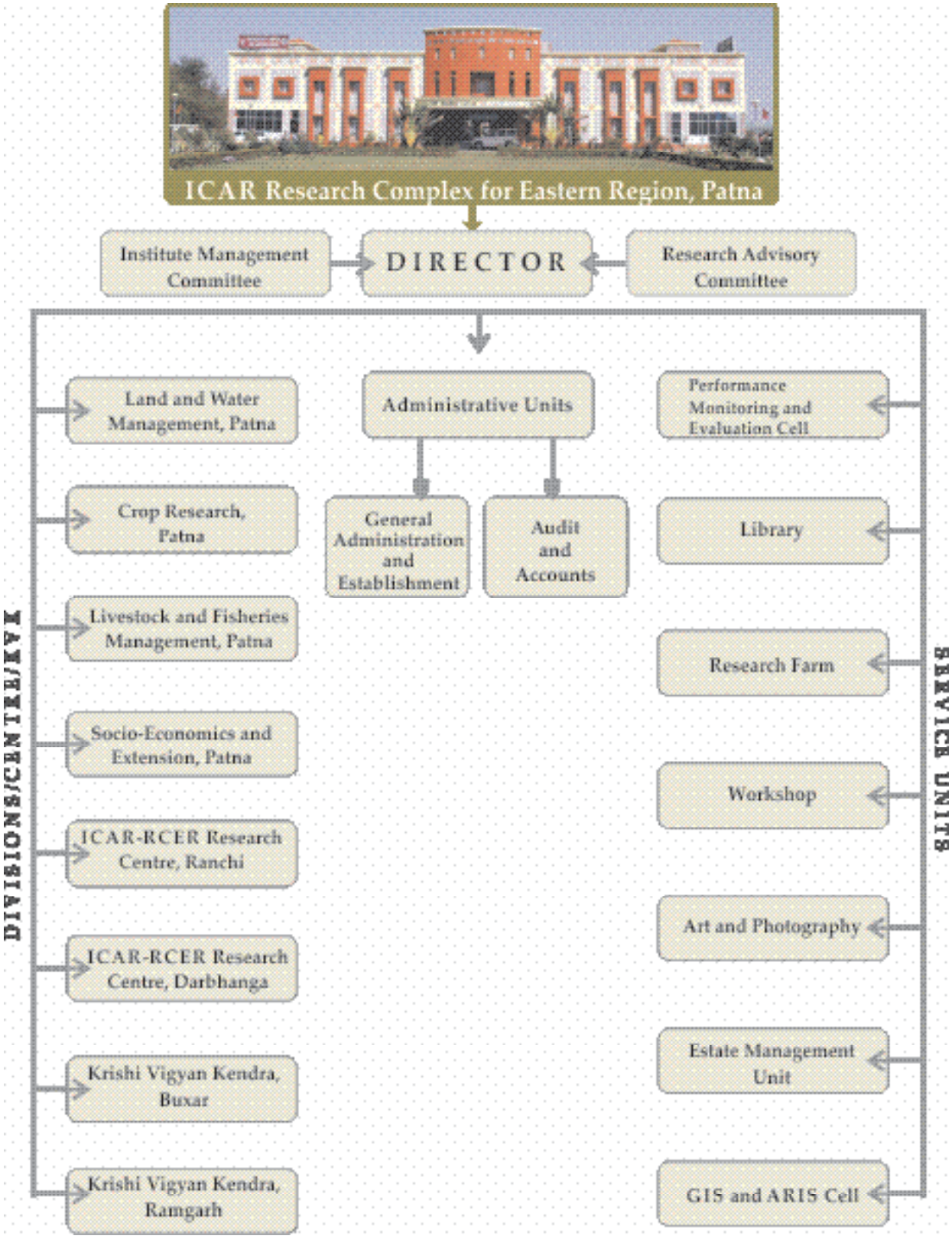

Fig. 2.1. Organogram of ICAR Research Complex for Eastern Region, Patna

3. Weather

Weather parameters *viz.* air temperature, relative humidity, bright sunshine hours, rainfall, pan evaporation, wind speed and direction were recorded twice in a day at ICAR-RCER, Patna and RC, Ranchi. At Patna, mean monthly maximum temperature ranged from 21.8°C (January) to 36.1°C (April) showing that April month was the warmest month for year 2017 (Table 3.1). Similarly the mean monthly minimum temperature varied from 10.4°C (January) to 27.4°C (June), depicting January as the coldest month for 2017. However, the average minimum temperature for the year (20.6°C) was 1°C higher than the normal (19.6 °C). Mean monthly relative humidity was found to be the lowest in April (53.6%) and the highest in August (81.5%). It was also observed that relative humidity reaches its peak during monsoon months (June to September) while summer months (March to May) were recorded as driest months of the year with least relative humidity, less number of rainy days and a significant amount of water loss from the soil as evaporation. Mean monthly bright sunshine hours (BSSH) were relatively more during February (6.7 hrs.) and the least during December (1.6 hrs) due to the persistent foggy atmospheric conditions. Presence of clouds during monsoon months resulted into less number of BSSH whereas it was fairly good enough during summer months as the sky was devoid of any atmospheric obstructions. During post-monsoon and winter seasons mean monthly wind speed was reported as "light air" with the minimum wind speed of 2.0 km/hr in November and reached a peak of 9.4 km/hr in April. These mean monthly variations for 2017 have also been depicted in Fig 3.1.

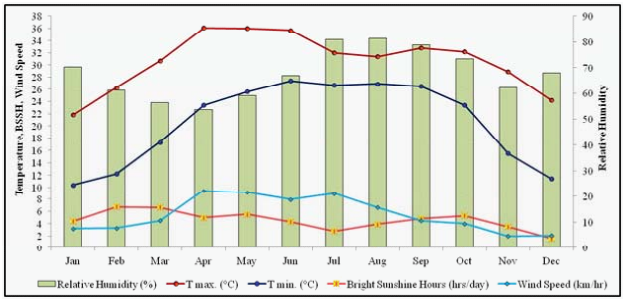

Fig. 3.1. Mean monthly variation of weather parameters during 2017

Table 3.1. Mean monthly weather data of 2017 at ICAR-RCER, Patna

Month	Mean Temperature (°C)				Mean Relative Humidity (%)	Mean Bright Sunshine Hours (hrs/day)	Total Rainfall (mm)		Total Rainy days	Total Pan Evaporation (mm)	Mean wind Speed (km/hr)
	Max.	Normal	Min.	Normal			Observed	Normal			
January	21.8	23.0	10.4	9.3	70.3	4.4	1.0	20.4	0	49.1	3.2
February	26.3	26.1	12.2	11.6	61.3	6.7	0.0	11.1	0	74.2	3.3
March	30.7	32.4	17.3	16.4	56.5	6.6	11.4	11.4	1	152.0	4.5
April	36.1	37.4	23.4	22.1	53.6	5.0	6.6	9.0	1	263.3	9.4
May	36.0	38.4	25.6	25.1	59.2	5.5	29.0	35.6	3	250.5	9.1
June	35.7	36.7	27.4	26.7	66.9	4.3	119.5	141.1	6	206.7	7.9
July	32.0	32.9	26.7	26.1	81.1	2.8	315.6	319.2	15	119.0	8.9
August	31.4	32.5	26.9	26.1	81.5	3.9	319.9	279.0	12	106.5	6.6
September	32.8	32.2	26.5	25.3	78.9	4.8	68.5	212.6	5	112.9	4.5
October	32.2	31.7	23.4	21.6	73.4	5.3	16.1	72.3	2	101.2	4.0
November	28.9	28.9	15.5	14.8	62.3	3.5	0.0	8.2	0	83.9	2.0
December	24.2	24.6	11.4	10.1	67.9	1.6	0.0	7.4	0	49.9	2.1
Annual	**30.7**	**31.4**	**20.6**	**19.6**	**67.7**	**4.5**	**887.6**	**1127.3**	**45**	**1569.2**	**5.5**

Year 2017 was reported as a deficit year for the total amount of rainfall. The total amount of rainfall received during the year was 887.6 mm which was only 78.74% of long period rainfall average (1127.3 mm) for the station. As per the IMD's guidelines when the amount of total rainfall received is less than 90% of the long period average (LPA) it is reported as "Deficit". The similar situation was also observed during four monsoon months from June to September as it was only 823.5 mm in spite of 951.9 mm as the long period average for monsoon months showing a deficit of 13.49%. Winter season received no rainfall. A comparative analysis of total monthly rainfall received, normal rainfall as a LPA and water loss from surface as evaporation has been depicted in Fig 3.2. Number of total rainy days were recorded maximum in July (15 Nos.) while it was 45 days only for the whole year. Total pan evaporation in 2017 was 1569.2 mm. The lowest evaporation (49.1 mm) was recorded in the month of January and the highest (263.3 mm) in April.

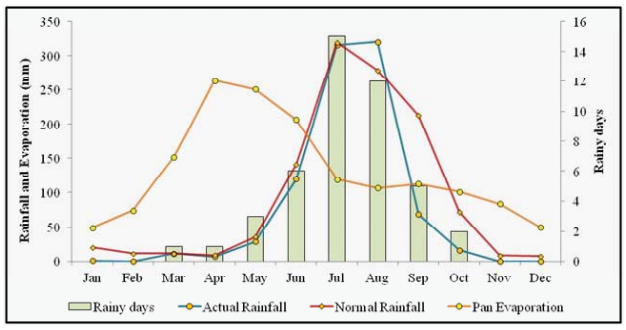

Fig. 3.2. Comparative analysis of total monthly rainfall, normal rainfall, rainy days and evaporation

Fig 3.3 shows the comparison of mean monthly maximum and minimum temperatures over the normal values of temperature. Data clearly revealed a maximum deviation of -2.4 °C during May. Similarly for mean monthly minimum temperature a deviation of +1.8 °C was observed over the normal during October. In totality for the year 2017, minimum temperature remained above normal with the overall deviation of +1.0 °C. Similar trends of higher minimum temperatures have been reported in past years, indicating that the minimum temperature is increasing gradually.

Extremes in weather variables for 2017 have also been recorded in Table 3.2, where 22nd May was recorded as the warmest day of the year (42.0°C) and 14th January was the coldest day (4.4

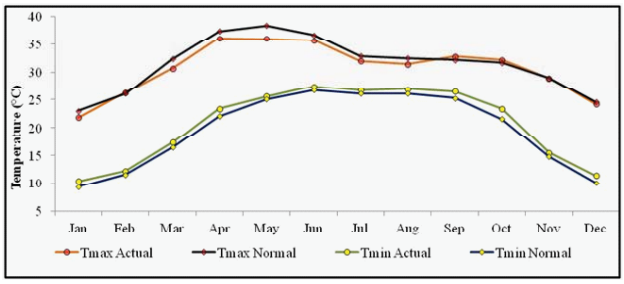

Fig. 3.3. Comparison of mean monthly maximum and minimum temperatures over the normal values

Table 3.2: Extremes of weather observed during 2017

Parameter	Date	Value
Warmest day	22st May 2017	42°C (Tmax)
Coldest day	14th January 2017	4.4°C (Tmin)
Most Humid day	10th July 2017	96% (RH)
Least humid day	26th April 2017	29% (RH)
Most rainy day	9th July 2017	75.2 mm (Rainfall)
Most shiny day	19th August 2017	10 hrs 36 min (BSSH)
Most windy day	9th July 2017	22.23 km/hr (Wind speed)

°C). Maximum amount of rainfall in a day (75.2 mm) was recorded on 9th May with the highest wind speed (22.23 km/hr. Maximum bright sunshine hours (10 hrs 36 min) was recorded on 19th August.

At Ranchi, total annual rainfall for the year 2017 was 1386 mm which was very close to the normal rainfall (1398 mm). Monsoon months (June-September) received 90.7% of annual rainfall. Rainfall during the months of June and October was about 73 and 15% higher than the normal rainfall of the respective months while rainfall in all other months was slightly below the normal. Comparison of monthly rainfall received with the monthly

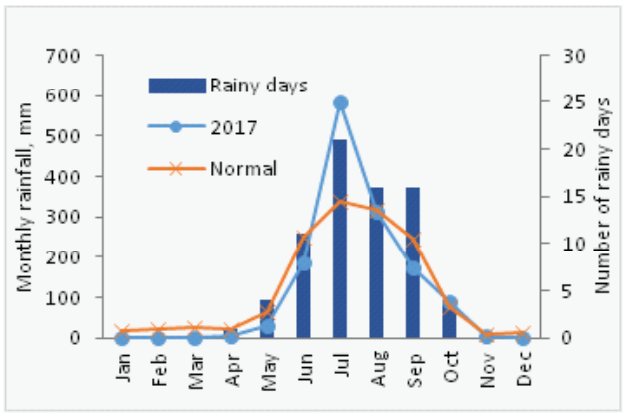

Fig 3.4. Comparison of monthly normal rainfall with monthly rainfall for the year 2017

normal rainfall is presented in Fig. 3.4. The relative humidity (RH) ranged from 84.3 to 91.8%. Summary of the monthly climatic parameters has been presented in Table 3.3. A total of 73 rainy days were recorded during 2017, of which 64 rainy days occurred during the monsoon season. The month of July recorded maximum (21) number of rainy days. Trends of the mean monthly maximum and minimum temperature at Ranchi have been presented in Fig 3.5. During 2017, January was the coldest month with mean monthly minimum temperature of 9.6°C while May was the hottest month with mean maximum temperature of 38.4°C.

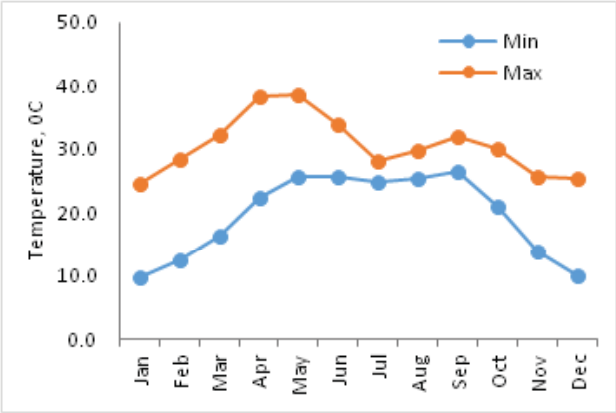

Fig. 3.5. Mean monthly minimum and maximum air temperature during 2017

Table 3.3. Mean monthly weather parameters at ICAR-RCER, Research Centre Ranchi for 2017

Month	Average temperature (°C)		Mean relative humidity (%)	Monthly rainfall (mm)
	Minimum	Maximum		
Jan	9.6	24.5	85.8	0
Feb	12.4	28.5	85.3	0
Mar	16.3	32.1	86.1	0
Apr	22.4	38.1	84.3	6
May	25.7	38.4	88.3	32
Jun	25.6	33.9	89.1	188
Jul	24.7	28.1	91.8	583
Aug	25.4	29.6	91.1	311
Sep	26.5	32.0	90.7	175
Oct	20.9	29.9	91.0	88
Nov	13.8	25.5	88.3	4
Dec	10.1	25.4	87.0	0
Average	19.5	30.5	88.2	1386*

*Total annual rainfall

4. Climate Change

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

Invasion potential of indigenous restricted mango fruit borer in India

Mango fruit borer [*Citripestis eutraphera* (Meyrick)], originally confined to Andaman Islands is a recent invasion in mainland of India. With changes in climatic conditions, the pest is likely to spread in most of the mango growing areas of the country, and pose serious threat to mango production. In this backdrop, we attempted to delineate the potential distribution of invasive *C. eutraphera* in India under different climate change scenarios using modeling approach in MaxEnt. Data on current climatic and future conditions (HADGEM2-AO GCM) of 19 'bioclimatic' variables were extracted from the WorldClim database, version 1.4 (http://www.worldclim.org/) at a spatial resolution of 2.5 arc min (approx. ~ 5 km resolution at the equator). The potential distribution of pest was defined by integration of point data on current occurrence of pest in India and corresponding bioclimatic variables in the MaxEnt. Spatial analysis tool in ArcGIS (version10.1) was used for mapping the predicted distributions. Isothermality (mean diurnal range/temperature annual range) and temperature seasonality were the predominant variables affecting *C. eutraphera* distribution. It was found that mango growing pockets of South-Western part of Gujarat, part of Kerala and Tamil Nadu states were moderately to highly suitable for *C. eutraphera* distribution in the year 2050 and 2070 (Fig. 4.1). The findings of the present study could be an important guide for selecting monitoring and surveillance sites and designing integrated pest management policies in the context of climate change against this invasive pest insect of mango.

Predicted potential impact of climate change on habitat suitability for fruit fly

Fruit fly (*Bactrocera correcta*) is the one of most economically damaging insect pest of mango, and its management is a key priority for plant protection. Species distribution model (MaxENT) was used, to map suitable habitat for this fruit fly under current climate and for 2050 and 2070

(A)

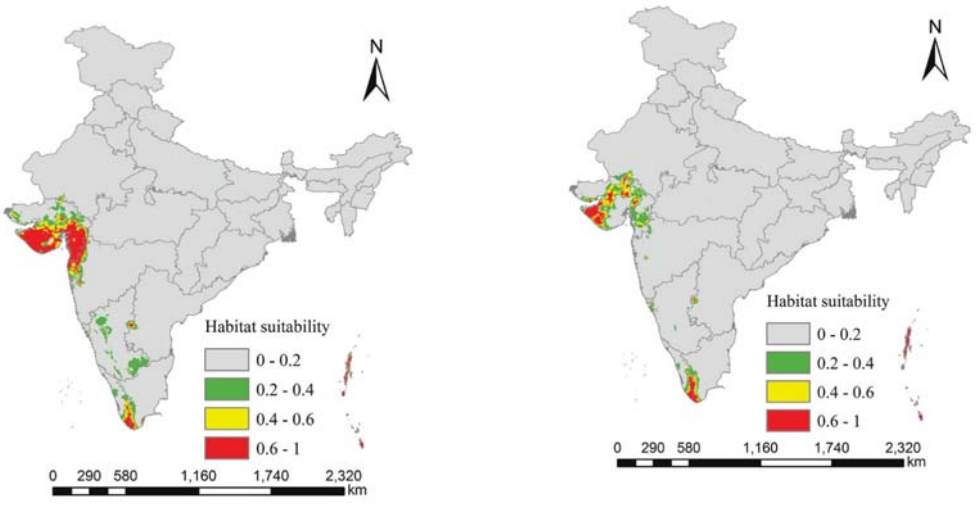

Fig.4.1. Future distribution models map of *C. eutraphera* in India under climate change scenarios RCP 8.5-2050 (A) and RCP 8.5-2070 (B). Gray = unsuitable habitat area; Green = low habitat suitability area; Orange = moderate habitat suitability area; Red = highly habitat suitability area.

climate change scenarios. Only ten bioclimatic variables and the model predictions matched with the available data of *B. correcta* occurrence. Temperature seasonality, precipitation of driest month and annual precipitation were the strongest contributors for prediction of *B. correcta*. Jackknife test was done for evaluating importance of each variable (Fig. 4.2A). The environmental variables with higher training gain were isothermality and temperature seasonality, which therefore appears as important for prediction. The AUC plot shows that the temperature seasonality had the highest AUC and was the most effective single variable for predicting the distribution of the occurrence data that was set aside for testing. (Fig. 4.2B). Relative importance of temperature seasonality was also noticeable in training gain plots where it was approximately similar with isothermality.

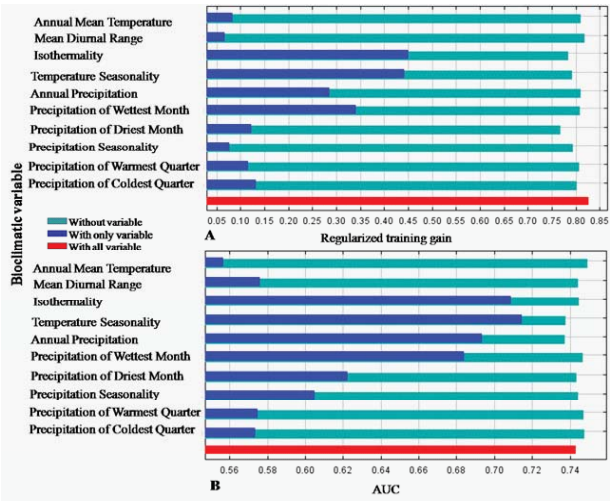

Fig. 4.2. Relative importance of bioclimatic variables based on results of jackknife tests in the development of MaxEnt. Graphics show variable contributions to (A) regularized training gain and (B) AUC (area under the ROC curve).

Results revealed that south-western India and some part of northern India are currently suitable for *B. correcta* (Fig. 4.3A). There is an agreement that currently suitable area will remain so until 2070 along with part of north India (Fig. 4.3B). The research outputs highlights the need for long-term vigilance across northern part of India to prevent further range expansion of this species.

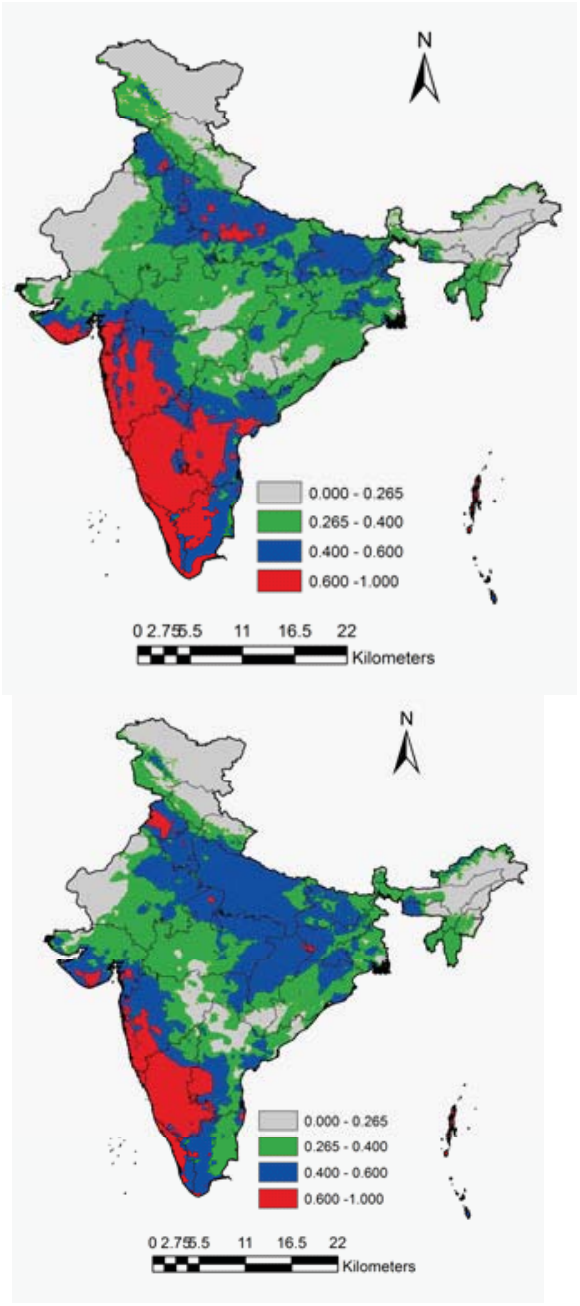

Fig. 4.3. (A) current and (B) future distribution map of *B. correcta* in India based on presence data and bioclimatic variables using Species distribution model.

5. Cereals

RICE

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

Twenty four rice genotypes were evaluated during *Kharif* 2017 under dry direct-seeded condition for drought stress tolerance at various growth stages (Fig. 5.1). In stress treatment only one irrigation was applied immediately after sowing to ensure proper seed germination. The non-stress treatment was maintained by applying irrigations as and when required. Results revealed that seven rice genotypes (Table 5.1) were found promising under multi-stages drought stress condition as compared to checks Grain yield of different genotypes varied from 0.838 to 2.87 t/ha and 3.09 to 5.08 t/ha under stress and non-stress conditions, respectively. Irrespective of genotypes, drought stress at various growth stages caused significant reduction in grain yield (58.35%), plant height (9.96%), number of tillers/m^2 (15.3%), panicle length (9.74%), test weight (11.01%), spikelet fertility (31.9%), relative water content (31.59%), photosynthetic rate (40.5%), stomatal conductance rate (19.2%) and chlorophyll content (10.9%); however, the responses varied among genotype.

Table 5.1. Agro-morphological and physiological performance of promising rice genotypes and check varieties under drought stress and non-stress condition

Rice genotypes	Plant height (cm)		Grain yield (t/ha)		Test weight (g)		Photosynthetic rate [μ mol (CO_2) /m/s]		Relative water content (%)	
	S	NS	S	NS	S	NS	S	NS	S	NS
IR 84899-B-179-16-1-1-1	100	105.1	2.86	5.17	22.2	23.4	13.5	22.4	67.6	90.9
IR84898-B-168-24-1-1-1	88.9	107.0	2.57	4.66	24.5	23.7	14.9	21.3	69.5	86.8
IR84899-B-183-CRA-19-1	105.7	111.9	2.54	4.26	23.2	25.3	13.5	22.1	65.7	91.8
IR84894-143-CRA-17-1	106.1	108.0	2.51	4.19	19.5	23.1	12.1	24.8	63.6	93.4
IR83929-B-B-291-2-1-1-2	101.3	102.6	2.45	4.59	21.5	23.4	12.7	21.9	64.2	91.2
IR84899-B-182-3-1-1-2	104.5	107.8	2.45	4.72	19.4	23.5	11.8	19.6	62.8	86.9
IR 88964-24-2-1-4	95.1	104.2	2.42	5.31	21.8	23.9	13.4	22.0	60.8	91.1
Sahbhagi Dhan	94.4	108.2	1.91	4.25	17.3	22.2	12.4	18.4	61.3	83.3
DRR 42	93.6	103.7	1.87	4.36	19.1	23.9	11.3	18.7	59.2	86.8
Rajendra Sweta	67.3	100.8	0.49	4.83	10.4	11.6	9.50	23.5	57.0	93.2
Rajendra Bhagwati	91.9	103.4	0.73	4.54	17.9	25.0	7.79	19.7	56.8	91.4
IR64	75.9	99.0	0.62	4.52	17.4	22.9	6.67	20.6	53.3	85.6
MTU 1010	90.5	95.4	1.42	4.61	20.7	23.6	10.7	19.4	60.9	87.1
Mean	90.4	100.4	1.89	4.54	20.2	22.7	12.17	20.48	61.03	89.2
LSD (P=0.05)	6.7	8.3	0.29	0.78	1.17	1.86	1.42	2.07	3.91	4.88

S=Stress, NS=Non-stress


Fig 5.1. Screening of rice genotypes under multi-stages drought condition

Evaluation of Rice Genotypes for Vegetative Stage Drought Tolerance

Twenty four rice genotypes were screened for vegetative stage drought tolerance during *Kharif* 2017. Fourteen days old seedlings were transplanted into puddled fields. After transplanting, standing water up to 10 days was maintained. In order to create stress, field was drained out after maintaining initial 10 days standing water and no supplemental irrigation was provided till the harvest. Six genotypes *viz.* IR84899-B-179-16-1-1-1 (3.93 t/ha), IR84899-B-179-13-1-1-1 (3.84 t/ha), IR84899-B-182-3-1-1-2 (3.45 t/ha), IR84898-B-168-24-1-1-1 (3.43 t/ha), IR84899-B-183-CRA-19-1(3.42 t/ha) and IR83929-B-B-291-2-1-1-2 (3.36 t/ha), have been found tolerant to vegetative stage drought as compared to Sahbhagi Dhan (2.56 t/ha).

Evaluation and Development of Drought Tolerant Rice for Eastern region

The probability of occurrence of reproductive-stage drought is high in most rainfed regions due to the early withdrawal of monsoon rains. Thirty five rice genotypes received from IRRI along with some local varieties were evaluated during *Kharif* 2017 under STRASA Phase III project for drought tolerance at reproductive stage (Fig. 5.2). Fifty five days old crop was subjected to drought by withholding irrigation and withdrawing water from the field. Thereafter crop was left rainfed and no standing water was allowed till maturity. Non-stress irrigated treatment was kept continuously flooded after transplanting until 25 days before harvest. Grain yield varied from 4.75-7.21 t/ha and 2.11-4.56 t/ha under non-stress and stress conditions, respectively (Table 5.2). Drought stress at reproductive stage caused significant reduction in grain yield (42.57%), plant height (16.41%), plant biomass (35.03 %), tillers /m^2 (10.4%), panicle length (11.1%) and harvest index (8.65%). Among rice genotypes, IR 97073-26-1-1-3 (4.56 t/ha), IR 97069-1-1-1-1 (4.05 t/ha), IR14L572 (3.87 t/ha), IR 93329:61-B-21-12-21-1RGA-2RGA-1-B-B (3.84 t/ha), IR105690 -1-1-B?B (3.83 t/ha), IR 97034-21-2-1-3 (3.82 t/ha), IR 99739:2-1-1-2-1 (3.78 t/ha) and IR 93335:4-B-3-6-7-1RGA-2RGA-1-B-B (3.75 t/ha) have been found promising under. On average 42.5% yield reduction was observed under stress (3.28 t/ha) as compared to non-stress (5.68 t/ha) condition.

Performance of rice genotypes under 'head to head' trial

Nine rice genotypes were evaluated in 'head to head' trial under transplanted condition at on-station as well as on-farm (Fig. 5.3). Among rice genotypes, the highest grain yield was recorded in

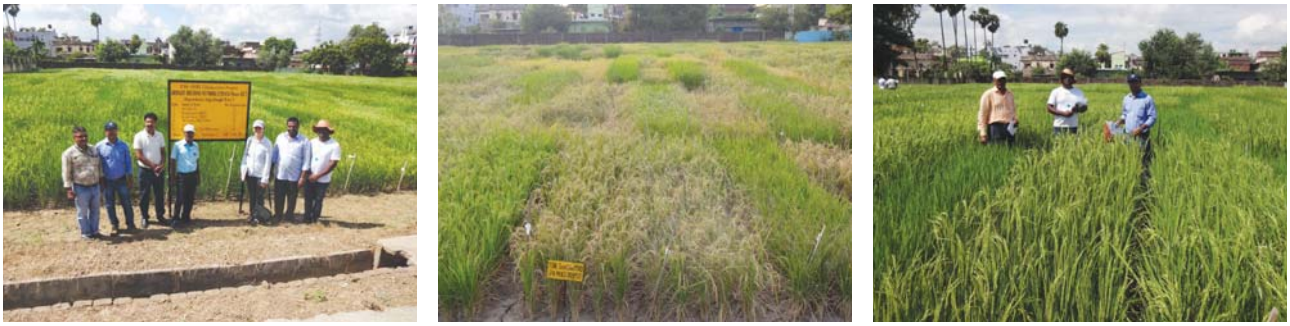

Fig. 5.2. Screening of rice genotypes under reproductive stage drought stress

Fig 5.3. Evaluation of rice genotypes under 'head to head' trial

Table 5.2. Performance of promising genotypes of rice under stress and non stress condition

Rice genotypes	Days to 50% flowering		Plant height (cm)		Grain yield (t/ha)	
	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress
IR 97073-26-1-1-3	79	84	99	110	4.56	6.65
IR 97069-1-1-1-1	78	84	98	115	4.05	5.35
IR14L572	80	89	99	123	3.86	7.07
IR 93329:61-B-21-12-21-	87	88	100	116	3.84	6.15
IR105690 -1-1-B-B	80	79	95	111	3.83	5.32
IR 97034-21-2-1-3	82	88	104	127	3.82	6.98
IR 99739:2-1-1-2-1	82	86	100	120	3.78	4.86
IR 93335:4-B-3-6-7-	86	90	93	121	3.74	6.69
IR 99044-6-2-1-2	81	84	93	114	3.71	5.42
IR14L360	82	84	97	116	3.13	6.67
Sahbhagi Dhan	77	84	101	119	3.02	4.75
IR 64	82	85	98	104	2.37	4.94
MTU 1010	76	84	97	107	2.90	4.90
Mean	82.4	86.8	97	116	3.28	5.71
LSD (P=0.05)	1	3	10	9	0.41	0.71

Swarna Shreya (5.86 t/ha) followed by IET 25618 (5.40 t/ha) and IET 25640 (5.30 t/ha) whereas, the lowest in Shushk Samrat (4.55 t/ha).

Resource re-mobilization during grain filling under drought

Fourteen rice genotypes were evaluated under drought and control condition with aim to identify the rice genotypes have contrasting harvest index (HI) but similar in days to flowering (DTF) and Biomass. Rice genotypes having similar DTF and biomass with contrasting HI under drought condition *viz.,* Wanni Dahanala and EZ I 124 (23.7 and 24.8), Camponi Sml and Gul Murali (29.7 & 23.2), Tchampa and Jabor Sail (31.9 and 23.2), Dular and Santhi Sufaid 207 (30.4 and 24.9), DZ78 and Aus 257 (20.1 & 24.0), ARC 10955 and Soloi (24.5 & 33.4) have been identified. Under drought condition, the average reduction in grain yield was 27.12 % as compared to control condition. Further, the maximum yield under stress was attained by IR7431-70-1-1 (3.49 t/ha) followed by Wanni Dahanala (2.74 t/ha) while lowest yield was obtained from Gul Murali (1.59 t/ha). Across the rice genotypes, the reduction in grain yield was minimum for Soloi (5.16%) followed by Camponi Sml (6.93%) and Wanni Dahanala (7.65%) while maximum reduction was observed in genotype IR64 (46.9%).

Breeding for Submergence Tolerance

Evaluation of rice genotypes for submergence tolerance at vegetative stage

Eighteen rice genotypes were evaluated for submergence tolerance along with Swarna sub1 as tolerant and Swarna as susceptible check. Thirty days old seedlings were transplanted on 19th July 2017. After twelve days of transplanting, the crop was completely submerged by filling water in the field (Fig. 5.4). The crop was kept submerged under 75.0 cm to 1.0 m water depth for 21 days and thereafter water was completely drained out of the field. The field was completely covered with the growth of submerged aquatic weed. After removal of the weed only three genotypes TP30495, TP30194 and TP30505 were found to survive and even the tolerant check Swarna sub1 was found completely damaged. The seeds of these surviving genotypes have been harvested and stored for further evaluation. The seed multiplication of the previously identified submergence tolerant genotypes IR09L342, IR10F198, IR10F365 and IR11F195 has been done for evaluation of their agronomic value.

Evaluation of elite rice genotypes under rainfed shallow lowland

A preliminary yield trial with twenty six elite rice genotypes selected from different crosses for

Fig. 5.4. (A) Plot view 21 days after de-submergence with mat of aquatic weeds (B) Mannual removal of aquatic weed after de-submergence (C) Regenerated plants of rice genotype TP30495.

the development of improved rice varieties for rainfed shallow lowland was conducted during *Kharif* 2017 under shallow lowland along with Swarna, Swarna sub1, Samba Mahsuri sub1 and Rajendra Bhagwati as checks. Observation on grain yield and other agro-morphological parameters were recorded. In terms of grain yield, genotypes B-13 (6.37 t/ha), B-21 (6.20 t/ha) and B-11 (6.00 t/ha) have performed better than the check variety Swarna (5.20 t/ha). These genotypes are 10 to18 days earlier than Swarna.

Evaluation of aromatic rice genotypes under stagnant flooding

Nine local aromatic rice genotypes of Bihar were evaluated along with improved aromatic rice varieties during *Kharif* 2017 in lowland under stagnant flooding condition (Table. 5.3). The traditional aromatic rice genotypes grew very tall and lodged at the time of maturity and hence their grain yield was very low (1.43 to 3.13 t/ha) as compared to improved variety like CR Dhan 909 (5.03 t/ha) and Rajendra Kasturi (4.68 t/ha). However, the traditional aromatic varieties are still grown by farmers due to their superior grain quality. There is scope to improve the grain yield in these traditional varieties by reducing their plant height through breeding as the other attributes like panicle length and number of tillers/plant are better in these genotypes.

Table 5.3. Performance of aromatic rice genotypes under stagnant water condition

Genotypes	Days to 50% flowering	No. of panicles / hill	Plant height (cm)	Panicle length (cm)	Grain yield (t/ha)
Sonachur	118	10.0	124	20.7	3.13
Shyamjeera-1	120	9.9	183	30.9	2.53
Shyamjeera-2	120	9.1	187	32.7	2.90
Basmati Lal Sataria	124	11.2	192	31.9	2.57
Local Basmati 1	121	12.6	180	29.9	1.90
Local Basmati 2	119	11.8	179	32.0	1.43
Local Basmati 3	123	12.0	196	27.0	2.37
Local Basmati 4	126	11.3	172	27.1	2.93
Kalanamak-2	116	10.7	169	31.3	1.85
Black Manipuri Rice	120	12.1	187	30.2	1.81
Pusa 1612	94	9.9	103	20.1	1.40
Rajendra Kasturi	117	12.0	137	24.5	4.68
CR Dhan 909	115	13.2	132	28.1	5.03
LSD (P=0.05)	2	1.6	7	3.1	0.52

Generation Advancement and Selection

Observation nursery of 75 BC_1 F_6 progenies were raised during *Kharif* 2017 and 16 uniform lines with mid-early to medium maturity duration have been selected based on the plant type, panicle and grain features, field reaction to insect pests and diseases. The BC1 F_7 seeds have been retained for further evaluation under preliminary yield trial.

Seed production and germplasm maintenance

During *Kharif* 2017, seed of improved aromatic rice varieties *viz.* CR Dhan 909 (1.2 t), Pratikhya (0.44 t) and Maudamini (0.27 t) has been produced for conducting FLD /OFT. Twenty five improved rice varieties of lowland situation have also been maintained.

Evaluation of rice varieties for semi-deep water situation

Ten improved rice varieties obtained from NRRI-Cuttack were evaluated under semi-deep water situation during 2017 *Kharif* (Fig. 5.5). Out of these CR Dhan 500 (4.70 t/ha) and CR Dhan 505 (4.38 t/ha) were found promising for semi-deep water condition (water depth >30 cm).

Fig. 5.5. Promising rice varieties for semi-deep water situation

Boro Rice

Effect of bio fertilizer in boro rice nursery

Effect of application of different bio-fertilizers *viz. Trichoderma viride*, *Pseudomonas fluorescens*, Azotobacter, Vesicular Arbuscular Mycorrhizae (VAM), Azolla and tea leaf waste and zinc were evaluated in boro rice nursery of IR64 during summer season 2016-17 (Table 5.4). Application of bio-fertilizers improved the seed germination, seedling vigour and checked leaf discoloration under low temperature stress as compared to the control. However, the overall effect of VAM on grain yield in IR64 was better.

Table 5.4. Performance of IR64 under different treatment of biofertilizer during *Boro* season 2016-17

Treatments	Plant height (cm)	Number of tillers/ hill	Number of panicle / hill	1000-grain weight (g)	Biological yield (t/ha)	Grains yield (t/ha)
Trichoderma viride	100.11	23.00	21.67	24.33	7.23	4.34
P. fluorescens	99.00	22.00	20.67	24.00	6.45	3.85
Azotobacter	97.34	20.22	18.00	23.53	6.69	4.04
VAM	103.89	25.00	23.67	25.43	7.81	4.70
Zinc	98.56	20.00	19.33	24.67	6.36	3.83
Tea leaf wastes	94.56	16.00	14.67	23.00	6.25	3.75
Azolla	95.78	17.00	15.67	22.00	6.73	4.07
Control	93.00	15.00	12.00	17.90	5.14	3.09
LSD (P=0.05)	3.35	3.27	3.44	1.75	2.95	2.98

Screening for seedling stage cold tolerance in boro rice

A number of rice varieties grown in boro season along with 16 genotypes under IRTON-2017 Set No. 1 obtained from IRRI, Philippines were screened for cold tolerance at seedling stage during 2017-18. Out of these only one genotype from IRTON *viz.*, TP30752 (IRTON 103) has been found to be highly cold tolerant at seedling stage (Fig. 5.6).

Response of rice genotypes to nitrogen under direct-seeded condition: A field trial was conducted during *Kharif* 2017 to find out the optimum levels of nitrogen for promising upland direct-seeded rice genotypes. Experimental treatments were comprised of 4 nitrogen levels (control, 50, 100 and 150% RDN) in main-plot and 7 rice genotypes (Swarna Shreya, RCPR-19-IR84899-B-179-13-1-1-1, RCPR-20-IR 83929-B-B-291-2-1-1-2, RCPR-21-IR84887-B-158-7-1-1-4, RCPR-22-IR84899-B-183-20-1-1-1, RCPR-16-IR 84894-143-CRA-17-1, Rajendra Bhagwati) in sub-plot (Table 5.5). Recommended dose of nitrogen (100% RDN) represents 100kg N/ha. Results revealed that application of 150% RDN (150 kg N/ha) produced significantly higher grain yield (2.90 t/ha). Among rice genotypes, Swana Shreya (2.54 t/ha) being on a par with RCPR-19-IR 84899-B-179-13-1-1-1 (2.43 t/ha) recorded significantly higher gain yield.

Fig 5.6. Screening for cold tolerance in rice: (a) tolerant genotype IRTON 103 (b) highly susceptible genotype IRTON 104

Table 5.5. Effect of nitrogen levels on yields of direct-seeded rice under upland condition

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index
Nitrogen level				
Control	1.57	3.24	4.80	0.33
50% RDN	2.01	4.37	6.38	0.32
100% RDN	2.49	5.22	7.71	0.33
150% RDN	2.90	5.78	8.68	0.34
LSD(P=0.05)	0.12	0.30	0.39	0.01
Genotypes				
Swarn Shreya	2.54	5.28	7.82	0.33
RCPR-19-IR 84899-B-179-13-1-1-1	2.43	5.39	7.82	0.31
RCPR-20-IR 83929-B-B-291-2-1-1-2	2.41	4.84	7.26	0.33
RCPR-21-IR 84887-B-158-7-1-1-4	2.08	4.10	6.18	0.34
RCPR-22-IR 84899-B-183-20-1-1-1	2.18	4.83	7.01	0.31
RCPR-16-IR 84894-143-CRA-17-1	2.05	4.17	6.22	0.33
Rajendra Bhagwati	2.00	3.94	5.94	0.34
LSD(P=0.05)	0.16	0.40	0.52	NS

Weed Competiveness of Promising Rice Genotypes under Aerobic Condition

A field experiment was conducted to evaluate the weed competitive ability of rice genotypes under direct-seeded aerobic condition during K*harif* 2017 (Table 5.6). Eight rice genotypes (V1: Swarn Shreya, V2: RCPR-19-IR84899-B-179-13-1-1-1,V3:RCPR-20-IR83929-B-B-291-2-1-1-2,V4:DRR-42,V5:RCPR-22-IR84899-B-183-20-1-1-1,V6:RCPR-16-IR84894-143-CRA-17-1,V7:DRR-44,V8: Rajendra Bhagwati)) were evaluated under 3 weed pressures [W1: low weed pressure, W2: medium weed pressure and W3: high weed pressure]. Treatments low, medium and high weed pressure represent, application of pendimethaline @1.0 kg *a.i.*/ha (pre-em. at 2 DAS) *fb* Bispyribac Na @ 30g/ha (post-em. at 20 DAS) *fb* 2 HW at 40 and 60 DAS; pendimethaline @ 1.0 kg *a.i.*/ha (pre-emergence at 2 DAS) *fb* Bispyribac Na @ 30 g/ha (post-em. at 20 DAS), and pendimethalin 1.0 *a.i.*/ha (pre-em. at 2 DAS) alone. The rice genotype RCPR-19-IR 84899-B-179-13-1-1-1 had significant reduction in weed density and weed dry matter, and higher grain yield (2.32 t/ha).

Response of rice genotypes to nitrogen under transplanted condition

A field experiment was conducted to find out the optimum levels of nitrogen for promising transplanted rice genotypes during *Kharif* 2017 (Fig. 5.7). Treatments were comprised of 4 nitrogen levels (control, 50, 100 and 150% RDN) in main-plot and 8 rice genotypes (RCPR-10-IR 83383-B-B-129-4, RCPR-11-IR 83387-B-B-27-4, RCPR-23-IR 88867-9-1-1-4, RCPR-25-IR 88964-24-2-1-4, RCPR-38-IR 88964-1-2-2-4, RCPR 39-IR 88966-39-1-4-4, Rajendra

Fig. 5.7. View of the rice genotypes under different levels of nitrogen

Table 5.6. Yield of direct seeded rice genotypes as influenced by weed management practices

Treatment	Weed density at 90DAS (no./m^2)	Weed dry matter at 90 DAS (g/m^2)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Crop productivity (kg/ha/day)
Weed management practices							
Low weed pressure	10.12 (102.41)	4.58 (21.0)	2.53	4.39	6.92	36.6	20.7
Medium weed pressure	14.18 (201.10)	6.27 (39.3)	2.01	4.24	6.25	32.2	16.3
High weed pressure	20.21 (408.4)	11.24 (124)	1.33	3.48	4.80	27.7	10.8
LSD (P=0.05)	1.04	0.97	0.07	0.18	0.22	0.9	0.5
Genotypes							
Swarna Shreya	14.30 (204.6)	6.01 (36.10)	2.18	4.18	6.36	33.4	17.6
RCPR-19-IR 84899-B-179-13-1-1-1	13.52 (182.8)	4.33 (18.75)	2.32	4.53	6.92	33.9	19.2
RCPR-20-IR 83929-B-B-291-2-1-1-2	15.02 (225.7)	7.37 (54.31)	2.08	4.40	6.49	31.5	17.4
DRR-42	15.35 (235.7)	7.23 (52.7)	1.77	3.62	5.38	32.7	14.7
RCPR-22-IR 84899-B-183-20-1-1-1	15.59 (243.2)	8.83 (77.97)	1.82	3.94	5.75	31.1	14.7
RCPR-16-IR 84894-143-CRA-17-1	15.11 (228.4)	6.89 (77.96)	1.63	3.55	5.18	31.1	13.2
DRR-44	14.46 (209.2)	7.70 (59.29)	2.01	4.36	6.32	30.7	15.8
Rajendra Bhagwati	15.33 (235.1)	8.9 (79.21)	1.84	3.72	5.54	32.7	14.8
LSD (P=0.05)	1.27	1.15	0.11	0.29	0.36	1.5	0.9

Sweta, Rajendra Bhagwati) in sub-plot (Table 5.7). Recommended dose of nitrogen (100% RDN) represents 100 kg N/ha. Results revealed that application of 150% RDN (150 kg N/ha) produced significantly higher grain yield (5.19 t/ha). Among rice genotypes, significantly higher gain yield was recorded with RCPR-10-IR 83383-B-B-129-4 (4.27 t/ha)

Ferti-fortification (Iron and Zinc) in direct seeded rice (DSR)

The field experiment was initiated in *Kharif* 2016, with the treatments of iron and zinc as foliar and basal application in direct seeded rice (var. Swarna Shreya) to evaluate the best method to increase nutrient content in grain and straw. The results revealed that highest concentration of iron in straw was recorded with RDF + Soil application of 25 kg/ha iron sulfate + Foliar Spray of Iron sulfate (1% $FeSO_4.7H_2O$) at 30, 60 and 75 DAS in both the years (Table 5.8). Soil application of 50 kg/ha Zinc sulphate along with recommended dose of NPK (T3) recorded significantly higher. There is no significant difference was recorded in grain iron content in the treatments which received iron as either foliar or soil application (Table 5.9). The maximum zinc concentration in grain was recorded in the treatment RDF + Zinc sulphate 25 kg/ha basal + Foliar application (0.5% zinc sulfate) at 30 and 45 DAS.

Table 5.7. Yield attributes of rice genotypes as influenced by different levels of nitrogen under transplanted condition

Treatment	No. of tillers/m row (no.)	Panicle length (cm)	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)
Nitrogen level					
Control	48.80	25.55	21.84	2.61	5.71
50% RDN	57.77	27.83	22.96	3.42	6.53
100% RDN	61.22	28.21	23.64	4.56	7.86
150% RDN	64.53	29.42	24.91	5.19	8.09
LSD (P=0.05)	3.05	0.71	0.71	0.11	0.25
Genotypes					
RCPR-10-IR 83383-B-B-129-4	68.50	29.93	24.33	4.27	7.67
RCPR-11-IR 83387-B-B-27-4	63.73	30.15	24.83	4.09	7.26
RCPR-23-IR 88867-9-1-1-4	55.45	26.46	24.05	3.89	6.65
RCPR-25-IR 88964-24-2-1-4	57.35	28.41	23.76	3.97	7.47
RCPR-38-IR 88964-1-2-2-4	54.17	27.59	23.77	4.07	7.15
RCPR 39-IR 88966-39-1-4-4	58.57	26.44	21.36	3.77	6.41
Rajendra Sweta	56.66	24.07	21.46	3.96	7.22
Rajendra Bhagwati	50.21	28.95	23.13	3.54	6.55
(P=0.05)	4.31	1.01	1.00	0.15	0.36

Table 5.8. Macro and micro nutrient concentration in rice straw

Treatment	N (%)		P (%)		K (%)		Zn (mg/kg)		Fe (mg/kg)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T_1	1.07^{ab}	1.01^{bcd}	0.32^{ab}	0.38^{de}	1.74^{ab}	1.80^{bcd}	28.2^{a}	26.4^{a}	236.5^{a}	263^{a}
T_2	1.08^{ab}	0.92^{ab}	0.28^{a}	0.28^{b}	1.63^{ab}	1.59^{a}	39.4^{cd}	37.0^{c}	289.7^{bc}	293^{b}
T_3	1.01^{a}	1.04^{cd}	0.34^{ab}	0.40^{e}	1.67^{abc}	1.74^{abc}	40.2^{cd}	44.8^{e}	255.7^{abc}	246^{a}
T_4	1.03^{b}	1.04^{cd}	0.27^{a}	0.23^{a}	1.76^{ab}	1.79^{bc}	38.2^{bcd}	39.6^{cd}	245.1^{ab}	274^{ab}
T_5	1.07^{ab}	0.98^{abc}	0.27^{a}	0.23^{a}	1.57^{a}	1.65^{ab}	34.6^{abcd}	28.0^{ab}	238.1^{a}	263^{a}
T_6	1.02^{ab}	0.90^{a}	0.28^{a}	0.33^{c}	1.75^{ab}	1.96^{d}	42.7^{d}	41.0^{d}	300.2^{cd}	272^{ab}
T_7	1.08^{ab}	1.06^{cde}	0.32^{ab}	0.32^{c}	1.74^{ab}	1.82^{bcd}	30.2^{ab}	31.4^{b}	395.1fg	362^{d}
T_8	0.99^{ab}	1.09^{de}f	0.38^{b}	0.37^{d}	1.74^{ab}	1.65^{ab}	30.0^{ab}	25.8^{a}	428.5g	420^{e}
T_9	1.19^{ab}	1.18f	0.31^{ab}	0.40^{e}	1.80^{c}	1.86^{cd}	33.4^{abc}	39.4^{cd}	344.3^{de}	325^{c}
T_{10}	1.16^{ab}	1.15^{e}f	0.30^{ab}	0.29^{b}	1.62^{ab}	1.57^{a}	41.5^{cd}	40.8^{d}	351.9^{e}f	344^{cd}

T_1: Control (RDF) : N,P_2O_5, K_2O at 100:40:30 kg/ha, T_2: RDF + Zinc sulphate 25 kg/ha basal, T_3: RDF + Zinc sulphate 50 kg/haas basal, T_4: RDF + Foliar application (0.5% zinc sulphate) at 30 and 45 DAS, T_5: RDF + Zinc sulphate 25kg/ha basal + Foliar application (0.5% zinc sulphate) at 30 and 45 DAS, T_6: RDF + Soil application of 25 kg/ha iron sulphate, T_7: RDF + Foliar Spray of Iron sulphate (3% $FeSO_4.7H_2O$) at 30, 60 and 75 DAS, T_8: RDF + Soil application of 25 kg/hairon sulphate +Foliar Spray of Iron sulphate (1% $FeSO_4.7H_2O$) at 30, 60 and 75 DAS, T_9: RDF + Soil application of Zinc sulphate 25 kg/ha+ iron sulphate 25 kg/ha, T10: RDF + Tank mixed foliar spray of 0.5% zinc sulphate and 3% iron sulphate at 30 and 60 DAS

Table. 5.9. Macro and micro nutrient concentration in rice grain

Treatment	N (%)		P (%)		K (%)		Zn (mg/kg)		Fe (mg/kg)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T_1	0.77^{a}	0.76^{e}	0.18^{a}	0.18^{e}	0.76^{ab}	0.49^{a}	26.7^{abc}	29.1^{b}	115^{a}	104^{a}
T_2	0.73^{a}	0.68^{d}	0.20^{ab}	0.18^{e}	0.88^{ab}	0.96^{e}	31.1^{bc}	30.8^{b}	114^{a}	108^{a}
T_3	0.64^{a}	0.48^{a}	0.15^{a}	0.14^{b}	0.58^{a}	0.69^{b}	33.6^{bc}	34.3^{c}	126^{ab}	127^{ab}
T_4	0.89^{a}	0.7^{e}	0.20^{ab}	0.19^{e}	0.85^{ab}	0.81^{cd}	36.3^{cd}	37.8^{cd}	124^{ab}	118^{ab}
T_5	0.77^{a}	0.70^{de}	0.22^{ab}	0.16^{c}	0.96^{b}	0.82^{cd}	38.8^{d}	40.4^{d}	130^{ab}	137^{bc}
T_6	0.74^{a}	0.59^{b}	0.17^{a}	0.18^{cd}	0.81^{ab}	0.76^{bc}	28.4^{ab}	29.3^{b}	139^{b}	142^{c}
T_7	0.79^{a}	0.67^{cd}	0.28^{b}	0.24^{f}	0.96^{b}	0.76^{bc}	29.3^{ab}	30.8^{b}	171^{d}	171^{d}
T_8	0.72^{a}	0.62^{bc}	0.23^{ab}	0.14^{ab}	1.00^{b}	0.86^{d}	28.7^{ab}	27.6^{ab}	157^{cd}	160^{cd}
T_9	0.78^{a}	0.76^{e}	0.22^{ab}	0.13^{a}	0.97^{b}	0.83^{cd}	22.4^{a}	22.2^{a}	164^{d}	169^{d}
T_{10}	0.73^{a}	0.87^{f}	0.28^{b}	0.23^{f}	0.99^{b}	0.96^{e}	24.2^{ab}	23.0^{a}	166^{d}	176^{d}

Integrated Weed Management in Direct-Seeded Rice

Surveys in different rice growing districts of Bihar *viz.* Patna, Nalanda, Nawada, Vaishali, Motihari, Betiah, Gaya and Samastipur were conducted to explore and identify the weeds in rice fields. Samples of different weed species were collected from different rice ecosystems and studies on weed phytosociology was initiated. Weed spp., Total occurrence of individual weed (TOI), Total no. of individuals in a given area, frequency (F), weed density (D), weed abundance (A), relative frequency (R.F.), relative density (R.D.) and relative abundance (R.A.) etc. parameters were taken into consideration for this study. From the study it was revealed that the most frequent species is *Cyperus difformis* (44%), followed by *T. portulacastrum* (42%), *E. crus-galli* (36%), *E. indica*, *Digitaria adsendens*, *Cynodon dactylon* (32%), *Cyperus iria*, *L. chinensis* and *E. colona* (30%) in the rice fields. Weeds like *Cyperus difformis*,*T. portulacastrumand E. crusgalli* are most likely to occur in a given area. Data on other parameters has been presented in Table 5.10.

Studies on importance value index (IVI) of weed were also undertaken in rice fields (Fig. 5.8). The important value index of individual weed species emerged in the rice fields identified as *E. crus-galli* (23.1%); most important species in relation to weed management strategies followed by *E. colona* (20.2), *Cyperus difformis* (19.8) and *T. portulacastrum* (18.2). The detailed studies on IVI for different

Table 5.10. Phyto-sociological studies on weed species in rice field

Name of weeds	TNQ	TOI	TNI	F	D	A	RF	RD	RA	IVI
E. colona	50	15	38	30	0.76	2.5	6.0	7.9	6.1	20.2
E. crus-galli	50	18	46	36	0.92	2.5	7.2	9.6	6.2	23.1
L. chinensis	50	15	26	30	0.52	1.7	6.0	5.4	4.2	15.7
D. sanguinalis	50	10	20	20	0.4	2.0	4.0	4.2	4.8	13.1
T. portulacastrum	50	21	30	42	0.6	1.4	8.5	6.3	3.4	18.2
C iria	50	15	22	30	0.44	1.4	6.0	4.6	3.5	14.2
C. difformis	50	22	34	44	0.68	1.5	8.9	7.1	3.7	19.8
C. rotundus	50	11	26	22	0.52	2.3	4.4	5.4	5.7	15.6
Elusine indica	50	16	23	32	0.46	1.4	6.4	4.8	3.5	14.8
D. aegyptium	50	10	15	20	0.3	1.5	4.0	3.1	3.6	10.8
Digitaria adsendens	50	16	30	32	0.6	1.8	6.4	6.3	4.5	17.3
Panicum repens	50	8	20	16	0.4	2.5	3.2	4.2	6.1	13.5
Fimbristlysis miliacea	50	5	16	10	0.32	3.2	2.0	3.3	7.8	13.2
Commelina communis	50	9	17	18	0.34	1.8	3.6	3.5	4.6	11.8
Celome viscosa	50	7	16	14	0.32	2.2	2.8	3.3	5.5	11.78
Ludwigia parviflora	50	12	21	24	0.42	1.7	4.8	4.4	4.2	13.5
Monocharia vaginalis	50	7	15	14	0.3	2.1	2.8	3.1	5.2	11.22
Physalis minima	50	10	22	20	0.44	2.2	4.0	4.6	5.3	14.0
Cynodon dactylon	50	16	28	32	0.56	1.7	6.4	5.8	4.2	16.6
Brachiaria repens	50	4	11	8	0.22	2.7	1.6	2.3	6.7	10.6
Total	1000	247	476	494	9.5	40.9				

Fig. 5.8. Weed infestation in rice

weed species has been presented in Table. 5.10. The findings obtained have clearly established the fact that the weed diversity in this region is high and of complex in nature due to diverse range of ecological conditions. This study is important and will help in planning a suitable strategy for their control as these weeds competes with rice crops for resources and thus the yield of rice is reduced especially in case of dry seeded rice.

Evaluation of Weed Management Techniques in SRI under Shallow Lowland

Weed management is a major concern in SRI due to limited water management. Seven weed management treatments *viz.*, conoweeder thrice on 15, 25, and 35 DAT, conoweeder twice on 15 and 30 DAT, post emergence application of bispyribac sodium at 250 g/ha + conoweeder use at 35 DAT, mechanical weeding 15 DAT + bispyribac sodium as PoE 250 g/ha 25 DAT, mechanical weeding 15 DAT + bispyribac sodium as PoE 250 g/ha 25 DAT + mechanical weeding 25 DAT, unweeded check and farmers' practice. The major weed flora observed

in the experimental field were *Echinochloa crus-galli* (36%), *Cynodon dactylon* (25%), *Cyperus rotundus* (14%), *Fimbristylis miliacea* (12%) and *Cyperus iria* (13%). Results (Table 5.11) revealed that mechanical weeding by conoweeder at 15, 30 and 45 DAT was found to be the most effective up to 60 DAT.

Evaluation of Weed Management Techniques in System of Wheat Intensification (SWI)

Controlling weeds is the major challenge in wheat cultivation. Introduction of some of the principles of SWI helped farmers to successfully control the weeds. The rotary weeder (wheel hoe) is perfectly designed to remove the weeds, besides it also aerates the soil and saves time and expenses on labour. However, herbicide use to control weeds in wheat is more common. Herbicide alone is, however, not sufficient to provide satisfactory weed control in SWI. Hence, an experiment on evaluation of weed management techniques in SWI was initiated during *Rabi* 2017. The major weed flora in the field were *Cyperus rotundus* (58.56%), *Chenopodium album* (19.84%), *Fumaria parviflora* (1.57%), *Physalis minima* (19.06%) and *Argemone mexicana* (0.97%). Results revealed that use of wheel hoe once at 30 days after sowing (DAS) followed by hand weeding (HW) at 50 DAS proved the most effective and recorded significantly lower density and dry biomass of weeds than hand weeding twice at 30 and 50 DAS and unweeded check (Table 5.12).

Phytosociology of Weeds Associated with important Agricultural Crops in Eastern Plateau and Hill region

Phytosociological studies on weeds under selected land use systems during monsoon season indicated that weeds like *Cyperus difformis*, *Scirpus juncoides*, *Ludwigia parviflora* and *Brachiaria deflexa* were considered as dominant weeds based on maximum IVI (Importance Value Index). The highest Shannon's diversity index value of weeds (0.95 ± 0.04) was recorded in cowpea – potato – methi system (upland) and the lowest value (0.50 ± 0.11) was recorded in case of rice – fallow system. Total dry weed biomass (2.41 ± 0.46 t/ha) was recorded higher in case of cowpea – potato – methi system. In total 61 species of weeds had been identified. In case of winter-summer season, the weeds like

Table 5.11. Growth, yield attributes and yield of rice under different weed management

Treatments	Plant height at harvest (cm)	No. of panicles /m^2	Panicle weight (g)	No. of grain/ panicle	1000-grain weight (g)	Grain yield (t /ha)	Straw yield (t/ha)	*No. of weeds/ m^2 at 60 DAT	*Weed dry weight g/ m^2 at 60 DAT	Weed control efficiency (%) at 60 DAT
Conoweeder thrice on 15, 25, and 35 DAT	88.0	338	2.30	94	21.00	5.80	8.0	5.97 (30)	5.08 (21)	82.5
Conoweeder twice on 15 and 30 DAT	90.6	294	2.16	89	20.00	5.40	7.4	6.33 (34)	5.26 (22.66)	81.66
Post- emergence application of bispyribac sodium 250 g/ ha + conoweeder use 35 DAT	90.6	234	2.13	78	19.00	4.50	6.4	6.82 (40)	5.91 (29.33)	75.83
Mechanical weeding 15 DAT + bispyribac sodium as PoE 250 g/ha 25 DAT	85.0	249	2.26	80	20.00	4.80	6.2	6.05 (36)	5.79 (28)	76.66
Mechanical weeding 15 DAT + bispyribac sodium as PoE 250 g/ha 25 DAT + mechanical weeding 25 DAT	88.3	255	2.30	82	21.00	5.00	6.6	6.15 (32)	5.50 (25)	79.16
Unweeded check	90.6	184	1.90	74	19.00	3.80	4.5	12.37 (141)	11.45 (120)	-
Farmer's practice	84.3	217	1.96	75	20.00	4.00	4.8	6.82 (40)	5.97 (30)	75.00
LSD (P=0.05)	NS	44	0.28	11	NS	1.2	1.2	0.13	0.12	-

*The data are squared root transformed and the values in the parentheses are original; PoE – Post-emergence; HW – Hand weeding; DAT-Days after transplanting

Table 5.12. Effect of weed management techniques on weeds growth and yield of wheat

Treatment	No. of weeds /m^2	Weed dry biomass (g) /m^2	Weed control efficiency (%)	No. of tillers/ m^2	No. of grains/ spike	Grain yield (t/ha)	Straw yield (t/ha)
T_1-Unweeded check	13.21 (174.0)	6.68 (44.00)	-	145	65	3.08	4.0
T_2-Mandwa weeder once at 30DAS	6.23 (38.33)	2.97 (8.00)	81.81	200	73	3.75	5.25
T_3-Wheel hoe once at 30 DAS	6.06 (36.33)	2.93 (7.66)	82.59	249	73	4.10	5.74
T_4-Sulfosulfuron + metsulfuron at 30 DAS (40g product/ha)	4.74 (22.66)	2.49 (5.33)	87.88	204	71	3.52	4.94
T_5-Hand weeding twice at 30 and 50 DAS	7.38 (54.33)	3.67 (12.66)	71.22	195	70	3.22	4.50
T_6-T_2+I HW at 45 DAS	5.85 (33.66)	2.68 (6.33)	85.61	246	71	4.01	6.0
T_7-T_3+1 HW at 50 DAS	4.40 (19.00)	2.12 (4.50)	89.77	255	75	4.15	6.22
T_8-T_4+ 1 HW at 45 DAS	4.47 (19.33)	2.44 (5.00)	88.63	195	71	3.65	5.11
LSD (P=0.05)	1.2	0.5	-	63	NS	0.58	0.98

*The data are squared root transformed and the values in the in parentheses are original value; HW – Hand weeding; DAS -Days after Sowing.

Spilanthes paniculata, Cyperus rotundus, Digitaria ciliaris and *Dactyloctenium aegyptium* were recorded as dominant in Chene, Hundru and Sarjomdih, Plandu and Sarjomdih. The highest Shannon's diversity index value of weeds (0.87 ± 0.04) was found to be in cowpea – potato – methi system and the lowest (0.48 ± 0.09) in rice – fallow system. When compared with different seasons, 12.11% of the weeds of monsoon season under rice – fallow system, 25.32% under rice – wheat system and 46.66 % under cowpea – potato – methi were found common during winter-summer season.

Ethnobotanical uses of different weeds

In eastern Plateau and Hill region, tribal peoples have identified the medicinal values of weeds. Information on ethnobotanical uses of different weeds have been compiled and presented in Table 15.13 .

Sorghum

Improving nitrogen use efficiency in grain sorghum

Performance of 9 grain sorghum cultivars including 5 hybrids (CSH 13, CSH 14, CSH 16, CSH 25, CSH 30) and 4 varieties (CSV 15, CSV 20, CSV 23 and CSV 27) was evaluated under four levels of N (0, 40, 80 and 120 kg N/ha) during summer seasons of 2017 (Table 5.14 and Fig. 5.9). Significantly higher grain yield was recorded with application of 120 kg N/ha. Among the sorghum cultivars, CSH 30 recorded significantly higher grain yield (4.9 t/ha).

Table 5.14. Effect of nitrogen levels and cultivars on grain yield of sorghum in summer season

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Bio-logical yield (t/ha)	Har-vest index (%)
N levels (kg/ha)				
0	2.9	15.0	17.9	15.3
40	3.5	19.5	22.9	20.0
80	4.1	24.4	28.5	25.0
120	4.8	28.4	33.3	29.2
LSD (P=0.05)	0.20	1.36	1.42	1.39
Cultivars				
CSH 13	3.9	22.1	26.0	22.7
CSH 14	4.0	23.0	27.0	23.6
CSH 16	4.1	23.9	28.0	24.5
CSH 25	4.1	23.7	27.8	24.2
CSH 30	4.9	28.0	32.9	28.7
CSV 15	3.2	18.5	21.7	18.9
CSV 20	3.7	20.6	24.2	21.1
CSV 23	3.0	17.4	20.4	17.8
CSV 27	3.4	19.4	22.8	19.9
LSD (P=0.05)	0.2	0.9	1.0	0.90

Fig. 5.9. Performance of sorghum cultivars under different levels of N

Table 5.13 Ethnobotanical uses of different weeds from the study area (Plandu, Hundru, Chene and Sarjomdih)

Species	Local name	Parts consumed*	Methods of consumption	Medicinal value	Season of availability
Centella asiatica	Beng	WP	In the form of juice (empty stomach)	Jaundice	Monsoon and winter
			As saag	Improve digestion	
			Paste	Skin disorder	
Hygrophila polyspe	Muchari	L, S (Tender)	As saag	Constipation, Stomach ache	Monsoon
Polygonum plebeium	Chemti	WP	As saag	Improves gastric problem, Cures fever and cough, Prevent dysentery	Monsoon and winter
Lepidium sativum	Padrahi saag	L	As saag	Helps in constipation and gastric problems	Monsoon and winter
Scoparia dulcis	Piplipi-ong	L	Paste	Cures any cut and wounds	Monsoon and winter
Cyperus rotundus	Jangli payaj	R	Pastes of Roots + other ingredients like haldi	Cures fever in animals	Monsoon and winter
Dactyloctenium aegyptium	Namak ghas	Seeds	Paste + Water (Empty stomach)	Check vomiting, cures stomach infection, reduces body heat	Monsoon and winter
Cynodon dactylon	Dubla	L	Paste of leaves + Haldi	Helps in blood clotting	All season
Lantana camera	Putus	L (Tender)	Paste of leaves + Red chilli	Act as Tetanus	All season
Cassia tora	Chakodh	L (Tender), R	As saag	Maintain suger level, Relieves constipation	All season
			Roots paste (Pasted on head)	Relieves from head ache	
Oxalis corniculata	Netho	L, S	As saag	Prevents Fever, urinary tract infection, Cures Skin disorder and leaves work as antidote for poison as snakebite	All season
Trianthema portulacastrum	Khapra	L, S (Tender)	As saag	Prevents Skin disorder, asthma, eye infection, heart problem	Monsoon
Alternanthera sessila	Garundi	L, S	As saag	Good to eyes, maintain blood in body, treats hepatitis, asthma and good for hairs	Monsoon and winter
Euphorbia hirta	Dudhi	L, R	Juice/ saag	Treats asthma, diabetes	Monsoon and winter
			Pastes	Heals skin problem	
Oxalis articulata	Khatta netho	WP	As saag	Prevents urinary tract infections and provides comfort in fever(due to its cooling property)	Monsoon and winter
			Paste	Ointment for wounds/cut/burns	
Conyza sp.	Minjur Jhuti	R	Powder+ other ingredients	Intestinal problem, urinary tract infection	Monsoon
Portulaca oleracea	Golgola	WP	As saag	Prevents Liver and lung problem, reduces body heat, enhance immune function and improves oral cavity	Monsoon, winter
Oxybasis rubra	Jangli bathua	L	As saag	Prevents from heat stroke	Monsoon, winter

*L = Leaves, S= Stem, R = Roots and WP = Whole Plant

6. Pulses

Pigeonpea

Genetic improvement for yield and biotic stress resistance

Eighteen land races of pigeonpea collected from Jharkhand and Chhattisgarh through NBPGR, Ranchi were evaluated for various morphological and yield related traits, and seed yield with three checks (NDA-1, Bahar and Asha). A total of thirteen genotypes germinated. IC 611232 yielded the highest (3.6 t/ha) and was early (98 days to 50% flowering and 204 days to harvest). The five genotypes selected for further evaluation are presented in Table 6.1.

Table 6.1. Mean performance of the best five pigeonpea genotypes for morphological and yield characters

Genotype	Days to 50% flowering	Days to harvest	Seed yield (t/ha)	No. of seeds/pod	Shelling %	100 seed weight (g)
IC 611212	119	204	2.3	7.0	67	10.05
IC 611215	119	249	2.6	8.0	60	7.97
IC 611232	98	204	3.6	8.2	80	9.72
IC 611261	109	204	2.0	5.3	62	10.39
IC 611682	109	204	1.7	6.4	57	11.99

Ten genotypes *viz.*, Type-7, DBGA-7-10, RCEA 14-5, NDA-2, IPA-203, RCEA 14-1, Pusa-9, RCEA 14-6, NDA-1 and Bahar were evaluated for identification of the best genotypes for breeding programme. DBGA-7-10 recorded susceptibility to PSB under natural conditions while DBGA7-10 showed non shattering habit. There were three genotypes (RCEA 14-1, RCEA 14-5 and RCEA 14-6) which showed cleistogamous flowers without 9+1 condition of stamens and no out crossing was reported in them. NDA-1 recorded the highest yield of 2.59 t/ha followed by Bahar (2.16 t/ha). RCEA 14-6 was early (97.6 days to 505 flowering) and determinate growth habit. Statistical analysis showed that all the characters except biological yield were significant for the ten genotypes (Table 6.2).

Table 6.2. Mean performance of 10 pigeonpea genotypes for morphological and yield characters under RBD

Character	Range	C.D	C.V.	ANOVA 'F test'
Days to 50% flowering	97.67-154.00	13.95	5.60	HS
Plant height (m)	2.17-3.33	0.38	7.61	HS
Raceme number	7.67-20.33	4.61	17.86	HS
Pod bearing length (m)	0.97-1.50	0.31	15.32	S
Biological yield (t/ha)	69.57-158.26	NA	44.99	NS
Yield (t/ha)	0.54-2.59	0.97	34.99	HS
No. of seeds per pod	5.06-8.08	1.69	15.11	HS
Shelling %	53.3-77.8	0.12	10.82	S
100 seed weight (g)	7.63-12.79	0.18	1.01	HS

S= Significant; HS= Highly significant

Promising genotypes for different nutritional characters have been selected and listed in Table 6.3.

Table 6.3. Nutritional analysis of promising pigeonpea genotypes

Character	Range	CV	Promising genotypes
Protein g/100g	1.30–2.12	13.60	RCEA 14-5
P mg/100g	204.12–434.70	15.65	RCEA 14-6
K mg/100g	14.50–30.44	19.89	IC 611261
S mg/100g	19.98–189.81	57.93	IC 611244
Ca mg/100g	10.20–38.05	31.68	RCEA 14-6
Mg mg/100g	0.02–0.12	35.58	IC 611682
Fe mg/100g	3.55–17.72	47.14	SKB 1/89, IC 611212
Mn mg/100g	1.16–3.42	23.67	RCEA 14-5
Cu mg/100g	0.93–1.31	11.56	IC 611212, IC 611215
Zn mg/100g	2.84–4.73	12.78	Pusa 9
100 seed weight	6.71–19.40	25.02	RCRP-1
Shelling %	53 - 80	11.88	RCEA 14-1

Performance of NDT and DT "cleisto" lines of Pigeonpea

Two NDT (RCEA 14-1 and RCEA 14-5) and one DT (RCEA 14-6) "cleisto" lines were evaluated in pigeonpea station trial at RC, Ranchi during 2016-17 (Table 6.4). Like previous year, all the three test lines bred *true to the type* for the "cleisto" traits (standard petal wrapped with wings, enlarged keels and free stamens) and did not show any natural crossing (*zero* per cent outcrossing). The "cleisto" line 'RCEA 14-5' yielded (1.6 t/ha) more than the parent and check variety 'IPA 203' (~1.5 t/ha) during the year 2016-17.

Table 6.4. Per cent natural outcrossing in promising "cleisto" lines of pigeonpea

Genotype	Population size*		Off type plants		Per cent out-crossing	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
RCEA 14-1	105	142	1	0	1	0
RCEA 14-5	109	169	0	0	0	0
RCEA 14-6	111	175	0	0	0	0
IPA 203	107	–	17	–	15.88	–

*Plants grown from open-pollinated seeds

Faba bean

Maintenance of faba bean promising lines

Maintenance, multiplication and seed production of faba bean varieties Swarna Gaurav and Swarna Suraksha developed by ICAR Research Complex for Eastern Region Patna, and recommended by State Varietal Release Committee for cultivation under rainfed as well as irrigated ecologies have been done. Five faba bean promising genotypes *viz.* RCPFB01, RCPFB02, RCPFB03, RCPFB04 and RCPFB05 were also under varietal development programme. (Fig. 6.1)

Fig. 6.1. Maintenance and management Faba bean germplams

Chickpea

Station trial : A station trial comprising 8 treatments including 4 checks was conducted under normal sown condition (first fortnight of November 2016) following randomized complete block design (RCBD) in three replications to select the promising genotypes for the north east plain zone (NEPZ). The test entries 'DBGC 1' (2880 kg/ha) and 'DBGC 3' (2860 kg/ha) with 100 seed wt of 31 g and 24 g, respectively were identified as the promising genotypes (Table 6.5). Another station comprising 6 entries was conducted under late sown condition (second fortnight of December 2016) at KVK, Buxar. Yield, seed wt and maturity duration of genotypes were reduced significantly compared to those under normal sown. The test genotypes yielded at par with the best check 'Pusa 256' (2100 kg/ha).

Table 6.5. Mean performance of chickpea genotypes in station trials

Genotypes	Yield (t/ha)		100 seed wt (g)		Maturity duration (days)	
	Normal sown	Late sown	Normal sown	Late sown	Normal sown	Late sown
DBGC 1	2.88	–	31.0	–	124	–
DBGC 2	2.83	2.05	31.5	26.5	129	109
DBGC 3	2.86	2.08	24.1	16.0	125	113
DBGC 4	2.50	–	30.5	–	130	–
Pusa 256	2.36	2.10	31.8	21.4	131	115
Pusa 372	2.53	1.70	15.2	11.4	125	107
Pusa 547	2.70	2.08	30.0	21.0	126	109
Pusa 1103	2.34	1.51	27.0	19.6	128	110
LSD (P=0.05)	0.12	1.41	1.49	2.41	1.99	2.3

Breeding materials and germplasm maintained during 2016-17

The advance breeding line 'DBGC 2' was grown in demonstration plot along with 'Pusa 547', each in an area of 36 m^2. 'DBGC 2' (2791 kg/ha) showed an yield advantage of ~10% over 'Pusa 547' (2560 kg/ha). Three breeding lines suitable for mechanical harvesting, 5 other promising lines, 5 released varieties of chickpea (Pusa 256, Pusa 372, Pusa 547, Pusa 1103, Pusa 1003 and Shubhra), 5 putative heterozygotes, 4 determinate types of Kabuli chickpea (RCECK 15-1, RCECK 15-2, RCECK 15-3 and RCECK 15-4) were advanced and maintained.

49 DT (Desi + Kabuli) plants from F_3 population were also selected.

Genetic information generated (2016-17)

Parents and their F_1's, F_2's and F_3's (Shubhra × BGD 9971 and JG 16 × BGD 9971) generations indicated partial and complete dominance of NDT (Shubhra/JG 16) over the DT (BGD 9971) type. F_2 generation showed a 15 (NDT):1 (DT) ratio. The same was confirmed in the F_3 generation. All the 6 putative heterozygotes (natural crosses) selected from the DT genotype 'BGD 9971' segregated for different traits, confirming occurrence of natural crossing through honeybees in chickpea (Fig. 6.2).

Fig. 6.2. Field view of chickpea station trial

Lentil

Station trial : A station trial comprising 8 treatments including 4 checks was conducted under normal sown condition (first fortnight of November 2016) following randomized complete block design (RCBD) in three replications to select the promising lentil genotypes for the north east plain zone (NEPZ) (Fig. 6.3). The test entry 'DBGL 135' yielded the highest (2.18 t/ha) with 100 seed wt and maturity duration of 2.1 g and 110 days, respectively (Table 6.6). Another station comprising 7 entries was conducted under late sown condition (second fortnight of December 2016) at KVK, Buxar. Seed yield and maturity duration of genotypes were reduced significantly compared to those under normal sown condition. The test genotype 'DBGL 105' yielded the highest (1.52 t/ha); however, the genotype 'DBGL 135' with yield (1.35 t/ha) was at par with the best check 'IPL 220' (1.34 kg/ha) appeared as the earliest maturing (86 days).

Fig. 6.3. Field view of lentil station trial

Table 6.6. Mean performance of lentil genotypes in station trials

Genotypes	Yield (t/ha)		100 seed wt (g)		Maturity duration (days)	
	Normal sown	Late sown	Normal sown	Late sown	Normal sown	Late sown
DBGL 62	1.37	1.04	2.1	2.0	125	97
DBGL 105	2.01	1.52	2.8	2.2	122	104
DBGL 135	2.18	1.35	2.1	2.1	110	86
DBGL 138	1.91	–	1.9	–	111	–
Pusa Vaibhav	1.61	–	1.9	–	120	–
DPL 15	1.80	1.10	2.9	2.1	122	102
KLS 218	2.03	1.04	2.1	2.2	119	105
HUL 57	2.03	1.34	2.2	2.2	118	104
IPL 220	--	1.34	--	2.1	--	107
LSD (P=0.05)	0.089	0.10	0.10	0.11	2.7	3.3

Demonstration: Four advance breeding lines (DBGL 62, DBGL 105, DBGL 135 and DBGL 138) along with one released variety (IPL 220) were grown in demonstration blocks. DBGL 138 (1541 kg/ha) and 'DBGL 135' (1490 kg/ha) out-yielded 'IPL 220' (1.10 t/ha) by over 35%.

Breeding materials and germplasm maintained during 2016-17

Fifteen advance breeding lines and 14 released varieties were grown, purified and maintained. A total of 24 SPS (10 from ILWL 118 × DPL 58 and 14 from varieties) was performed and kept for further multiplication. Five extra early spreading and 5 extra early tall and compact types (< 90 days) were also selected from segregating population.

Grass pea

Station trial: A station trial of grass pea comprising 8 treatments including 4 local checks was conducted during the second fortnight of

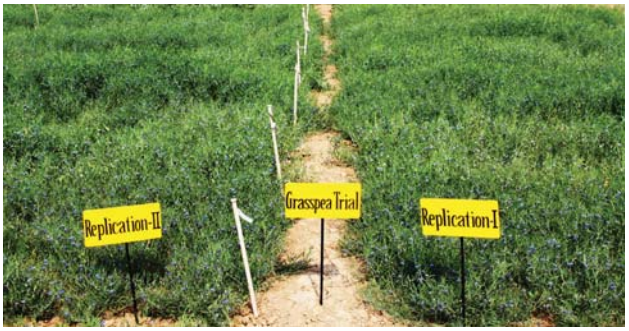

Fig. 6.4. Field view of grass pea station trial

November 2016 following randomized complete block design (RCBD) in three replications to select the promising genotype(s) for the north east plain zone (NEPZ) (Fig, 6.4). The test entry 'RCEGP 16-2' yielded the highest (1288 kg/ha) with 100 seed wt and maturity duration of 7.1 g and 111 days, respectively (Table 6.7).

Table 6.7. Mean performance of grass pea genotypes in station trial

Genotypes	Seed yield (kg/ha)	100 seed wt (g)	Maturity duration (days)
RCEGP 16-5	949	7.4	113
RCEGP 16-4	809	6.8	112
RCEGP 16-3	1018	6.5	111
RCEGP 16-2	1288	7.1	111
Local-1	762	6.2C	121
Local-2	900	5.9	122
Local-3	977	5.2	121
Local-4	850	5.6	122
LSD (P=0.05)	71	0.3	2.1

Breeding materials generated in grass pea during 2016-17: A white flowered genotype 'RCEGP 16-1' selected from germplasm (low ODAP content ICARDA line '63101') was multiplied for its use in genetic studies in future.

Pulse Seed Hub

Under the aegis of NFSM funded mega project on "Creation of seed hubs for increasing indigenous production of pulses in India", quality seed production of lentil, field pea, chickpea, mungbean and pigeonpea has been undertaken at Patna, Buxar, Darbhanga and Ranchi. Details of quality seed produced are mentioned in the Table 6.8.

Table 6.8. Quality seed production of pulses (2016-17)

Pulse Seed Hub	Crop	Variety	Class of Seed	Quantity (ton)
ICAR RCER, Patna	Lentil	HUL 57	C/S	9.8
		KLS 218	T/L	1.5
	Field pea	HUDP 15	T/L	1.5
		Swarna Mukti	T/L	0.5
	Chickpea	Pusa 547	T/L	1.2
		Shubhra	T/L	0.1
	Pigeonpea	IPA 203	Nucleus	0.02
	Mungbean	Samrat	T/L	0.6
		IPM 02-3		1.8
		IPM 02-14		0.1
KVK, Buxar	Chickpea	Pusa 547	T/L	40

C/S: Certified seed; T/L: Truthfully labelled seed

Fig. 6.5. Quality seed production of mungbean variety 'IPM 02-03' , 'IPM 02-14 and Samrat

7 Fruits

Evaluation of Germplasm/Varieties under Hill and Plateau Conditions

Mango

Eight new mango segregants developed by the institute were evaluated for fruit quality (Table 7.1). The average fruit weight ranged between 126.60g (CHM 3) to 267.20g (CHM 4). The genotype CHM 7 recorded the minimum peel content (13.25%) and maximum pulp content (70.05%). The maximum TSS (19.50°B) was recorded in case of CHM 1. Keeping in view the fruit quality (Fruit weight 186 g, pulp content 70.05 %, TSS 18.8°B and presence of anthocyanin pigmentation on the peel), the CHM 7 was found to be the most promising genotype (Fig 7.1).

Fig. 7.1. Mango genotype 'CHM 7'

Sapota

A total of nine sapota varieties conserved in the field gene bank were evaluated for fruit quality. The varieties differed significantly among each other with respect to quality parameters. Maximum fruit weight was recorded in DHS 1 (110g) followed by Kalipatti and Murabba (Table 7.2). The highest pulp % was recorded in Mahayati (89.91%) followed by Murabba (88.91%). The minimum number of seeds was found in the Murabba, Mahayati and Kalipatti (1.5 in each variety). The maximum TSS was recorded in case of DHS 1 (31.10°B) followed by Murabba (30.70°B). The highest non reducing and total sugar was recorded in Murabba (8.93% and 16.67%, respectively). Hence, based on fruit quality, the sapota varieties Murabba, kalipatti and D.H.S.-1 were found most promising during the year (Fig. 7.2).

Table 7.1. Fruit characteristics of new mango genotypes

Genotype	Fruit colour	Fruit weight (g)	Pulp %	TSS (°B)	Titratable acidity (%)	Total sugar (%)
CHM 1	Greenish yellow	227	67.04	19.60	0.11	9.43
CHM 2	Greenish yellow	262	66.07	19.50	0.17	9.43
CHM 3	Greenish yellow with red blush on the shoulder	127	56.52	18.80	0.13	8.62
CHM 4	Greenish yellow with red blush on the shoulder	267	67.91	18.40	0.16	11.90
CHM 5	Greenish yellow with red blush on the shoulder	199	66.11	17.00	0.20	8.62
CHM 6	Yellow with red pigmentation on the fruit	259	68.67	17.20	0.11	10.20
CHM 7	Yellow with red pigmentation on the fruit	187	70.05	18.80	0.35	10.42
CHM 8	Yellow with red pigmentation on the fruit	185	65.48	19.30	0.11	10.20

Table 7.2 Fruit quality parameters of different sapota varieties.

Variety	Fruit weight (g)	No. of seeds/ fruit	Pulp (%)	TSS (°B)	Titratable acidity (%)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)
Murabba	105	1.50	88.91	30.70	0.11	8.93	7.74	16.67
DHS 1	110	2.00	86.95	31.10	0.14	8.33	6.82	15.15
PKM 1	94	5.00	85.04	24.20	0.13	6.76	5.74	12.50
Mahayati	65	1.50	89.91	24.00	0.10	5.88	6.62	12.50
Kalipatti	106	1.50	88.11	30.10	0.07	8.77	5.12	13.89
Jhumkiya	58	3.00	87.14	22.70	0.09	5.62	6.01	11.63
DHS 2	91	2.00	86.77	28.60	0.07	8.33	6.82	15.15
Cricket Ball	96	2.00	86.39	25.20	0.06	8.93	5.78	14.71
Bhuripatti	53	3.00	41.99	27.90	0.06	10.42	2.08	12.50

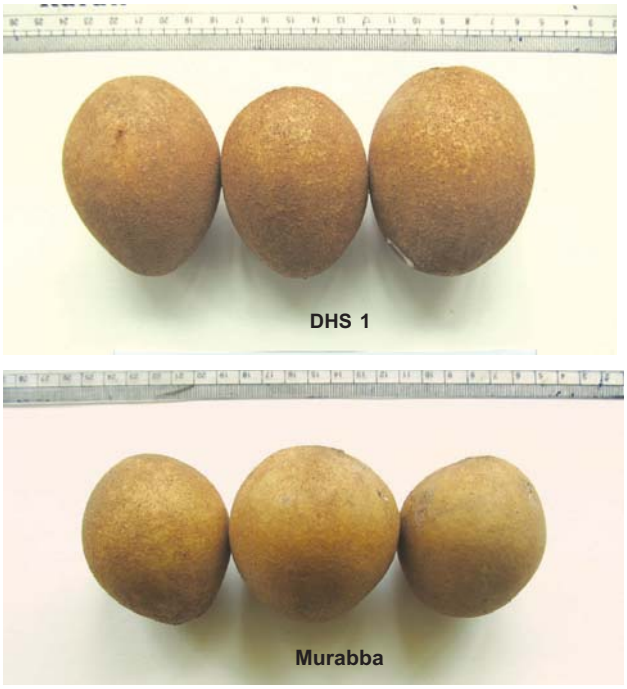

Fig. 7.2. Sapota genotypes 'DHS'

Tamarind

Thirty six tamarind genotypes conserved at the field gene bank of the institute were evaluated for their performance based on fruit quality characters. Average fruit weight ranged between 07.60 g (ICAR RCER TS 2/3) to 19.20g (ICAR RCER TS 5/3). Pulp content ranged between 33.25% (ICAR RCER TS 8/4) to 57.86% (ICAR RCER TS 7/1). The genotype ICAR RCER TS 2/1 recorded the minimum number of seeds per fruit (2.4). The maximum TSS (60.20°B) was recorded with ICAR RCER TS 4/5. Hence, based on overall performance the tamarind genotype ICAR RCER TS 5/3, (Fruit weight: 19.20g, pulp: 50.98%, TSS: 51.40°B) was found to be the most promising for fruit quality.

Collection and Conservation of Jackfruit Germplasm for Vegetable Purpose

Seven promising jackfruit germplasm suitable for vegetable purpose were identified from the farmers' fields. A promising genotype (IC-0625182) was collected from the Gadri Tonka Toli village of Ranchi district of Jharkhand (Fig. 7.3). The tree is more than 100 years old. In this plant, fruiting takes place, twice a year. First fruiting starts from 15th December indicating early fruiting behavior and second fruiting takes place during July. Present yield level (Vegetable stage) is 700-800 kg /tree. It is very much suitable for culinary purpose as its firmness after boiling is 1.56 lbs as against 3 lbs and above in other vegetable type jackfruits.

Fig. 7.3. Promising jackfruit collection IC-0625182

This accession of jackfruit is being maintained at National germplasm repository of sub-tropical fruit crops, at ICAR - Research Complex for Eastern Region, Research Centre, Ranchi, Jharkhand.

Standardization of Shoot Bending as Canopy Management Technique for Crop Regulation in Guava

An experiment was initiated at ICAR-RCER, Patna to standardize the shoot bending technique in guava. Five-year-old guava plants were selected for bending experiment. Two other treatments *viz.* pruning with leaves and pruning without leaves were also included along with control. Results revealed that bending technique increased the production of lateral new shoots by 6 times, and flower emergence by 14 times over control (Fig. 7.4 and 7.5). Pruning with leaves resulted in no fruit setting. Although the percentage of fruit set was lower in bending (64.55%) as compared to pruning with no leaves (100%), fruit retention percentage was higher in bending (95.71%) as compared to pruning with no leaves (81.25%) and control plant (85%). However, fruit size reduced in bending plant (170g) as compared to pruning with no leaves or control (approximate weight was 200g). Fruit yield per plant was higher in bending treatment.

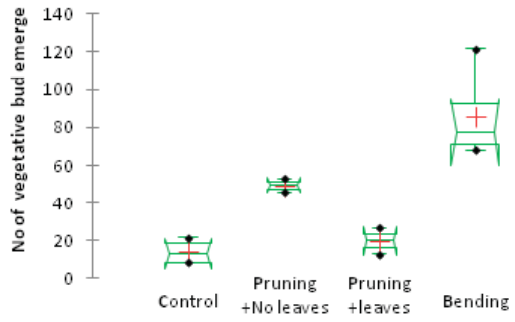

Fig. 7.4. Effect of bending on vegetative bud emergence on guava branch

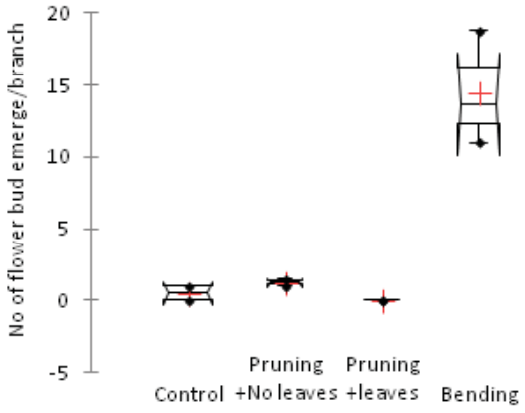

Fig. 7.5. Effect of bending on flower-bud emergence on guava branch

During autumn season bending was carried out in high-density orchard of guava from October to November at fortnight interval. Among four periods of bending, October bending resulted in profuse flowering (Fig. 7.6) but no fruit setting due to severe winter in January, which might have restricted the growth and development of ovary. However, plants subjected to bending in November produced profuse flowers in March.

Fig 7.6. Effect of bending on shoot emergence in guava

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

During the fourth year of experimentation, the maximum dry biomass yield was recorded in case of Tephrosia (37.0±3.13 t/ha) followed by Subabul (24.7±1.17 t/ha) (Fig. 7.7 and 7.8). Estimation of total nutrient content in the biomass based on their respective nutrient composition indicated recycling of nitrogen, phosphorus and potassium by 1.09 t/ha, 0.06 t/ha and 0.39 t/ha, respectively through the biomass of Tephrosia. However, there was poor regeneration of shoots from the four year old Tephrosia plants after the 2nd harvesting of the biomass in July, 2017 leading to mortality of the plants. This necessitated resowing of Tephrosia seeds for gap filling after the fourth year.

Significant effects of the treatments on basin enrichment were recorded in organic carbon in the soil at both 0-15 cm and 15-30 cm depths. At 0-15 cm soil depth, mulching of Subabul resulted in significantly higher organic carbon content (0.73%) over that of control (0.48%) whereas at 15-30 cm soil depth, soil incorporation of rice bean biomass

resulted in significantly higher organic carbon (0.70%) over control (0.39%). All the treatments on mulching resulted in significant reduction in soil bulk density in the basin area of bael plants (Fig. 7.7 and 7.8).

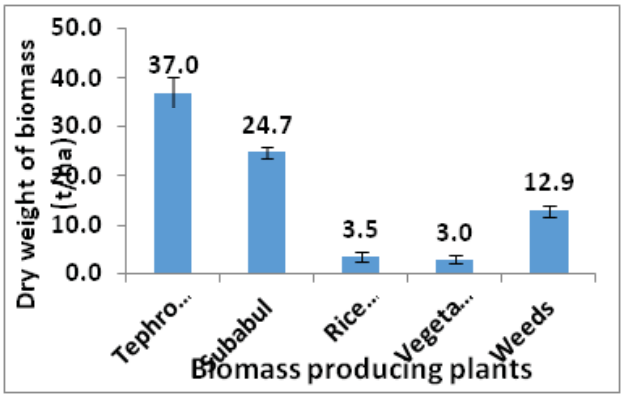

Fig. 7.7. Effect of mulching on bulk density of soil

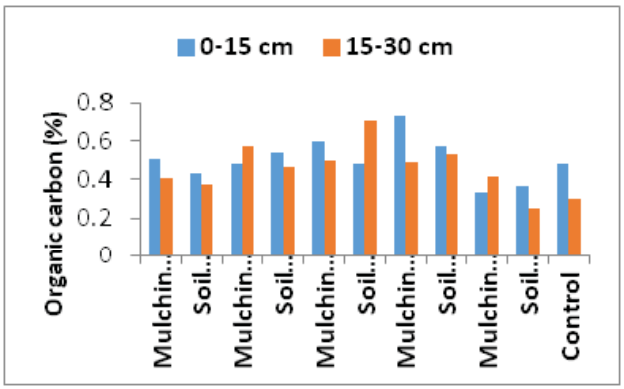

Fig. 7.8. Effect of basin enrichment on trunk circumference and canopy spread of bael plants

Plant growth parameters like trunk circumference and canopy spread of five year old bael plants were significantly affected by different treatments. All the treatments except soil incorporation of rice bean, subabul and weeds resulted in significant increase in trunk circumference over that of control. Basin enrichment with biomass of Tephrosia, rice bean and weed resulted in significant increase in plant canopy spread over that of control. All the treatments on basin enrichment resulted in initiation of fruiting whereas no fruiting was observed in the control plants.

Litter decomposition studies indicated slower rate of nutrient release in case of mulching of biomass than that of soil incorporation of biomass (Figs 7.9. & 7.10). Among the different biomass yielding plants, slowest rate of nutrient release was recorded in case of vegetable soybean followed by rice bean whereas, the rates in case of tephrosia and subabul were at par.

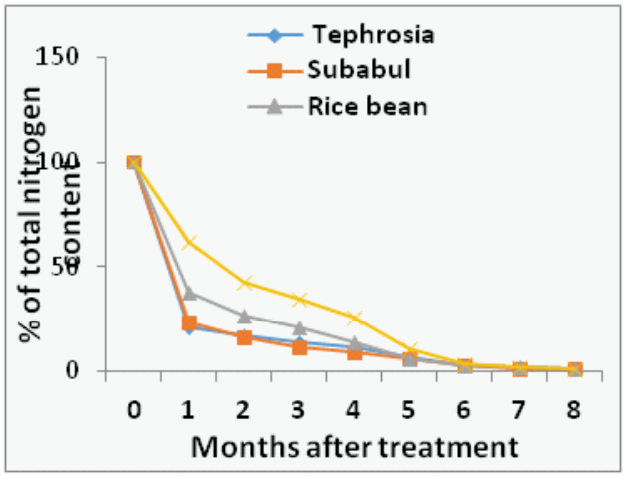

Fig. 7.9. Nitrogen release pattern under different treatments of mulching

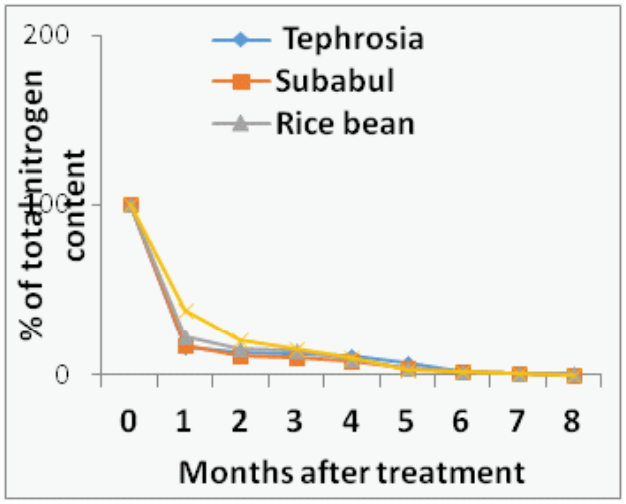

Fig. 7.10. Nitrogen release pattern under different treatments of soil incorporation

8. Vegetables

Brinjal

Collection, Evaluation and Development of Bacterial Wilt Resistant Germplasm of Brinjal

Evaluation of bacterial wilt resistant F1s and germplasm

Four wilt resistant and high yielding F_1s with desirable fruit quality were further evaluated for yield and fruit characters. Seed multiplication was done for multilocation trials. Also four wilt resistant germplasm collected from Odisha and Jharkhand during previous year were evaluated for yield and fruit characters (Table 8.1).

In another experiment, five wilt resistant varieties of brinjal released from OUAT, Bhubaneswar and three wild type collections were screened for wilt resistance and yield parameters (Table 8.2 and Fig. 8.1). All of them were wilt resistant under wilt sick plot conditions but didn't have desirable fruit quality.

Evaluation of line x tester crosses

Crosses made in Line x Tester design were evaluated for wilt resistance, yield and yield parameters (Fig. 8.2). Fourteen crosses made with HAB-901 and IC-545901 as testers and HAB-792, HAB-913, HABR-6, HABR-21, Swarna Shyamali, Swarna Pratibha and Swarna Abhilamb with desired fruit quality characters as lines, were evaluated along with the parents. All the parents and crosses were bacterial wilt resistant under natural field conditions. Promising genotypes are listed in Table 8.3.

Table 8.2 Performance of brinjal germplasm collected from Odisha

Genotype	Yield (t/ha)	Fruit weight (g)	Fruit length (cm)	Fruit shape
Utkal Anushree	5.70	50	10.2	Long purple
Utkal Madhuri	17.8	80	9.3	Oblong purple
Utkal Tarini	23.1	70	12.8	Oblong green striped
Utkal Jyothi	12.8	50	8.7	Oblong green spiny calyx
Utkal Keshri	15.2	208	12.1	Oblong purple striped
HAB-918 (wild type)	21.0	125	16.2	Oblong purple spiny very small fruits
HAB-919 (wild type)	-	20	2.1	Round small purple spiny very small fruits
HAB-920 (wild type)	-	30	2.2	Round small purple spiny very small fruits

Table 8.1. Performance of bacterial wilt resistant germplasm for yield and fruit quality

Genotype	Yield (t/ha)	No. of fruits / plant	Fruit weight (g)	Fruit length (cm)	Fruit shape
HAB-905 x IC-545901	32.80	21.76	72.00	17.83	Long purple
HAB-906 x IC-545901	38.69	28.33	78.67	17.30	Long purple
IC-545901 x IC 261786	32.89	17.36	87.00	17.37	Long purple
IC 261786 x IC-545901	29.55	16.62	79.67	17.20	Long purple
HAB-914 (Odisha)	26.22	17.19	88.67	13.03	Oval green striped
HAB-915 (Odisha)	22.74	6.71	200.67	9.10	Round green striped
HAB-916 (Odisha)	26.87	8.12	147.00	8.63	Round green striped
HAB-917 (Jharkhand)	24.57	8.26	132.00	8.17	Round dark purple

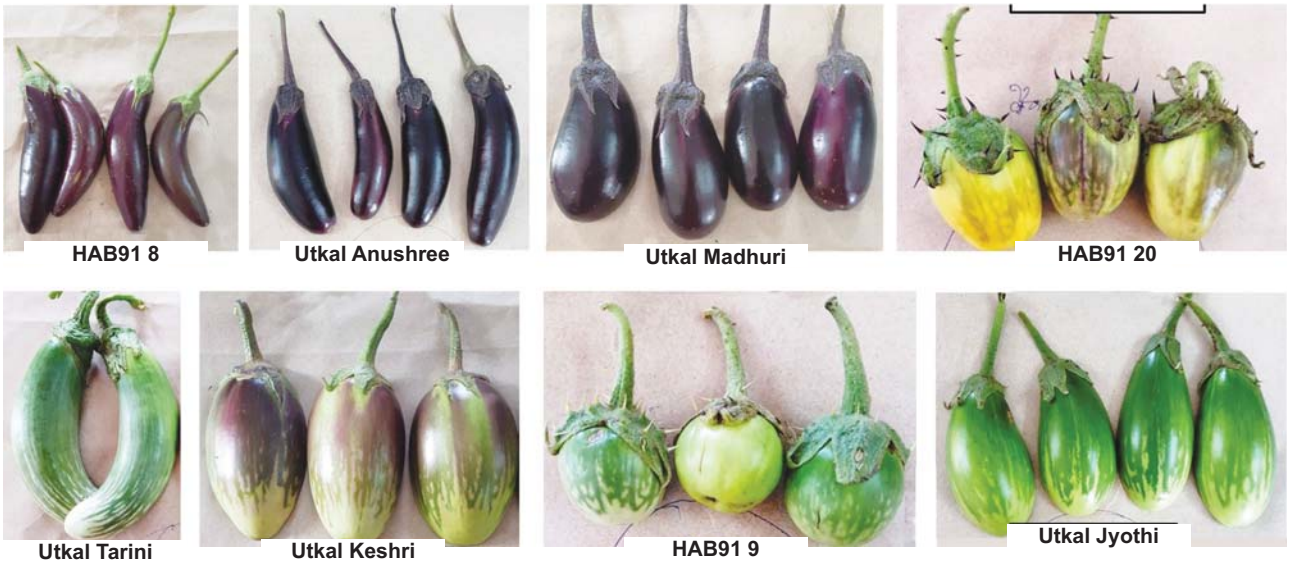

Fig. 8.1. Promising germplasm from Odisha

Table 8.3. Promising L x T crosses

Genotype	Yield (t/ha)	Fruit weight (g)	Fruit length (cm)	Days to 50% flower-ing	Fruit shape
Swarna Abhilamb x IC 545901	32.42	62.66	14.23	47	Long purple
Swarna Abhilamb x HAB-901	30.42	64.33	12.87	53	Long dark purple
HAB-792 x IC 545901	31.75	55.30	13.5	48	Long dark purple
HABR-6 x IC 545901	48.78	116	11.57	49	Oblong purple
HABR-6 x HAB-901	37.53	121	8.77	47	Round dark purple

Fig. 8.2. Promising L x T crosses of brinjal

Tuber Crops and Wild Edibles

Total **256** germplasm collected through survey in Jharkhand, Chhattisgarh, Nagaland, Odisha and West Bengal were multiplied in the field for characterization and evaluation. These include germplasm of *Dioscorea* spp. (56), *Ipomoea batatas* (12), *Maranta arundinacea* (3), *Colocasia* spp. (112), *Amorphophallus* spp. (47), *Alocasia* spp. (7), *Manihot* spp. (7), *Xanthosoma* spp. (5) and *Cucumis melo* var *agrestis* (7).

Sweet potato

Eleven germplasm lines were evaluated for yield and nutritional traits. On the basis of ORSI values, tuber shape and skin colour, **ACC-161** (a collection from Mardu village under Silli block of Ranchi district of Jharkhand (Fig. 8.3); ORSI

Fig. 8.3. Promising line of sweet potato 'ACC 161'

value 0.78; tuber yield 8.25 t/ha; tuber carbohydrate 17.09 g/100g; total mineral 672.92 mg/100g; anti-oxidant activity 186.89 mg AEAC/100g; beta carotene 7775.28 mg/100g; total sugar 3.86%), **ACC-229** (a collection from Pustiguda village under Thuamula Rampur block of Kalahandi district of Odisha; ORSI value 0.68; tuber yield 13.20 t/ha; tuber carbohydrate 14.48 g/100g; total mineral 844.77 mg/100g; anti-oxidant activity 196.90 mg AEAC/100g; beta carotene 1523.82 mg/100g; total sugar 3.13%) were identified promising genotypes for further multiplication and promotion as pre-released varieties.

Taro/Colocasia

Forty five genotypes of taro were evaluated for yield, nutritional, anti-nutritional, and biotic stress traits. On the basis of ORSI values, corm size and shape, **ACC-118** (a collection from Pathari village under Kanker block of Uttar Bastar Kanker district of Chhattisgarh; ORSI value 0.17; corm yield 889.04 g/plant; 44.45 t/ha; corm carbohydrate 35.54 g/100g; total mineral 1.447g/100g; anti-oxidant activity 229.30 mg AEAC/100g; leaf oxalate 61.41 mg/100g; corm oxalate 50.30 mg/100g; petiole oxalate 8.38 mg/100 g) and **ACC-280** (a collection from Tanhai village under Wakching block of Mon district of Nagaland (Fig. 8.4); ORSI value 0.17; corm yield 2052.50 g/plant; 51.25 t/ha; corm carbohydrate 25.74 g/100g; total mineral 1.732 g/100g; anti-oxidant activity 310.10 mg AEAC/100g; leaf oxalate 86.75 mg/100g; corm oxalate 37.99 mg/100g; petiole oxalate 4.23 mg/100 g) were identified as promising genotypes for further multiplication and promotion as pre-released varieties.

Fig. 8.4. Promising line of Colocasia 'ACC 280'

Elephant Foot Yam

Ten germplasm lines were evaluated for yield and nutritional traits. On the basis of ORSI values, corm size and shape, **ACC-136** (Fig. 8.5) (a collection from Chirkubera forest under Bandgaon block of West Singhbhum district of Jharkhand; ORSI value 0.61; corm yield 2.63 kg/plant; 32.87 t/ha; corm carbohydrate 24.36 g/100g; total mineral 503.09 mg/100g; anti-oxidant activity 50.31 mg AEAC/100g; oxalate 9.22 mg/100g) and **ACC-204** (a collection from Arjunjora village under Hura block of Purulia district of West Bengal; ORSI value 0.60; corm yield 1.49 kg/plant; 18.62 t/ha; corm carbohydrate 26.15 g/100g; total mineral 532.98 mg/100g; anti-oxidant activity 230.42 mg AEAC/100g; oxalate 7.84 mg/100g) were identified promising genotypes for further multiplication and promotion as pre-released varieties.

Fig. 8.5. Promising genotype of elephant foot yam 'ACC 136'

Cassava

Six germplasm lines of cassava were evaluated for yield and quality related traits. On the basis of ORSI values, tuber size and shape, **ACC-139** (a collection from Chirkubera forest under Bandgaon block of West Singhbhum district of Jharkhand; ORSI value 0.81; tuber yield 19.75 t/ha; tuber carbohydrate 30.68 g/100g; total mineral 751.89 mg/100g; anti-oxidant activity 297.71 mg AEAC/100g) and **ACC-53** (Fig. 8.6) (a collection from Mayurnacha village under Dumka block of Dumka district of Jharkhand; ORSI value 0.81; tuber yield 27.25 t/ha; tuber carbohydrate 38.68 g/100g; total mineral 766.92 mg/100g; anti-oxidant activity 89.94 mg AEAC/100g) were identified promising genotypes for further multiplication and promotion as pre-released varieties.

Fig. 8.6. Promising genotype of cassava 'ACC 53'

Potato/Aerial yam

Six germplasm lines of potato/aerial yam were evaluated for yield and quality related traits. On the basis of ORSI values, aerial tuber size and shape, **ACC-28** (Fig. 8.7) (a collection from Katud nichetola village under Khunti block of Khunti district of Jharkhand; ORSI value 1.77; aerial tuber yield 9.18 t/ha; tuber carbohydrate 17.01 g/100g; protein 5.05 g/100g; total mineral 1.8 g/100g; anti-oxidant activity 65.64 mg AEAC/100g) and **ACC-123** (a collection from Amajhola village under Kanker block of Uttar Bastar Kanker district of Chhattisgarh; ORSI value 0.96; aerial tuber yield 9.48 t/ha; tuber carbohydrate 7.19 g/100g; protein 5.45 g/100g; total mineral 1.3 g/100g; anti-oxidant activity 31.50 mg AEAC/100g) were identified promising genotypes for further multiplication and promotion.

Regarding underground tuber yield, **ACC-123** (10.63 t/ha) and **ACC-129** (a collection from Kotela village under Charama block of Uttar Bastar Kanker district of Chhattisgarh; 10.14 t/ha) were promising and at par with each other.

Greater Yam

Seven germplasm lines of greater yam were evaluated for 16 yield and quality related traits.

Fig. 8.7. Promising line of potato yam 'ACC 28'

Fig. 8.8. Promising line of greater yam 'ACC 34'

On the basis of ORSI values, tuber size and shape, **ACC-113** (a collection from Amajhola village under Kanker block of Uttar Bastar Kanker district of Chhattisgarh; ORSI value 0.73; tuber yield 16.02 t/ha; tuber carbohydrate 27.19 g/100g; total mineral 1156.95 mg/100g; anti-oxidant activity 190.97 mg AEAC/100g) and **ACC-34** (a collection from Tunko village under Namkum block of Ranchi district of Jharkhand (Fig. 8.8); ORSI value 0.55; tuber yield 42.77 t/ha; tuber carbohydrate 15.61 g/100g; total mineral 642.13 mg/100g; anti-oxidant activity 102.76 mg AEAC/100g) were identified promising genotypes for further multiplication and promotion as pre-released varieties.

Lesser yam

Seven germplasm lines of lesser yam were evaluated for yield and quality related traits. On the basis of ORSI values, tuber size and shape, **Lotni** (Fig. 8.9) (a variety from Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar; ORSI value 0.91; tuber yield 30.77 t/ha; tuber carbohydrate 22.24 g/100g; total mineral 516.50 mg/100g; anti-oxidant activity 187.95 mg AEAC/100g) and **Adamoul-4** (ORSI value 0.79; tuber yield 29.79 t/

Fig. 8.9. Promising line of lesser yam 'Lotni'

ha; tuber carbohydrate 25.15 g/100g; total mineral 613.11 mg/100g; anti-oxidant activity 76.91 mg AEAC/100g) were identified promising genotypes for further multiplication and promotion.

Wild Muskmelon/Kachri

Six germplasm lines of wild muskmelon/kachri were evaluated for five yield and quality related traits. On the basis of ORSI values, the genotypes **HAWMM-1 (**Fig. 8.10**)** (ORSI value 1.21; fruit yield 3.32 t/ha; fruit carbohydrate 1.94 g/100g; protein 1.21 g/100g; total mineral 2.99 g/100g; antioxidant activity 866.67 mg AEAC/100g) and **HAWMM-3** (ORSI value 0.88; fruit yield 3.76 t/ha; fruit carbohydrate 0.82 g/100g; protein 1.33 g/100g; total mineral 1.97 g/100g; antioxidant activity 1043.75 mg AEAC/100g) were identified promising genotypes for further multiplication and promotion as pre-released varieties.

Fig. 8.10. Promising line of wild musk melon 'HAWMM-1'

Yam Bean

Out of seven genotypes including check evaluated, HAYB-1 (A collection from village Khirpai of Pashchim Medinipur district of West Bengal; 52.22 t/ha) (Fig. 8.11) and DPH-88 (46.57 t/ha) performed better than the check variety Rajendra Mishrikand-1 (42.66 t/ha) and were at par with each other in respect of tuber yield.

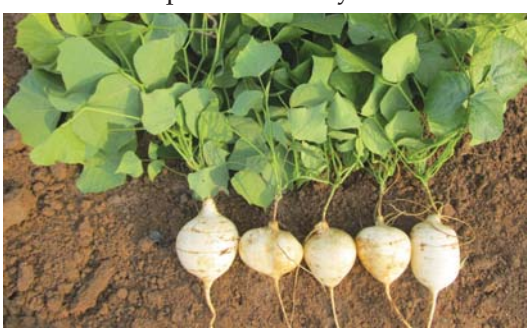

Fig. 8.11. Promising line of yambean 'HAYB-1'

Nutritional Characterization and Value Addition of Potential underutilized Leafy Vegetables of Jharkhand

Six leafy vegetables *viz*., *munga, muchari, beng, chimti, koinaar* and *green gandhari* were analyzed for their nutrient content in three different drying methods *viz*. sun, solar box and cabinet drying. For solar drying of the leafy vegetables, a low cost solar dryer of base size- 95 cm x 100 cm and incline size- 95 cm x 103.5 cm was fabricated (Fig. 8.12). A black colour coated perforated aluminium tray was fitted inside to provide platform for keeping the vegetables. The dryer was covered with glass of 6 mm thickness to penetrate enough sunlight inside the chamber. The dryer has the capacity of drying 2 kg leafy vegetables per batch.

The dried leaves were analyzed for different quality parameters. Total phenols content among the six leafy vegetables ranged between 4.28±0.11 to 87.63±2.30 mg GAE/100g FW. Though sun drying is the most commonly practiced method of drying of leafy vegetables by the local people, the solar drying was found to be most effective for higher content of total phenol and antioxidant activity of *munga* and *beng* saag. Among the dried samples solar box dried *munga* saag recorded highest amount of total phenols (87.63±2.30 mg GAE/100g FW). Antioxidant activity in these leafy vegetables ranged between 361.09±22.58 to 2908.00±52.33 mg AEAC/100 g FW. Solar box dried *Munga* saag measured highest antioxidant activity (2908.00±52.33 mg AEAC/100 g FW) followed by sun dried *chimti* saag (1923.27±7.73 mg AEAC/100 g FW). Total chlorophyll in the samples ranged between 30.61±4.34 to 117.67±10.76 mg/100 g FW. Higher amount of total chlorophyll was obtained in cabinet dried *Munga* saag (117.67±10.76 mg/100 g FW) followed by sun dried *muchari* saag (108.03±5.22 mg/100 g FW). Carotenoids content of leafy vegetables ranged between 8.82±0.29 to

Fig. 8.12. Low cost solar dryer

48.23±4.10 mg/100 g FW. Cabinet dried *munga* saag recorded highest amount of carotenoids (48.23±4.10 mg/100 g FW) followed by sun dried *chimti* saag (38.89±2.22 mg/100 g FW).

Mineral content of the leafy vegetables was also measured on dry weight basis. Potassium content in the leafy vegetables ranged between 2064.33±76.83 (sun dried *beng saag*) to 3817.00±6.35 mg/100 g (solar dried *green gandhari saag*). The sodium content in the dried leaves ranged between 13.67±0.33 (*munga saag*) to 926.00±12.12 mg/100 g (*beng saag*). The highest Sulphur content was recorded in solar dried *muchari* saag (1948.90±0.70 mg/100 g). The content of zinc, copper, iron and manganese varied from 3.49±0.18 to 18.86±0.37 mg/100 g, 0.81±0.05 to 5.12±0.05 mg/100 g, 33.46±2.27 to 130.67±5.53 mg/100 g and 5.32±0.40 to 85.16±0.39 mg/100 g, respectively.

Development and Evaluation of Disease Suppressive Potting Mixtures in Vegetable Crops

Seven combinations of disease suppressive formulations *viz.*, soil application of *Tricoderma asperellum* alone, *T. asperellum* + vermicompost, *T. asperellum* + FYM, root dipping in *T. asperellum*, root dipping in microbial consortia (*T. asperellum* + *Pseudomonas florescens* + *Rhizobium* spp.) and drenching of phosphoric acid (1ml/L) along with control were evaluated against bacterial wilt of tomato and blackleg disease of cabbage under field condition. *T. asperellum* + vermicompost and consortial root dip showed minimum blackleg disease infested plant of cabbage (7.78%) followed by *T. asperellum* + FYM (8.89%) (Table 8.4). In bacterial wilt of tomato, phosphoric acid showed strong antibacterial activity (30% plant mortality) followed by *T. asperellum* + vermicompost (31.1%) and *T. asperellum* + FYM (32.2%) as compared to control (55.6%) after 90 days of transplanting.

Bio-efficacy of insecticide molecules against cucurbit fruit flies

Fruit flies are the economically important pests of cucurbits in eastern part of India. Management of fruit flies in cucurbits is one of the difficult tasks due to its nature and intensity of infestation. The field experiment was conducted at ICAR RCER, RC Ranchi in search of effective molecules/bio-molecules to control fruit flies. Treatments were applied after 10 days of interval. Based on mean infestation of fruit flies, deltamethrin @1.0 ml/L, chlorphenapyr @1.5ml/L and spinosad @0.30ml/L of water were found effective. (Table 8.5).

Table 8.5. Percent infestation of cucumber by fruit fly at different concentration of insecticides

Treatments	Cumulative infestation after				Mean infestation
	First spray	Second spray	Third spray	Fourth	
Spinosad	9.94	8.43	8.11	9.37	8.96
Deltmethrin	5.27	6.94	4.62	8.27	6.27
Cypermethrin	13.44	11.55	11.26	16.70	13.24
Acephate	19.12	16.31	16.26	17.69	17.35
Chlorphenapyr	7.17	9.80	9.33	9.14	8.86
Nimbecidine @5ml/L	21.03	21.53	17.68	19.68	19.98
Control	30.63	26.92	23.12	24.48	26.29
LSD (P=0.05)	4.1	3.4	3.3	3.6	2.3

Table 8.4. Performance of disease suppressive formulations against blackleg of cabbage and bacterial wilt of tomato

Treatment	% blackleg infested cabbage (days)			Yield (t/ha)	% mortality by bacterial wilt of tomato			Yield (t/ha)
	30	45	60		60	75	90	
Control	7.78	15.56	20.00	20.6	17.8	27.8	55.6	9.75
T. asperellum alone	4.44	8.89	10.00	26.1	11.1	22.2	52.2	10.67
T. asperellum + Vermicompost	2.22	4.44	7.78	29.6	13.3	20.0	31.1	10.95
T. asperellum + FYM	2.22	5.56	8.89	26.0	11.1	16.7	32.2	10.25
T. asperellum root dip	3.33	7.78	11.11	20.95	10.0	18.9	34.4	9.83
Consortia root dip	4.44	4.44	7.78	25.35	13.3	17.8	34.4	10.78
Soil drenching of phosphoric acid (1ml/litre)	4.44	6.67	10.00	21.43	6.7	15.6	30.0	12.05

9. Mushroom

Collection, Identification and Conservation of Wild Edible Mushroomfrom Forest and Local Market

Three wildly grown edible mushrooms were collected from the campus of ICAR-RCER Ranchi, Jharkhand. Two of them were identified as *Termitomyces* sp. (Fig. 9.1) and the third one was *T. microcarpus* (Fig. 9.2). These mushrooms were sold at a premium price @ Rs. 600-800/kg in the local market of Ranchi. One *Pleurotus* species was collected from Arjun (*Terminalia arjuna*) tree and isolated on PDA medium (Fig. 9.3). Biological efficiency, size and numbers of sporophores per bag of isolated *Pleurotus* species were evaluated. This species showed 72% biological efficiency under Ranchi condition.

Advance Varietal Trial-1 of High Yielding Varieties/Strains of Oyster Mushroom (*Pleurotus* spp.)

Four high yielding strains of *Pleurotus* species (PL-17-01 to PL-17-04) were evaluated during September - October, 2017 (>20°C Temp.) and December, 2017-January, 2018 (<20 °C) for their performance under Ranchi conditions (Fig. 9.4) (Table 9.1). During September - October, 2017, the highest biological efficiency and average sporophore weight were recorded in PL-17-01 (62% and 6.11g, respectively). During December, 2017-January, 2018, the highest biological efficiency was recorded in PL-17-03 and PL-17-04 (63.5%), while the highest average weight of sporophores was recorded in PL-17-01 (Fig. 9.4).

Table 9.1. Biological efficiency of Advance varietal trials of four strains of *Pleurotus* species under Ranchi condition

Strains of Oyster	Yield parameters		
	Biological Efficiency (%)	Avg. no. of sporophores bag	Avg. wt. of sporophore (g)
	Summer season (>20 °C)		
PL-17-01	62.0	101.4	6.11
PL-17-02	54.5	107.4	5.07
PL-17-03	58.5	102.8	5.69
PL-17-04	59.0	103.4	5.71
	Winter season (<20°C)		
PL-17-01	57.5	115.8	4.97
PL-17-02	58.5	111.6	5.24
PL-17-03	63.5	105.8	6.00
PL-17-04	63.5	111.2	5.71

Fig. 9.1. *Termitomyces* species

Fig. 9.2. *Termitomyces microcarpus*

Fig. 9.3. *Pleurotus* spp. collected from *Terminalia arjuna* tree

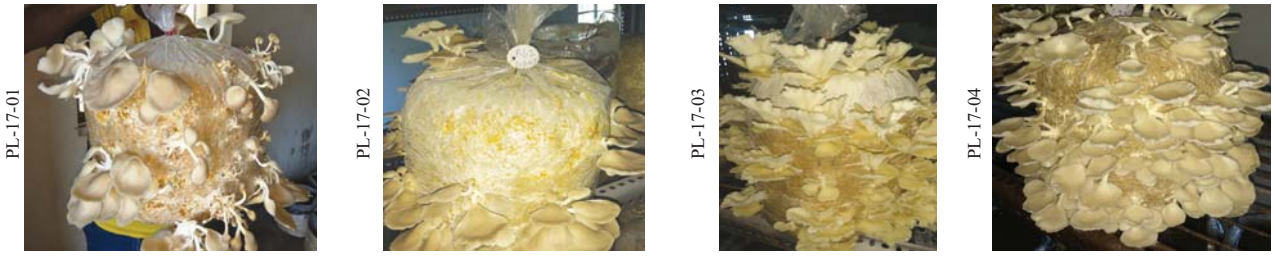

Fig. 9.4. Performance of four strains of *Pleurotus* spp. at Ranchi, Jharkhand

10. Makhana

Maintenance of Makhana Germplasm

Relative performance of twenty eight makhana germplasm was studied at RCM, Darbhanga during 2017-18. The variation in vegetative and floral characters were observed in 10 types of germplasm viz; Manipur-2, Manipur-4 Manipur-7, Manipur-9, Selection-17, Selection-23, Selection-27, Selection-28, Superior Selection-1 and cv. Swarna Vaidehi. Manipur-9 was the smallest in height (90.88 cm) and having less number of flowers (8.33) as compared to Superior selection -1 which was vigorous in nature and plant height was 114.23 cm (Table 10.1). The number of leaves (16.44) and flowers (16.33/plant) were found maximum in Superior Selection -1 The number of fruits/plant varied from 7.22 (Manipur-9) to 13.20 (Superior Selection-1) and the flowering period was about 40 days. However, peak pollination was observed between 60-70 days after transplanting. The number of seed/plant varied from 80 in Manipur-2 to 114 in Superior Selection-1. Manipur-9 recorded the minimum yield of 2.33 t/ha but Superior Selection -1 registered the maximum yield of 6.13 t/ha. Superior Selection -1 was early maturing (3.75 months) promising high yielding makhana cultivar for the wet land ecosystem of North Bihar (Fig. 10.1).

Fig. 10.1. Makhana germplasm : Superior Selection-1

Evaluation of different genotypes of water chestnut (*Trapa bispinosa*)

Twenty six germplasm were collected from different states and sown for selection of best performer in terms of growth, yield and nutritional parameters. Results (Table 10.2) revealed

Table 10.1. Morphological and yield characteristics of makhana germplasm grown under wetland ecosystem of North Bihar

Germplasm	Plant height (cm)	No of leaves/ plant	Leaf area (m^2)	No of flowers / plant	No. of mature fruits / plant	No. of seed / plant	100 seed weight (g)	Yield / plant (g)	Harvestable yield (t/ha)
Manipur -2	92.34	13.00	1.00	14.12	12.00	80	85	816	3.52
Manipur-4	96.45	12.00	0.94	11.25	8.22	102	90	754	3.26
Manipur- 7	91.22	11.00	0.92	9.69	8.55	93	92	731	3.16
Manipur- 9	90.88	10.25	0.85	8.33	7.22	85	88	540	2.33
Selection 17	100.25	13.77	1.16	10.88	8.00	90	99	713	3.08
Selection 23	105.92	14.00	1.11	11.34	10.00	98	92	901	3.89
Selection 27	101.63	13.78	1.18	12.87	9.50	107	102	1037	4.48
Selection 28	104.33	12.95	1.14	13.05	9.25	110	89	906	3.91
Superior Selection-1	114.23	16.44	1.14	16.33	13.20	114	102	1253	6.13
Swarna Vaidehi	106.77	14.45	1.21	13.74	9.20	102	97	910	3.93
LSD (P=0.05)	5.28	1.023	0.07	2.16	1.98	3	1	45	0.73

that germplasm JR2 (Jabalpur Red 2) performed the best followed by JG4 (Jabalpur Green 4) and DR2 (Darbhanga Red 2). Out of 26 germplasms, eleven germplasms collected from different regions of Uttar Pradesh could not perform well in their first year of planting. Nutritional quality parameters have been given in Table 10.3.

Table 10.2. Yield and nutritional properties of water chestnut plants

Genotype	No. of fruiting branches/ plant	Raw fruit weight (g/ fruit)	Shelf life (days)	Storage life at 10°C	Total soluble solid (°B)	Juice (%)	Yield per plant (kg)
JR1	5	25.1	4.0	8.0	8.8	55.3	3.88
JR2	5	26.2	4.0	8.0	9.6	58.8	5.67
JR3	4	25.8	4.0	8.0	8.6	54.6	4.75
JR4	3	20.1	4.0	8.0	8.5	54.7	4.97
JR5	4	19.5	4.0	8.0	8.1	53.4	5.09
JR6	5	18.0	4.0	8.0	8.3	53.7	5.12
JR7	3	24.6	4.0	8.0	8.4	56.2	5.01
JR8	2	25.0	4.0	8.0	8.4	56.8	5.05
JG1	4	14.8	4.0	8.0	8.0	56.8	4.25
JG2	5	21.0	4.0	8.0	8.3	55.7	4.27
JG3	4	16.0	4.0	8.0	8.4	54.5	4.39
JG4	4	23.4	4.5	8.0	8.5	57.7	4.54
JG5	4	15.5	3.5	8.0	8.4	55.3	3.95
DR1	4	10.5	3.0	6.5	8.0	55.4	3.68
DR2	5	10.9	3.0	6.5	7.8	55.6	3.89

Table 10.3. Nutritional qualities of water chestnut

Genotype	Acidity (%)	Total sugar (%)	Protein (%)	Fat (%)	Fiber (%)	Water (%)	Carbohydrate (%)	Mineral (%)
JR1	0.22	4.80	4.8	0.4	0.5	68	25	1.1
JR2	0.20	4.88	5.6	0.3	0.6	65	28	1.4
JR3	0.23	4.65	4.5	0.5	0.4	70	24	1.3
JR4	0.21	4.67	5.1	0.3	0.5	72	22	1.2
JR5	0.24	4.81	5.2	0.4	0.3	74	20	1.1
JR6	0.23	4.63	4.5	0.6	0.3	69	25	1.0
JR7	0.25	4.66	4.6	0.6	0.5	71	23	1.2
JR8	0.23	4.76	4.6	0.5	0.2	72	22	1.4
JG1	0.25	4.36	4.5	0.4	0.4	70	24	1.2
JG2	0.26	4.22	4.4	0.5	0.3	71	23	1.3
JG3	0.25	3.86	4.7	0.4	0.2	69	25	1.3
JG4	0.24	4.58	5.3	0.2	0.5	67	27	1.3
JG5	0.25	4.55	4.7	0.3	0.4	72	22	1.2
DR1	0.28	3.85	4.3	0.4	0.4	70	24	1.2
DR2	0.27	3.98	4.5	0.3	0.5	70	24	1.2

Introduction of Sweet Flag and Tuber Vegetables under Wetland Ecosystem with Makhana Crop for North Bihar

Alocasia

Seven germplasm of alocasia from ICAR-RCER, RC, Ranchi were evaluated for yield and physical characteristics during 2017-2018 at RCM, Darbhanga. It was found that the cultivar ICAR-RCER, RC-6 had the maximum yield of 2.29 kg edible corm /plant (Table 10.4). This cultivar had another merits regarding production of 4.5 plantlets /plant during one year growth period. The plant height of this germplasm was 155.5cm. The leaf area of germplasm ICAR-RCER RC 7 was very large (961 cm^2). All the germplasm are edible having less quantity of calcium oxalate content. The minimum calcium oxalate was found in ICAR-RCER, RC- 4 (62.58 mg/100 g) followed by ICAR-RCER RC-6 (70.35 mg/100 g). The maximum calcium oxalate was found in ICAR-RCER-7 (76.86 mg/100 g).

Table 10.4. Morphological and biochemical characteristics of alocasia germplasm at RCM, Darbhanga during 2017-2018

Alocasia Acc. No.	Height (cm)	Leaf area (cm^2)	Plantlets/ plant	Yield /plant (kg)	Calcium oxalate content mg/100g edible tuber
ICAR-RCER, RC-1	80.5	630	3.0	0.85	71.15
ICAR-RCER, RC-2	90.7	375	3.0	0.97	75.33
ICAR-RCER, RC-3	82.5	280	2.0	0.76	72.64
ICAR-RCER, RC-4	90.25	442	3.0	1.45	62.58
ICAR-RCER, RC-5	82.75	559	3.2	0.94	71.67
ICAR-RCER,RC-6	155.5	840	4.5	2.29	70.35
ICAR-RCER, RC-7	96.4	961	1.7	0.92	76.86
LSD (P=0.05)	4.43	134	2.2	0.12	0.63

Sweet Flag

Eight sweet flag germplasm from Jharkhand, Bihar and Karnatatka were evaluated at RCM Darbhanga during 2017-2018 for their morphological characters and yield. Among the gemplasm Tumkur-1, and Tumkur-2 perfomed well under Darbhanga conditions and produced the maximum rhizome yield of 8.1 t/ha and 7.52 t/ha during 2017,

respectively (Table 10.5). The maximum plant height was observed in Tumkur-2 (85.1 cm). However, rhizome length and girth was maximum in Tumkur-1 (65.2 cm and 8.4 cm girth). Batch -1 (7.28 t/ha) collected from BIT Mesra, Ranchi, Jharkhand was another promising sweet flag germplasm under wetland ecosystem of North Bihar.

Table 10.5. Morphological and yield characteristics of sweet flag germplasm at RCM Darbhanga during 2017-18

Sweet flag Acc. No.	Height (cm)	Rhizome lenth (cm)	Rhizome girth (cm)	Yield /plant (g)	Yield t/ha
Bach-1	40.9	45.0	5.3	160	7.20
Bach-2	60.2	52.0	7.5	146	6.57
Supaul -1	42.6	40.5	6.2	112	5.04
Supual-2	60.4	50.8	6.4	128	5.76
Araria-1	42.2	50.4	6.5	118	5.31
Tumkur-1	80.7	65.2	8.4	180	8.10
Tumkur-2	85.1	50.4	7.8	167	7.52
Mandya-1	70.3	40.6	8.2	132	5.94
LSD (P=0.05)	3.32	1.79	NS	7.55	0.28

Production and Value Chain Analysis of Makhana

In order to study the production, marketing and value addition in makhana at different levels and its constraints, a survey of makhana growers, processors and market intermediaries *viz.* wholesalers and retailers was carried out in Darbhanga and Madhubani districts of Bihar.

Production system

It was observed that makhana is largely cultivated by traditional methods in ponds in both Darbhanga and Madhubani district. Area under field system of makhana cultivation was negligible. As per data of Fisheries Deptt., Govt. of Bihar, there were a total of 910 ponds in Darbhanga which covered an area of 2134.76 ha. These ponds are mostly Government ponds (77.25%). Similarly in Madhubani, a total of 2,111 ponds were available for makhana which covered 2097.43 ha of area. Here also, 83.4% of all ponds were from Govt. Sector. These Govt. ponds are leased out to a contractor of fisherman community called "Matasya Mantri" in each block who is also the secretary of fisherman cooperative Society of that block. The lease rate increases every year. These "Matasya Mantri" then provide these ponds to a group of farmers for cultivation of makhana as well as fishes on annual rent basis. The rent per unit area varies from pond to pond based on quality of pond, depth of water etc.

Analysis of socio-economic characteristics revealed that a majority (80%) of the makhana growers are member of a fishermen cooperative society. The average size of households involved in makhana cultivation was 5 to 6 members. More than one third of the farmers were illiterate and 94 per cent of them belonged to Mallah community mostly called 'Sahni' and 'Mukhiya'. Moreover, the average number of ponds cultivated per household was 2.15. While 43.3% of the farmers cultivate makhana in only one pond, 25% of the households reported to cultivate it in more than three ponds. The average pond area cultivated per household was 3.62 acres and the average production per household in 2017 was nearly 2.9 tons of makhana seeds.

Operational cost of makhana cultivation and processing

Component wise cost of cultivation of makhana was estimated. It was observed that operational cost of makhana cultivation was Rs 88,300/ha. Among different components, cost of harvesting contributed the highest to the extent of 41% of total cost (Fig. 10.2). Makhana cultivation is labour intensive and therefore labour cost for cleaning, sowing, thinning and weeding also contributed to nearly one third of total cost of cultivation. Since, the crop is cultivated in ponds, fertilizers are applied in negligible quantity and they contribute lowest in total cost.

Makhana seed is processed into popped lava after a series of activity. The processing is still

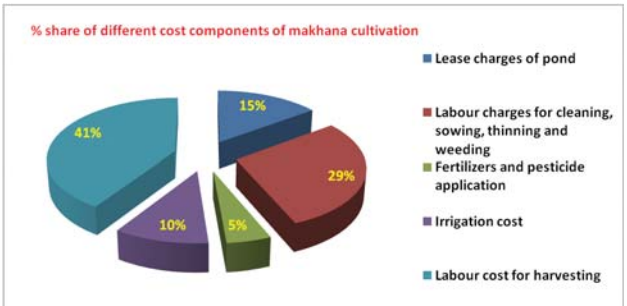

Fig. 10.2. Contribution of different components in cost of cultivation of makhana

done by traditional method which involves a lot of drudgeries. Women members have active role in processing. The Processing cost of makhana was also estimated which largely involved cost of labour and cost of fuel. The processing cost was estimated to be Rs 2030 per quintal of makhana seed. The labour component of cost contributed 86.2% while fuel cost contributed to the extent of 11.2%.

Marketing and price spread analysis in local market of Darbhanga and Madhubani

Data collected from processors, wholesalers and retailers were analyzed and summarized in Fig. 10.3. In general, makhana seed cultivated by farmers reaches to processors called "Phodia" who convert it to popped lava and sell it to wholesalers. Farmers get the highest margin of Rs 52.2/kg of makhana seed. Processor's cost includes cost of seed and processing cost. They only get Rs 30.5/kg of lava. In both the market, there are few wholesalers who purchase popped makahna from processors and sell it to retailers in local market as well to distant market at Delhi, Kanpur, Varanasi *etc*. The wholesalers get Rs 34.2/kg of lava while retailers got minimum i.e Rs 16.3/kg lava. The price spread in the marketing channel was estimated to be 48.55 per cent which implies that the producers shared 51.45 per cent of the price paid by the consumer.

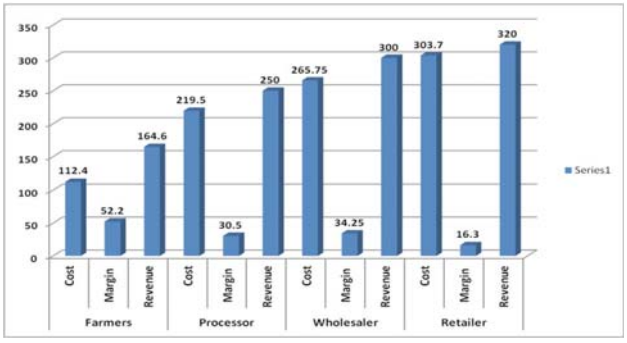

Fig 10.3. Cost and margins of different intermediaries in marketing of Makhana (per kg)

11. Farming System Research

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

Farming system is a resource management strategy to avail the maximum efficiency of a particular system. Studies revealed the higher energy efficiency ratio crop + fish + poultry integrations followed by rice- mustard- greengram system. Integration of fish and cattle enterprises with rice-vegetable system required the highest energy input whereas crop + fish integration recorded the least requirement of energy (Table 11.1). The energy output was maximum with crop + fish + cattle integration but energy efficiency ratio with this integration was recorded the least. The output and input energy for rice- mustard-greengram system was found reasonably good (14530 and 62490 MJ, respectively). Human energy profitability was found the highest with crop+ fish +duck+ goat integration (65.42 MJ) followed by crop+ fish + goat and Crop + fish + cattle integration. The renewable energy was the highest with those systems where animals or birds were integrated which ranged from 3930 to 92420 MJ. It is thus evident that efficient utilization of scarce and costly resource is the need of the hour and can be accrued by following the concept of IFS through supplementation of allied agro-enterprises.

Further, it was observed that under one acre IFS model (crop + goat + poultry + mushroom), the total input and output energy were calculated as 68, 491 MJ and 2,17,548 MJ, respectively (input/output ratio: 1: 3.2), while under two acre IFS model (crop + fish/duck + livestock) it was reported as 2,96,709MJ and 7,52,415 MJ, respectively (input/output ratio: 1: 2.5), indicating that crop + goat + poultry + mushroom integration was more energy efficient over crop + fish/duck+ livestock integration (Fig. 11.1).

Component wise total energy input/output, efficiency, profitability and other forms of energy were analysed and calculated. From calculated energy budgeting it was revealed that maximum

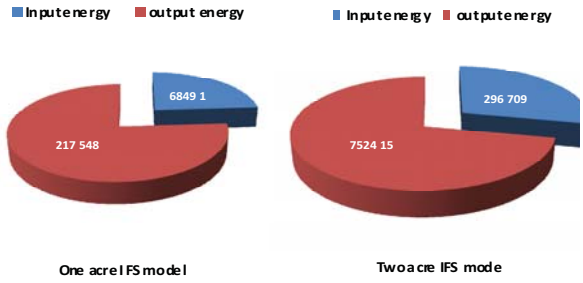

Fig. 11.1. Total input and output energy in 1 acre and 2 acre IFS models.

Table 11.1. Energy budgeting (MJ/ha) for individual components of integrated farming systems

Forms of energy (MJ)	Crops	Vegetables	Fruits	Fodder	Mushroom	Poultry	Goatry	Dairy	Fish	Duck	Vermicompost
Unit	0.4ha	0.05ha	0.05ha	0.15ha	100 bags	700 nos.	21no.	2no.	0.1ha	40 no.	0.015ha
Total energy input (MJ)	14530	3720	3320	4110	190	1910	14840	70300	2940	3790	1250
Total energy output (MJ)	62490	22350	27200	23630	1540	7580	52220	71500	9510	7650	2930
Energy efficiency ratio	4.30	6.01	8.19	5.75	8.11	3.97	3.52	1.02	3.23	2.02	2.34
Net energy gain (MJ)	47960	18630	23880	19520	1350	5670	37380	1200	6570	3860	1680
Energy profitability	3.30	5.01	7.19	4.75	7.11	2.97	2.52	0.02	2.23	1.02	1.34
Direct energy (MJ)	2980	1180	370	1280	190	460	310	1850	1340	1150	490
Indirect energy (MJ)	6990	2540	1750	1450	20	1020	10530	88450	2600	12650	2440
Renewable energy (MJ)	1750	1040	560	330	190	1220	4390	89710	960	13190	2930
Non-renewable energy (MJ)	6230	2680	1560	2400	20	260	450	590	2980	600	10
Human energy profitability	225.60	16.58	28.9	49.47	1.53	2.28	26.18	25.33	17.35	7.51	7.47

input energy was required by dairy component (7,03,00 MJ) with energy efficiency ratio of 1.02 while the least input energy was required by mushroom with energy efficiency ratio of 8.11 while the highest energy efficiency ratio was found with fruit component (8.19). Net energy gain was found to be the highest with crop component (62,490 MJ) and it was due to the fact that crop component had occupied the largest share of area (4000m^2). Renewable energy was the highest with dairy component with two cows only (89,710 MJ) while the least renewable energy was recorded with mushroom (190 MJ). Different forms of energy created by individual components and their budgeting has been given in Table 11.2. Thus, it is important to integrate such components which provide higher net energy gain for better energy profitability and energy efficiency ratio and in turn higher income and resource recycling.

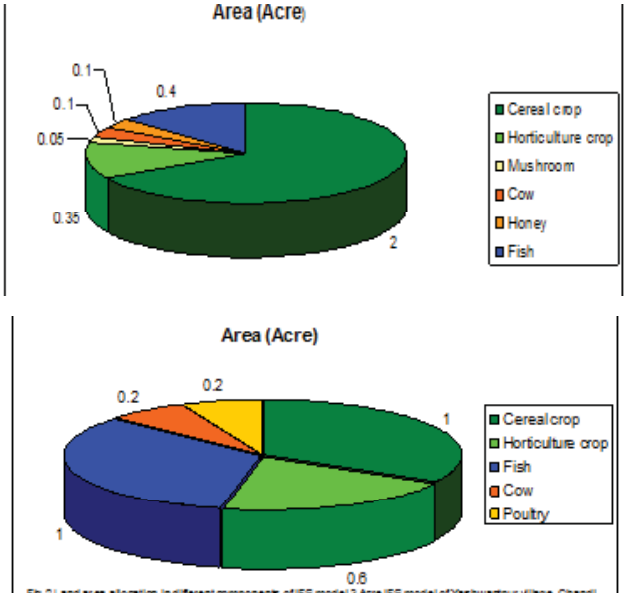

Fig. 11.2. Land area allocation among different components of IFS at farmers' fields

Evaluation and Optimization of Integrated Farming System Modules

Data were collected from different IFS models developed at ICAR-RCER, Patna, RC, Ranchi and at farmer's fields (two villages *viz.* Anantpur and Yashvantpur at Chandi block in Nalanda district). Farmer's field IFS model was of 3 acre and the main components of IFS were cereal (rice, wheat, maize), horticultural crop (guava, banana, lemon, aonla, mango, vegetables), honey, mushroom, mushroom spawn, livestock (cow) and fish. Land allocation among different components of IFS at Ananatpur village was: cereals (2 acre), horticulture crop (0.35 acre), mushroom (0.05 acre), cow (0.1 acre), honey (0.1 acre) and fish (0.4 acre) (Fig.11.2). Total cost of cultivation was Rs.2,53,400, gross income Rs.5,22,150 and net income from different components was Rs. 2,68,750 at Anantpur farm. Similarly at Yashvantpur village, the main components of IFS were cereal (rice, wheat, maize), horticulture crop (mango, Guava, banana, lemon, vegetables), fish, livestock (cow) and poultry, and area of different components were cereal (1 acre), horticulture crop (0.6 acre), fish pond (1 acre), cow (0.2 acre) and poultry (0.2 acre). Cost of cultivation was Rs.3,53,400. Maximum income (Rs.3,30,000) was recorded from fish production. Total annual income from different components was Rs.6,60,050 at Yashvantpur village. It was recommended that the area should be less in cereal crop whereas mushroom spawn production, horticulture crop and the area of fish production

Table 11.2. Energy budgeting (in MJ) for different combinations of integrated farming systems (8000m^2)

IFS components	TEIn	TEOp	EER	NEG	EF	DE	IE	RE	NRE	HEP
Rice-mustard-moong	14530	62490	4.30	47960	3.30	2980	6990	1750	6230	14.38
Crop (vegetables) + goat	18560	74570	4.02	56010	3.02	3290	17520	6140	6680	40.56
Crop + fish + goat	32310	124220	3.84	91910	2.84	4630	20120	7100	9660	57.95
Crop +fish + cattle	87770	143500	1.63	55730	0.63	6170	98048	92420	7420	57.06
Crop + fish +duck + goat	36100	131870	3.65	95770	2.65	5780	32770	20290	10260	65.42
Crop + fish+ duck	21260	79650	3.75	58390	2.75	5470	22240	15900	7430	39.24
Crop + fish + mushroom	17660	73540	4.16	55880	3.16	4510	9610	2900	6850	33.26
Crop + fish+ poultry	18380	79580	4.33	61200	3.33	4780	10610	3930	7090	34.01
Crop + fish	17470	72000	4.12	54530	3.12	4320	9590	2710	6830	31.73

Note: TEIn =Total energy input; TEOp=Total energy output; EER= Energy efficiency ratio; NEG=Net energy gain; EF= Energy profitability; DE= Direct energy; IE= Indirect energy; RE= Renewable energy; NRE= Non-renewable energy; HEP = Human energy profitability

should be increased and some components such as goatry, vermicompost, duckery may be included for getting more.

Development of location specific IFS models for rainfed ecosystem of Eastern Plateau and Hill region

A 0.75 acre IFS model (crop + horti + dairy) has been developed consisting of livestock (2 cows + 2 calf), fruits (guava, papaya) were integrated with cereals, pulses and oilseeds. During the year 2017-18, the total fruit yield was 316.6 kg which was sufficient for fulfilling the daily dietary requirement of 7.23 persons. The total milk production was 1676.4 lit. from two cows which was sufficient for the 22.96 persons indicating that the milk production was surplus in the IFS. The cereals, pulses and oilseeds obtained from IFS were 68.87 kg, 24.24 kg and 11.32 kg respectively (Table 11.3). During *Rabi* season, different crops were grown as mix, inter and sole cropping under rainfed conditions. The sole cropping of linseed produced the highest biological yield (5389 kg/ha) and paddy equivalent yield (3426) followed by mix cropping of gram + mustard + linseed + lentil (4336 kg/ha and 2072 kg/ha biological yield and paddy equivalent yield, respectively) (Table 11.4). Estimation of nutritional yield from the IFS indicated that a total of 181.75, 72.97, 83.93 and 19.45 kg of carbohydrates, protein, fat and dietary fiber, respectively could be obtained per year from the IFS. The per cent contribution of different component in production of these nutrient is depicted in the Fig. 11.3 showed that the highest contribution in the production of carbohydrates, protein, fat and calories was from dairy (45.20%, 78.12%, 91.88% and 66.47% of total carbohydrates, protein, fat and calories produced, respectively)

Table 11.3. Total yield of different components under rainfed condition

Components		Crops	Area in IFS (m^2)	Yield in IFS (kg)	No. of persons can fulfill the daily dietary requirement
Fruits		Guava	250	238.9	7.23
		Papaya	32	77.7	
Dairy		Milk	2 cow	1676.4 lit.	22.96
Pulses	*Kharif*	Blackgram	187	3.00	1.33
		Hoursegram	520	10.00	
		Arhar	90	6.75	
	Rabi	Chickpea	60	3.15	
		Lentil	60	1.34	
Cereals	*Kharif*	Rice	144	7.37	0.36
		Ragi	560	55	
	Rabi	Oats	190	6.5	
Oilseeds	*Rabi*	Linseed	54	4.9	0.69
		Mustard	54	6.42	

Table 11.4. Performance of different *rabi* crops under rainfed condition in IFS Model

Crops		Biological yield (kg/ha)		Grain yield (kg/ha)		PEY (kg/ha)
Gram		3194		600		1501
Lentil		986		180		451
Linseed		5389		1028		3426
Mustard		4160		958		1997
Oat		1237		347		520
Mix cropping	Gram	625	Total = 4336	69	Total = 847	Total = 2072
	Lentil	556		83		
	Linseed	1236		194		
	Mustard	1919		500		
Inter cropping	Gram	944	Total = 3978	111	Total = 633	Total = 1572
	Lentil	581		81		
	Linseed	861		139		
	Mustard	1592		302		

Mix cropping of *Rabi* crops

Inter cropping of *Rabi* crops

Sole cropping of mustard

Sole cropping of linseed

Fig 11.3. Per cent distribution of carbohydrates, protein, fat, calories and dietary fiber through different component of IFS.

and most of the dietary fiber was obtained from the fruits (67.05%).

The total FYM production was recorded as 3.84 t/year whereas the vermicompost production from the unit was 1.34 t/year. A total of 3464.37 litres of cow urine was collected from two cows and two calf. Cow dung production from an adult cow was 14.48 kg/day. Milk production during April, 2017 to March, 2018 was 1676.40 litres. Apart from these, total fuelwood produced from the system was 142.5 kg.

Development of Climate Resilient Farming System Models for Livelihood Improvement

In order to meet out the major challenges of low productivity in agriculture sector, a project was implemented in four Panchayats of East Champaran district of Bihar with the aim to reduce the poverty in the area by improving the productivity, profitability and sustainability of smallholder agriculture through development of climate resilient farming system models. Following development activities were carried out in the project.

Development of on-Farm Water Management for Increasing Land and Water Productivity

Water harvesting through reshaping and bunding of existing water bodies

Three old ponds (two in Jasauli Patti and one in Chintamanpur) were renovated and re-shaped for storage of water for irrigation purpose and for fish production. In addition, two new ponds were constructed one each in Chandrahiya and Khairimal villages (Fig. 11.4). Farmers have statarted making use of these ponds for fish production too. These ponds can also be used to provide supplemental irrigation to crops in the event of dry spell or delayed monsoon as life saving to the field crops.

Solar energy operated water pumping system

To provide timely ground water irrigation to newly established agro-forestry species and field crops, a 3 HP capacity DC submersible pump has been installed in Chandrahiya village of Motihari block. It is being used by the farmers for irrigation

Fig. 11.4. Water harvesting structure for irrigation and fish farming

purpose. The average discharge of the pump was estimated to be in the range of 130-150 m^3/day at the solar radiation of 5-6.4 kWh/m^2/day.

Installation of bore wells in adopted villages

To provide timely ground water irrigation to crops and to supplement the water in ponds during summer season, three bore wells of size 8″/6″ with 7.5 HP submersible pumps were provided at three locations, one each in Chandrahiya (Fig. 11.5), Chintamanpur and Khairimal in the adopted

Fig. 11.5. Borewel installed at farmer's field for irrigation

villages of project area. Sixteen number of tube wells of size 4" were also installed in adopted villages for utilization of ground water to irrigate the field crops.

Fish farming for improving fish production and livelihood support

The fingerlings of four different carps species namely, *Catla catla* (Catla), *Labeo rohita* (rohu), *Cirrhinus mrigala* (Mrigal) and *Ctenopharyngodon idella* (Grass carp) were stocked at the rate of 10000 fingerlings/ha. The total area covered under the project as fish ponds is about 0.53 ha which includes five numbers of ponds. The average weight of fingerlings was 22.5±0.5 g at the time of stocking and 6-7 months after stocking it attained the weight ranging between 350- 750 g at various locations (Fig. 11.6).

Fig. 11.6. Harvesting of fish from newly constructed pond

Integration of agroforestry species for multiple production system

Perennial trees are less vulnerable than annual crops to weather aberrations and hence inclusion of perennial trees in the farming systems can improve the climate resilience of the system besides biomass augmentation and soil fertility buildup. Keeping this in view, different agro-forestry systems are being tested under the project for their suitability to be integrated in the farming systems. In total more than ten thousand horticultural and agro-forestry species have been planted in adopted villages. Among the horticulture tree species mango, litchi, guava and jackfruit have been planted whereas, plantation of teak, mahogany, simal, gamhar and siris as agro-forestry species have been done in an area of about 110 acres. During the first year of planting, the survival rate of different species varied between 60.4 - 97.2 per cent, the minimm survial per cent was in sirish (60.4) and maximm was in simal (97.2) which was mainly attributed to prevalence of flooded conditions for prolonged period in particular villages. Different intercrops were grown under various agroforestry systems. Intercropping of turmeric during the first year was found promising (Fig. 11.7). The growth of different perennial trees under different agroforestry systems was also recorded and data were analyzed based on mean value. For estimation of per cent increase in plant height and trunk diameter, the plant growth parameters were recorded after 15 days of planting and in 2nd week of March, 2018. Irrespective of intercrops, the maximum increase in plant height (27.86±8.29%) and trunk diameter (71.05±10.26%) was recorded in case of teak (Border plantation). Among the fruit species, the minimum increase in plant growth was recorded in case of litchi (19.93±3.55%) whereas in case of the timber species, the minimum values were recorded in case of Mahogany (18.13±6.95%) during the 1st year of planting.

Fig. 11.7. An overview of intercropping of turmeric with mango.

Introduction of improved varieties in major crops and its production technologies

Quality seeds of high yielding varieties of paddy (CR Dhan 909), wheat (HD-2967 and HD-2733), potato (Kufri Sinduri) and lentil (KLS 218)

were distributed among 440 farm families in the adopted villages of the project site for improving the crop productivity and livelihood of the farming community. During *kharif* 2017, 250 kg quality seed of paddy (CR Dhan 909) were distributed among the farmers, which was sown in 24 acres land. Yield data recorded after harvest revealed average productivity of 4.83 t/ha. This indicated that high yielding varieties of paddy have good impact in improving the average crop productivity at farmer's fields, which is important for sustaining their livelihood. Similarly, during *Rabi* (2017-18), quality seeds of potato (26 t), wheat (5 t) and lentil (0.08 t) were distributed among the farmers in adopted villages, covering an area 112, 32 and 56 acres, respectively (Fig. 11.8).

Promotion of alternate income generation activities through backyard poultry, duck rearing, goatery and preventive health care

Interventions were carried out in back yard poultry, duck rearing and dairy cattle production and health management for improving the livelihood of farmers in the adopted villages. A total of 470 birds (breed- Vanraja) 6 week old and 370 Khaki Campbell adult ducks were distributed among the beneficiary farmers (Fig. 11.9). All the chicks were vaccinated against Marek's disease, IBD, IB and Newcastle disease and ducks were vaccinated against Duck Cholera and Duck Plague at 4th and 8th weeks of ages, respectively, before distributing them to the farmers. The farmers were given adequate exposure on scientific rearing of chicks and ducks, for its proper rearing management for better productivity and profitability. Knowledge on floor space, feeding and watering space requirements of both poultry species, production and reproduction characteristics of Vanraja birds and Khaki Campbell, and the important first aid measures were also imparted. Besides, two *Pashu Arogya Shivir*/Camps were organised, one in Chintamanpur village of Chakiya block and another in Chandrahiya village of Motihari block on 24th and 25th November 2017, respectively. During camps, 498 cases were attended which included the ailments of different livestock species, with cattle being predominant. All the cattle and buffaloes which arrived at the camp were vaccinated against Foot and Mouth disease (FMD), Haemorrhagic Septicaemia (HS) and Black Quarter (BQ). Goats in the camp were given vaccination against Peste des Petits Ruminants (PPR). Besides, all the animals were de-wormed with broad spectrum Fenbendazole with suitable dose requirements. Among the therapeutic cases treated, most of the cases were of reproductive failures with anoestrus being predominant.

Fig. 11.9. Backyard poultry and duck rearing for livelihood improvement

Fig. 11.8. Introduction of improved varieties of wheat, lentil and potao

12. Crop Diversification

Diversification of Rice-Wheat System through Climate Resilient Cropping in Eastern India

A long-term study was initiated at the ICAR RCER Patna, with 10 different cropping system (Table 12.1) during *Kharif* season of 2016 on clay loamy soil (Fig 12.1). Results revealed that significantly the highest system annual productivity (SREY) was recorded with maize cob-pigeonpea (22.41 t/ha) system followed by sorghum fodder-mustard-urdbean (15.97 t/ha) and soybean-maize (13.31 t/ha) systems (Fig. 12.2). The lowest system productivity was associated with finger millet-*tori*-fallow system (5.81 t/ha).

Fig.12.1. View of the crop diversification experiment during *kharif* season

Table 12.1. System rice equivalent yield (SREY) as influenced by diverse cropping system

Cropping system	REY (t/ha)		SREY (t/ha)
	Kharif	*Rabi*	
TPR-Wheat-Mungbean (FP)	4.75	5.49	10.53
DSR-Wheat(ZT)-Mungbean(ZT)(RCT)	5.35	5.89	11.48
Soybean-Maize (ZT)	3.65	9.18	13.31
DSR-Mustard (ZT)-Urdbean (ZT)	5.15	6.57	12.45
Foxtailmillet-Lentil (ZT)-Fallow	1.91	5.37	7.56
Pearlmillet-Chickpea (ZT)-Fallow	4.03	6.94	10.90
Fingermillet-Toria (ZT)-Fallow	2.01	3.61	5.81
Jowar (Grain)-Chickpea (ZT)-Fallow	4.35	7.54	11.54
Maize (Green cob)-Pigeonpea (ZT)	12.53	9.39	22.41
Sorghum (Fodder)-Mustard (ZT)-Urdbean (ZT)	9.72	6.26	15.97
LSD (P=0.05)	0.39	0.57	0.91

*REY: Rice equivalent yield, SREY: System rice equivalent yield

Diversification of Rainfed Upland Rice System in Eastern Plateau and Hill Region

Under rainfed upland conditions of Eastern Plateau and Hill region, the study was conducted on diversification of direct-seeded upland rice during *Kharif* season of 2017 (Fig. 12.3). The treatments included were: sole crop of rice cv. BVD-109, sole crop of finger millet cv. BBM-10, sole crop of black-

Fig. 12.2. Maize (Green cob)-Pigeonpea (ZT) cropping system

Fig. 12.3. Crop diversification in rainfed uplands in Hill and Plateau region

gram cv. Uttara, sole crop of horse gram cv. Birsa Kulthi-1, sole crop of pigeonpea cv. UPAS-120, sole crop of vegetable cowpea cv. Swarna Mukut, rice + blackgram 1:1, rice + horsegram 1:1, finger millet + blackgram 1:1 and finger millet + horsegram 1:1. Results revealed that the sole crop of vegetable cowpea recorded the maximum rice equivalent yield of 15.47 t/ha followed by pigeonpea (12.49 t/ha), blackgram (9.33 t/ha), horsegram (8.53 t/ha) and finger millet (8.13 t/ha). The rice equivalent yield of blackgram, horsegram and finger millet were at par with each other. Among the combination treatments *viz*., finger millet + horse gram (8.96 t/ha), finger millet + blackgram (7.61 t/ha) and T8 rice + horsegram (6.25 t/ha) were at par with each other in respect to rice equivalent yield. The sole crop of rice produced 2.08 t/ha only. Therefore, diversification of rainfed upland rice system with vegetable, pulses and millets would be more profitable in Eastern Plateau and Hill Region.

Development of multitier cropping system for rainfed uplands of Eastern Plateau and Hills

The project has been undertaken to develop multitier system for rainfed uplands of eastern Plateau and Hills. Treatment details are given in Table 12.2. The yield of intercrop under different multitier systems of three years age was recorded. The grain yield of rice (1.1 t/ha) and finger millet (1.64 t/ha) was the highest in sole rice and mahogany + mango + lemon + ragi multitier sytem,

Table 12.2. Performance of perennial plants and annual crops under different multitier systems

Systems	Crops	Plant height (m)	Stem girth (mm)	Mortality (%)	*Kharif* crop yield (t/ha)	*Rabi* crop yield (t/ha)
Mahogany + mango + lemon + rice-niger	Mahogany	3.6+0.07	86.00+6.01	0.00	1.05 (Rice)	0.12 (Niger)
	Mango	1.40+0.06	44.20+1.70	0.00		
	Lemon	0.62+0.35	14.18+7.38	56.00		
Mahogany+ mango+lemon+ragi	Mahogany	4.24+0.58	99.25+10.96	0.00	1.64 (Ragi)	Fallow
	Mango	1.28+0.25	35.2+11.03	0.00		
	Lemon	0.50+0.06	9.25+2.29	66.67		
Mahogany+ mango+aonla + rice-niger	Mahogany	3.21+0.09	85.00+2.47	0.00	1.08 (Rice)	0.11 (Niger)
	Mango	1.29+0.13	37.40+7.07	0.00		
	Aonla	1.75+0.17	44.30+6.16	20.00		
Mahogany+ mango+aonla + ragi	Mahogany	3.65+1.20	78.38+31.64	0.00	1.59 (Ragi)	Fallow
	Mango	1.28+0.06	37.80+1.13	20.00		
	Aonla	2.34+0.24	59.93+8.38	26.67		
Mahogany+ mango+peach+rice-niger	Mahogany	3.29+0.55	78.13+0.53	0.00	0.98 (Rice)	0.09 (Niger)
	Mango	1.29+0.16	37.05+5.02	20.00		
	Peach	2.90+0.77	68.69+20.89	26.67		
Mahogany+ mango+peach+ragi	Mahogany	3.91+0.51	85.25+13.79	0.00	1.58 (Ragi)	Fallow
	Mango	1.26+0.01	32.98+5.98	20.00		
	Peach	2.21+1.00	59.23+31.98	46.67		
Mahogany+ mango+rice-niger	Mahogany	2.87+0.58	63.33+11.61	0.00	1.01 (Rice)	0.10 (Niger)
	Mango	1.23+0.15	36.58+9.39	20.00		
Mahogany+ mango+ragi	Mahogany	3.37+0.35	79.92+6.29	0.00	1.53 (Ragi)	Fallow
	Mango	1.35+0.24	37.65+8.31	20.00		
Rice (sole cropping)-niger	—	—	—	—	1.10 (Rice)	(0.13)
Ragi (sole cropping)	—	—	—	—	1.57 (Ragi)	Fallow

Rice Ragi Niger

Fig.12.4. Performance of different intercrops in multitier systems

respectively. The second crop, niger was taken in rice field and the highest yield was obtained in the control (0.13 t/ha). The perennial components were planted in the year 2014-15 and after three years (2017-18) the highest per cent increment in plant height was recorded in mahogany (385.92%) followed by in mango (319.35%). Among the different filler crops, the highest per cent increment in plant height (306.35%) and stem girth (547.37%) was recorded in peach (Table 12.3).

Table 12.3. Plant height and stem girth of perennial components in multitier

	2015-16 (initial)		2017-18 (third year)		% Increase	
	Height (m)	Girth (mm)	Height (m)	Girth (mm)	Height	Girth
Mahogany	0.71	15.0	3.45	81.90	385.92	446.00
Mango	0.31	6.52	1.30	37.36	319.35	473.01
Lemon	0.53	7.2	0.56	11.72	5.66	62.78
Aonla	0.79	12.5	2.05	52.11	159.49	316.88
Peach	0.63	9.88	2.56	63.96	306.35	547.37

Rehabilitation of Coal mine affected areas through Agro forestry Interventions

An Agri-horti-silvi-pastural system is being developed at coal mine affected area of Phusri village, Near Charhi, Mandu, Ramgarh, Jharkhand (Fig. 12.5). Different agroforestry species planted in the system include *Aegle marmelos, Artocarpus heterophyllus, Citrus limon, Dalbergia latifolia, Mangifera indica, Melia azedarach, Pongamia pinnata, Psidium guajava, Punica granatum, Swietenia mahogany* and *Tectona grandis.* Among all MPTs, maximum mortality (33.33%) was recorded in *Swietenia mahogany followed by Dalbergia latifolia* (25.00%) whereas, in *Melia azedarach*, the survival was 100%. In case of fruit crops, maximum mortality was recorded in *Citrus limon* (45.45%) followed by *Psidium guajava* (31.43%) whereas, minimum mortality was recorded in *Punica granatum* (6.67%).The maximum plant height (2.75m) and stem diameter (13.81cm) was recorded in *Melia azedarach* compared to other MPTs. Among the fruit crops maximum plant height (1.45 m) and stem diameter (10.17cm) was recorded in the *Aegle marmelos*. The species like Bamboos, perennial grasses and *Tephrosia candida* were also introduced in the system for fodder as well as nutrient supplement purpose. As intercrops, the farmer could get returns of Rs. 70000/- approximately from rainy season crops (tomato, chilli and cucurbits) and Rs. 35000/- from winter crops (like cabbage, cauliflower and potato) from an area of 0.3 ha area.

Fig.12.5. Field view of plantation in coalmine affected area

13. Carbon Sequestration and Nutrient Dynamics

Evaluation of Different Production Systems for Carbon Sequestration Potential

Dry biomass and carbon stock in guava orchards

The destructive sampling of guava trees aged 2–10 years with measured collar diameter (CD) and dry biomass component were fitted in various predictive models namely Linear, Allometric, Logistic, Gompertz, Richard's, Negative exponential, Monomolecular, Mitcherlich, Von Bertalanffy and Weibull to find out the relationship between biomass and collar diameter of guava tree. Richard's model fulfills the validation criterions to the best possible extent and was selected for predicting biomass in different tree components. The total dry biomass in 2 to 10 years old guava orchards with a 5 × 5 m spacing (planting density 400 trees per ha) varied from 0.78 to 13.36 Mg/ha of which 77.4–80.7% was accounted by above ground components (bole, branch wood and leaf) (Table 13.1). For young age orchards (2 year old), the biomass distribution among tree components followed the order as, leaf >branch=bole >root. For higher age orchards of 4 to 10 year old, the contribution of different biomass components to above ground biomass was highest in branch followed by bole and leaf. The proportion of total biomass accounted by branches varied from 28.3–29.5%. The mean annual increment (MAI) for different aged guava plants varied from 0.39 Mg/ha/yr in 2 year to the highest of 1.34 Mg/ha/ yr in 10 year old orchards.

The carbon content in different tree components viz, bole (stem wood), branches, leaves, total above ground, total below ground and root biomass was estimated by using the Richard's model. The mean carbon content of different tree components of guava on percentage dry weight varied between 43.3 and 46.1%. The maximum carbon was recorded in leaf (46.1%) followed by root (45.6%), bole (43.9%) and branches (43.3%). The biomass carbon stock stored in guava orchards (branches, bole and roots) varied from 0.24 Mg/ha in 2 year to 4.55 Mg/ha in 10 year old orchards (Table 13.2). The emitted carbon corresponding to carbon stored in leaves varied from 0.11 to 1.41 Mg/ha in 2–10 year old guava orchards. The mitigation of carbon in 2–10 year old guava orchards varied from 0.13 to 3.14 Mg/ha, which sequestered 0.50–11.54 Mg/ha CO_2 from the atmosphere.

Table 13.1. Component wise biomass estimates (Mg/ha) in guava

Age (Years)	Average collar diameter (cm)	Predicted biomass of different tree components							MAI (Mg/ ha/ yr)
		Branch	Bole	Leaf	Root	Above ground (AGB)	Below ground (BGB)	Total biomass (AGB+ BGB)	
2	1.37 ± 0.21	0.20 ± 0.04 (25.54)	0.20 ± 0.04 (25.54)	0.23± 0.04 (29.68)	0.15± 0.03 (19.32)	0.63± 0.12 (80.76)	0.15± 0.03 (19.24)	0.78 ± 0.15	0.39 ± 0.07
4	3.36 ± 0.32	0.92 ± 0.15 (28.29)	0.87 ± 0.14 (26.85)	0.85± 0.12 (26.13)	0.61± 0.09 (18.85)	2.64± 0.38 (81.15)	0.61± 0.09 (18.85)	3.25 ± 0.47	0.81 ± 0.24
6	5.70 ± 0.30	2.24 ± 0.18 (29.25)	2.04 ± 0.15 (26.66)	1.86± 0.13 (24.22)	1.53± 0.13 (19.92)	6.14± 0.46 (80.13)	1.53± 0.13 (19.87)	7.67 ± 0.59	1.28 ± 0.29
8	7.28 ± 0.10	3.12 ± 0.05 (29.51)	2.75 ± 0.04 (26.06)	2.49± 0.03 (23.51)	2.22± 0.04 (20.96)	8.36± 0.12 (79.04)	2.22± 0.04 (20.96)	10.58 ± 0.16	1.32 ± 0.08
10	9.83 ± 1.05	3.95 ± 0.19 (29.56)	3.33 ± 0.12 (24.93)	3.06± 0.13 (22.86)	3.02± 0.22 (22.61)	10.34± 0.26 (77.36)	3.02± 0.22 (22.64)	13.36 ± 0.49	1.34 ± 0.25

Values in parenthesis indicates % allocation in different tree components; ± values indicate std. error; MAI, Mean annual increment

Table 13.2. Component wise carbon stock estimates (Mg/ha) in guava

Age (Years)	Average collar diameter (cm)	Stored				Emitted	Mitigated (Mg/ha)	CO_2 Stored (Mg/ha)
		Branch	Bole	Root	Total	Leaf		
2	1.37 ± 0.21	0.09 ± 0.04	0.08± 0.04	0.07 ± 0.03	0.24 ± 0.12	0.11 ± 0.05	0.13 ± 0.075	0.50 ± 0.27
4	3.36 ± 0.32	0.40 ± 0.16	0.38 ± 0.15	0.28 ± 0.10	1.06 ± 0.42	0.39 ± 0.14	0.67 ± 0.28	2.45 ± 1.03
6	5.70 ± 0.30	0.97 ± 0.19	0.89 ± 0.16	0.70 ± 0.15	2.56 ± 0.50	0.85 ± 0.15	1.71 ± 0.35	6.26 ± 1.29
8	7.28 ± 0.10	1.35 ± 0.05	1.21 ± 0.04	1.01 ± 0.05	3.57 ± 0.14	1.15 ± 0.04	2.42 ± 0.10	8.90 ± 0.37
10	9.83 ±1.05	1.71 ± 0.20	1.46 ± 0.12	1.38 ± 0.25	4.55 ± 0.58	1.41 ± 0.15	3.14 ± 0.43	11.54 ± 1.60

Assessment of total Soil Organic Carbon and Oxidisable Organic Carbon on different Agricultural Production Systems

SOC stock in orchard production system in eastern plateau and hill region of India

The investigation was undertaken to evaluate the dynamics of total soil organic carbon in 8 year old orchards of mango, guava and litchi in eastern plateau and hill region. The maximum total soil organic carbon (C_{tot}) in 0–0.60 m depth was 71.78 Mg/ha in mango orchard and resulted in 28.68 % increase over control. Similarly, the guava and litchi orchard recorded significantly higher C_{tot} and resulted in 26.1 and 23.9 % increase over control, respectively. The oxidizable organic carbon (C_{oc}) varied from 45.02 to 53.9 Mg C/ha soil among the different orchards under study. The relative preponderance of C_{oc} under different orchard systems was in the following order: mango orchard ≥ guava orchard ≥ litchi orchard > control (Table 13.3). This increase in C_{oc} in different orchards was due to significant increases in carbon input with organic manure and leaf litter of orchard system.

Irrespective of orchard system, the maximum active carbon pool was recorded in the 0–0.15 m layer being the highest in mango orchard (14 Mg/ha) and the lowest in control (10.84 Mg/ha). The maximum total active carbon pool (0–0.60 m) was recorded under mango orchard (42.4 Mg/ha) followed by guava orchard (41.41 Mg/ha). There was no significant difference in active pool of carbon among the different orchards. The maximum total passive carbon pool was recorded under mango orchard (29.38 Mg ha) followed by guava orchard (28.95 Mg/ha (Table 13.4).

The percentage of non–labile carbon to total carbon, which corresponds to recalcitrant character of SOC, gradually increased in litchi orchard over the years, whereas in mango and guava orchard the recalcitrant character of SOC remains constant (Fig.13.1). The higher percentage of non–labile

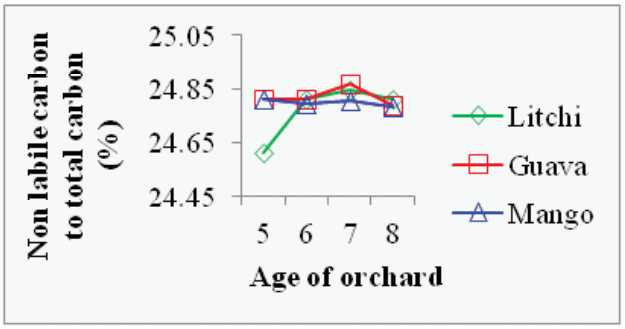

Fig.13.1 Recalcitrant character of SOC in different orchards

Table 13.3. Total and oxidisable organic C (Mg/ha soil) in soils in different layers (m) of 8 year old orchards

Orchard	Soil organic carbon (Mg/ha soil)									
	Total soil organic carbon (C_{tot})					Oxidizable organic carbon (C_{oc})				
	0–0.15	0.15–0.30	0.30–0.45	0.45–0.60	Total 0–0.60	0–0.15	0.15–0.30	0.30–0.45	0.45–0.60	Total 0–0.60
Control	18.43^{b}	14.36^{b}	12.82^{b}	10.17^{a}	55.78^{b}	14.08^{b}	11.72^{b}	10.76^{b}	8.47^{a}	45.02^{b}
Litchi	22.51^{a}	18.31^{a}	16.43^{a}	11.88^{a}	69.13^{a}	16.92^{a}	13.77^{a}	12.24^{a}	8.93^{a}	51.86^{a}
Guava	21.72^{a}	19.12^{a}	16.96^{a}	12.56^{a}	70.36^{a}	16.34^{a}	14.39^{a}	12.75^{a}	9.45^{a}	52.92^{a}
Mango	23.11^{a}	18.75^{a}	16.97^{a}	12.95^{a}	71.78^{a}	17.39^{a}	14.09^{a}	12.75^{a}	9.75^{a}	53.97^{a}
Mean	21.44	17.63	15.80	11.89	66.76	16.18	13.49	12.12	9.15	50.94

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

Table 13.4 Active and passive carbon pool in soils in different layers (m) of 8 year old orchards at Plandu.

Orchard	Active carbon pool (Mg/ha)					Passive carbon pool (Mg/ha)				
	0–0.15	0.15–0.30	0.30–0.45	0.45–0.60	Total 0–0.60	0–0.15	0.15–0.30	0.30–0.45	0.45–0.60	Total 0–0.60
Control	10.84^{c}	8.39^{b}	7.62^{b}	5.83^{b}	32.68^{b}	7.59^{b}	5.97^{b}	5.20^{b}	4.34^{b}	23.10^{b}
Litchi	13.88^{ab}	10.66^{a}	9.81^{a}	6.88^{a}	41.22^{a}	8.63^{a}	7.65^{a}	6.62^{a}	5.01^{ab}	27.91^{a}
Guava	13.02^{b}	11.01^{a}	10.37^{a}	7.01^{a}	41.41^{a}	8.70^{a}	8.11^{a}	6.59^{a}	5.54^{a}	28.95^{a}
Mango	14.01^{a}	10.78^{a}	10.19^{a}	7.42^{a}	42.40^{a}	9.10^{a}	7.96^{a}	6.78^{a}	5.53^{a}	29.38^{a}
Mean	12.94	10.21	9.50	6.78	39.43	8.51	7.42	6.30	5.11	27.33

carbon was possibly due to conversion of leaf litter residue and labile carbon fractions to recalcitrant form, and its persistence under favourable condition of moisture and minimal soil disturbance.

It has been observed that the SOC allocation percentage of native carbon in soil depth of 0–15 cm and 45–60 cm was higher in all the orchards compared to applied carbon. The applied carbon being stabilized in soil depth of 15–45 cm in all the orchards. Among the orchards, the percentage of SOC stabilized from applied carbon was higher in litchi and guava orchards compared to mango orchards.

SOC stock in rice ecosystem in Eastern Plateau and Hill region of India

The total SOC stock in 0–60 cm soil depth in low land rice soil was highest of 67.5 Mg/ha followed by both medium land (49.6 Mg/ha) and upland (50.1 Mg/ha) (Table 13.5). The total SOC was highest in 0–15 cm soil depth and gradually decreased with increasing depth. The lowland rice soil registered the highest total SOC of 24.3 Mg/ha in 0–15 cm soil depth and the least total SOC of 15.64 Mg/ha in control plot.

It was observed that the passive carbon pool was highest in low land rice soil compared to active carbon pool throughout the 60 cm soil depth. The highest passive carbon pool in low land rice was 12.9 Mg/ha in 0–15 cm soil depth and gradually decreased with increasing soil depth. The active carbon pool was highest in upland and medium land compared to low land rice soils. The highest active carbon pool was 12.3 Mg/ha in 0–15cm soil depth in upland and gradually decreased with the increasing soil depth (Fig. 13.2).

The per cent distribution of active pool of carbon was highest (65%) in upland and least in low land (47%). Similarly, the passive pool of carbon was highest (53.4%) in lowland and lowest in upland (34.9%) in the entire depth of soil profile from 0–60 cm (Fig. 13.2). These indicated that along depth in low land rice soil, a higher proportion of total SOC got allocated to non–labile recalcitrant forms with longer residence time highlighting the potential to increase SOC sequestration in soil by improving depth distribution of SOC.

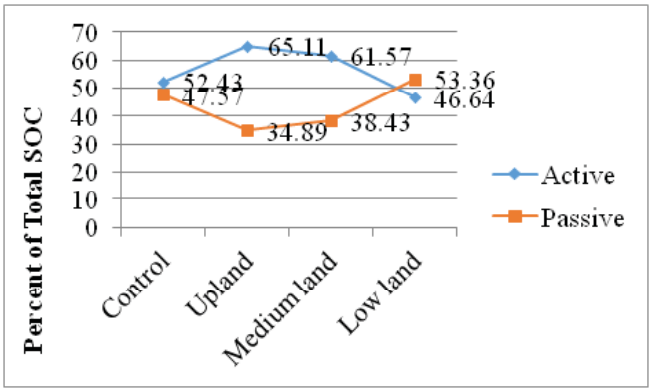

Fig.13.2 Percent distribution of active and passive pool of carbon under different rice ecosystems

Table 13.5. Total organic C (Mg/ha soil) in soils in different layers (m) of different rice ecosystems at eastern Plateau and Hill region.

Rice ecosystems	Total soil organic carbon (Mg/ha)				
	0–0.15	0.15–0.30	0.30–0.45	0.45–0.60	Total 0–0.60
Control	15.64^{c}	11.97^{b}	11.04^{b}	8.63^{ab}	47.11
Low land	24.30^{a}	19.73^{a}	14.02^{a}	9.48^{a}	67.57
Mid land	18.59^{b}	14.40^{b}	9.94^{b}	6.71^{c}	49.63
Up land	18.42^{b}	13.55^{b}	10.37^{b}	7.73^{bc}	50.10
Mean	19.24	14.91	11.34	8.14	53.60

14. Water Quality and Productivity

Evaluation of Vegetable Cropping Sequences Under Drip Irrigation with Mulching in Eastern Plateau and Hill Region

The experiment was undertaken with three irrigation methods viz., drip irrigation (DI), drip irrigation with bicolor polythene mulch (DIM), furrow irrigation (FI) and surface irrigation (SI) for cultivation of cabbage, cauliflower and broccoli in *Rabi*; okra, cowpea and french bean in summer and tomato, vegetable soybean and capsicum in *Kharif* (Fig. 14.1). Among the *Rabi* season crops, DIM recorded the highest yield of cauliflower (25.33 t/ha), cabbage (30.67 t/ha) and broccoli (7.09 t/ha) whereas FI recorded the lowest yield (cauliflower 12.61 t/ha, cabbage 27.26 t/ha, broccoli 5.21 t/ha). DIM resulted in the highest water use efficiency (16.23 kg/m^3, 13.40 kg/m^3 and 3.75 kg/m^3 in cabbage, cauliflower and broccoli, respectively) while the lowest was recorded in furrow irrigation (2.33 kg/m^3, 1.61 kg/m^3 and 0.41 kg/m^3 in cabbage, cauliflower and broccoli, respectively). Similarly, the highest water productivity was also recorded with DIM (Rs.162.3/m^3, Rs.134/m^3 and Rs. 75.0/m^3 in cabbage, cauliflower and broccoli, respectively).

In case of summer crops, DIM resulted in the highest yield (9.4 t/ha, 9.07 t/ha and 2.57 t/ha for okra, cowpea and french bean, respectively) while the lowest yields of 1.54 t/ha, 5.60 t/ha and 1.34 t/ha, respectively were recorded under furrow irrigation. The DIM also recorded the highest economic water productivity for okra (Rs. 216.77/m^3), cowpea (Rs. 83.30/m^3) and French bean (Rs. 29.44/m^3) whereas the lowest economic water productivity was recorded under furrow irrigated okra (Rs. 3.27/m^3), cowpea (Rs. 8.50/m^3) and French bean (Rs. 1.4/m^3).

Among the *Kharif* crops, DIM resulted in highest fruit yield (6.44 t/ha, 6.33 t/ha and 3.32 t/ha in tomato, vegetable soybean and capsicum, respectively) while the lowest yields were recorded in furrow irrigation (1.84 t/ha, 2.12 t/ha and 0.88 t/ha, respectively). The DIM also recorded the highest economic water productivity for tomato (28.79 Rs./m^3), vegetable soybean (Rs. 28.30/m^3) and capsicum (Rs. 29.69/m^3) whereas the lowest economic water productivity was recorded under furrow irrigation (Rs. 8.23/m^3, Rs. 9.49/m^3 and Rs. 7.86/m^3, respectively).

Hydrological Response of Micro-watersheds in Eastern Plateau and Hill Region

Hydrological response of two watersheds, Plandu and Keribanda, located in eastern Plateau and Hill region of India was evaluated. Sediment, runoff, nitrogen, phosphorus and potassium, yields were assessed at the outlets of both watersheds. Plandu and Keribanda watersheds covered an

Fig. 14.1. Field view of cropping sequences under drip, drip with mulch and surface irrigation

area of 1541 ha and 1865 ha with average slope of 1.15% and 2.24 %, respectively. Major land use in Plandu watershed is agriculture (64%) while in Keribanda, forest cover (47%) has largest share in the total watershed area. During the monsoon season of 2017, the peak rate of runoff was recorded as 8.58 and 11.8 m^3/sec for Plandu (Fig. 14.2) and Keribanda watersheds while runoff yield was 5.72 and 6.51 MCM, respectively. The observed runoff in the Plandu and Keribanda watershed was 28.5 and 25.6% of total rainfall recorded for the observation period. During the monsoon season of 2017, the sediment concentrations in runoff water of Plandu and Keribanda were in the range of 2 to153 and 3 to 218 g/m^3, respectively. Total sediment load of 496.6 and 404.5 ton, amounting to 322.2 and 216.9 kg/ha, was observed from Plandu and Keribanda watersheds, respectively. Temporal trends in nutrient loss closely followed the trend in runoff generation from these watersheds. Total N, P and K loss of 3.24, 0.20 and 16.5 kg/ha was observed in case of agriculture dominated Plandu watershed while in case of forested Keribanda watershed, it was 2.43, 0.23 and 28.49 kg/ha, respectively. Presence of mica ores in the top soils resulted higher K loss in runoff of the Keribanda watershed. The analysis clearly showed that nutrient loss from the watersheds is within the permissible limits and do not require special attention to develop fertilizer management strategy at watershed scale. In both the watersheds the sediment loss is below the permissible limit of 12.5 t/ha/yr. Higher runoff yield from these watersheds indicates that there is good potential to develop water harvesting and recharge structures that can augment groundwater and existing water supply to sustain dry season irrigation.

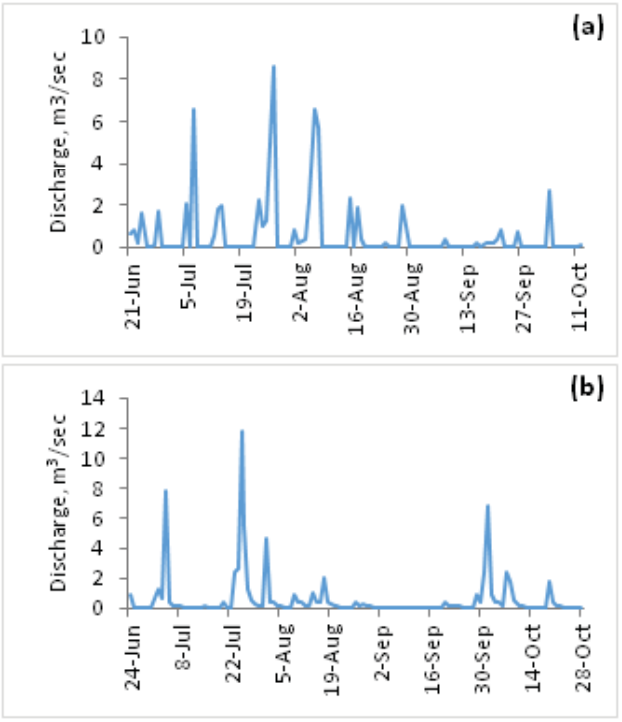

Fig. 14.2.Daily discharge at the outlet of (a) Plandu and (b) Keribanda watersheds

Improving Rice-Lentil-Greengram System Productivity through Water Management

An experiment was initiated in the year 2016 in rice-lentil-greengram system (Fig. 14.3). Two levels of land management, i.e., conventional

(a) Rice

(b) Lentil

(c) Greengram

Fig. 14.3. Field view of different crops under rice-lentil-greengram under improved land and water magement practices.

tillage (CT) and zero tillage (ZT), along with four water management levels (based on IW: CPE ratio) were evaluated. Results of the second year study revealed that land management systems did not influence the productivity of lentil (Table 14.1). However, irrigation scheduled at IW CPE raio (W_3) produced significantly higher seed yield (1.28 t/ha) and water productivity (2.08 kg/m^3) as compared to Wl (0.97 t/ha).

Table 14.1. Yield attributes and yields of lentil influenced by land and water management practices.

Treatments	Grain yield (t/ha)	HI (%)	Irrigation WP (kg/ m^3)
Land management			
ZT	1.08	26.4	1.61
CT	1.05	25.1	1.52
LSD (P=0.05)	NS	NS	NS
Water management			
W1 (rainfed)	0.97	23.4	1.16
W2(IW:CPE=0.2)	1.11	24.2	1.27
W3(IW:CPE=0.3)	1.28	29.3	2.08
W4(IW:CPE=0.4)	1.09	25.7	1.40
LSD (P=0.05)	0.18	5.3	0.39

Similarly in case of greengram the seed yield under ZT (1.48 t/ha) and CT (1.42 t/ha) was at par. In case of water management the highest greengram seed yield (2.17/ha) was recorded with IW: CPE = 0.6 (W_3). The lowest yield was recorded (1.78t/ha) with two irrigation at IW: CPE = 0.8 (W_4). Rainfed plots failed to bear seeds but able to produce biological yield due to intermittent rains during cropping season (Table 14.2). Land management practices did not influence water productivity, however, scheduling irrigation at IW:CPE ratio of 0.6 recorded significantly higher water productivity 2.71 kg /m^3.

Table 14.2. Yield of greengram as influenced by land and water management practices

Treatments	Biological yield (t/ha)	Grain yield (t/ha)	HI (%)	Irrigation WP (kg/m^3)
Land management				
ZT	4.21	1.48	0.35	1.85
CT	4.42	1.42	0.32	1.71
LSD (P=0.05)	NS	NS	NS	NS
Water management				
W1 (rainfed)	3.09	0.0	00	00.0
W2(IW:CPE=0.4)	4.82	1.85	0.38	2.31
W3(IW:CPE=0.6)	5.57	2.17	0.39	2.71
W4(IW:CPE=0.8)	5.12	1.78	0.35	1.22
LSD (P=0.05)	0.71	0.26	NS	0.17

Evaluation of vegetable varieties under different irrigation methods

A field study was conducted to evaluate different varieties of tomato, brinjal, cucumber and ridge gourd and their comparison with local variety under surface and drip irrigation method with and without plastic mulch. Drip irrigation proved its superiority over surface method of irrigation in tomato and brinjal due to precise and direct application of water in root zone. Drip irrigated tomato, brinjal and cucumber crop produced 17.7, 15.3 and 11.7 per cent higher yield over surface irrigation. However, no significant effect of drip irrigation was recorded in the yield of ridge gourd. Mulching significantly influenced the growth, development and yield of all four vegetable crops (Table 14.3). Seedlings emergence of both summer vegetable crops (cucumber and ridge gourd) was significantly earlier in mulched plots as compared to unmulched ones. The earliness in germination was about 4 and 3 days for cucumber and ridge gourd, respectively. In addition, appearance of first female flower of both vegetable crops was also advanced by 6 and 4 days as compared to

Table 14.3. Effect of irrigation, mulching and variety on yield (t/ha) of tomato, brinjal, cucumber and ridge gourd

Treatments	Tomato	Brinjal	Cucumber	Ridge gourd
Irrigation				
Surface irrigation	52.6	38.7	22.2	3.5
Drip irrigation	61.9	44.6	24.8	3.9
LSD (P=0.05)	3.5	1.2	0.98	NS
Mulching				
No mulch	49.8	37.8	21.1	37.8
Plastic mulch	64.7	45.5	25.9	45.5
LSD (P=0.05)	3.5	1.8	0.85	1.8
Varieties				
V1	64.4	42.7	23.4	42.7
V2	58.3	44.1	25.4	44.1
V3	49.2	38.1	22.0	38.1
LSD (P=0.05)	1.9	1.4	1.3	1.4

non-mulched plots. Mulching in tomato (29.9%), brinjal (20.4%), cucumber (22.7%) and ridge gourd (24.2%) produced higher yield over non- mulched crop. There was significant interaction effect of mulch and irrigation on tomato and brinjal yield (Table 14.3). The mulched treatments showed significantly less weed biomass production in comparison to non mulched treatments. Loss in yield due to weed infestation was very low i.e. 2-5% in mulched plot receiving drip irrigation while in unmulched surface irrigated plots, weed reduced the yield up to 26 per cent.

Tomato variety Swarna Sampada produced significantly higher fruit yield than Swarna Naveen and local variety irrespective of mulch and irrigation. Brinjal variety Swarna Shobha (V2) produced maximum yield than Swarna Pratibha (V1) and local variety (V3). In case of cucumber and ridge gourd also the yield of local variety was significantly lower than the other two varieties but bitterness in taste was found in cucumber variety Swarna Ageti and Swarna Sheetal.

Drip irrigated mulched vegetable crop showed highest water productivity irrespective of varieties. Water productivity was higher in rabi vegetables than summer vegetables (Fig. 14.4). In drip irrigated mulched tomato and brinjal water productivity was 24.3 kg/m^3 and 20.2 kg/m^3, respectively while in cucumber and ridge gourd, it was 8.6 kg/m^3 and 3.8 kg/m^3, respectively. Surface irrigated crop without mulch showed least water productivity in all vegetables. Irrigation through drip under mulched condition saved 32% irrigation water in tomato, 39% in brinjal, 41% in cucumber and 45% in ridge gourd as compared to surface irrigation. The economic water productivity of all drip irrigated mulched vegetable crops were higher than other treatments.

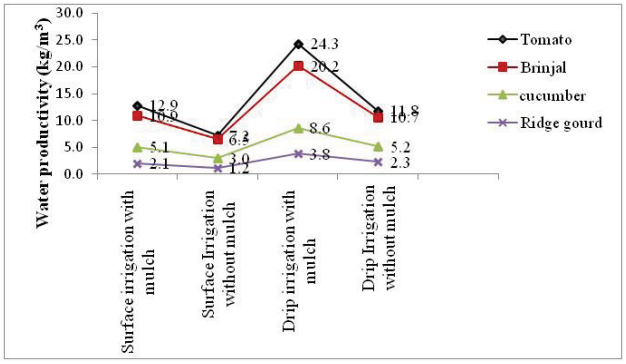

Fig. 14.4. Effect of irrigation and mulching on water productivity

15. Conservation Agriculture

Evaluation of Establishment Methods for Improving the Productivity of Rice Fallows

A long-term experiment has been initiated at ICAR-RCER, Patna from rainy season of 2016 on silty clay loam soil. Experiment was laid out (Fig. 15.1) in a split-plot design and comprising of three crop establishment method *viz*. zero-till direct-seeded rice (ZT-DSR), unpuddle transplanting (UPTR) and conventional transplanting (PTR) as main-plot and five winter crops *viz.*, chickpea (Pusa 256), lentil (HUL 57), mustard (Proagro 5111), linseed (T 397) and safflower (PBNS 12) with two residue management practices, i.e., retaining 30% rice residue and without residues as sub-plots and replicated thrice. Results revealed that among crop establishment (Table 15.1), PTR recorded significantly higher grain yield (5.18 t/ha) as compared to ZT-DSR (3.58 t/ha) and UPTR (2.53 t/ha). In residues management practices, paddy yield was recorded comparatively higher with 30% residue retention (3.77 t/ha) than that of control (3.75 t/ha). Comparatively higher grain yield of paddy was recorded with chickpea plot (3.88 t/ha) followed by safflower (3.85 t/ha) as compared to rest of the treatments.

Table 15.1. Yields parameters of paddy as influenced by crop establishment methods, residues management practice and preceding crops

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index
Crop establishment methods				
ZT-DSR	3.58	6.82	10.40	0.37
UPTR	2.53	4.65	7.18	0.35
PTR	5.18	7.55	12.73	0.42
LSD (P=0.05)	0.78	1.90	2.44	0.06
Residue management practices				
Control	3.75	4.84	8.59	0.44
30% residue retention	3.77	7.84	11.61	0.33
LSD (P=0.05)	NS	1.55	1.99	0.05
Winter crops				
Chickpea	3.88	6.96	10.81	0.37
Lentil	3.55	6.05	9.59	0.36
Safflower	3.85	6.19	10.05	0.40
Linseed	3.79	5.72	9.51	0.41
Mustard	3.76	6.78	10.54	0.36
LSD (P=0.05)	NS	1.20	1.40	0.03

Fig 15.1. Field view of the crops in rice-fallows

During winter season, productivity of succeeding crops, i.e., chickpea, lentil and safflower was higher after growing rice under CT-TPR. However, reverse trends were followed in linseed and safflower, where productivity were the maximum with ZT-DSR. Comparatively higher seed yields of winter crops was recorded in 30% residues retention as compared to control. Among winter crops, system annual productivity (SREY) was recorded the maximum in rice-chickpea (12206

kg/ha) followed by rice-lentil (11560 kg/ha) and linseed (9143 kg/ha) under CT-TPR. Similarly, comparatively higher SREY was recorded with 30% RT than control. The similar trends were followed in case of system production efficiency during the study.

Evaluation of lentil and linseed verities in rice fallows

Eleven linseed varieties were evaluated during the *rabi* season of 2017-18 after rice harvest in rice fallows plot under zero tillage system (Fig. 15.2). Results revealed that significantly higher lentil yield was recorded with cv. Pusa Masoor 5 (1560 kg/ha) followed by Vaibhav (1517 kg/ha) and DPL 15 (1507 kg/ha). In similar set of experiment, 11 linseed varieties were evaluated to find out the suitable cultivars of linseed. Results revealed (Table 15.2) that higher linseed yield was recorded with cv. Uma (1209 kg/ha).

Table 15.2. Performance of lentil and linseed cultivars under rice fallows system

Lentil variety	Seed yield (kg/ha)	Linseed variety	Seed yield (kg/ha)
HUL 57	1350	RLC 133	1064
DPL 62	1257	RLC 138	1138
Arun	1478	RLC 143	1175
DPL 15	1507	Uma	1209
Vaibhav	1517	Indu	1013
IPL 01	1417	BAU 06-03	1096
Ranjan	1233	BAU 2012-1	976
IPL 406	1324	BAUP 101	1128
K-75	1378	SLS 79	1085
IPL 316	1266	JLS 95	1066
Pusa Masoor 5	1560	Shekhar	1040
LSD (P=0.05)	119	LSD (P=0.05)	93

Fig. 15.2. Field view of lentil and linseed under zero tillage system in rice fallows

Long-term effect of CA practices on crop productivity, weed seed bank and earthworm population

A long-term study on effect of CA practices in rice-wheat system was initiated in 2009-10 in CSISA project. Results during 8th year revealed the rice yields under DSR (conventional or zero till) declined significantly (Fig. 15.3) as compared to conventional puddle transplanted conditions due to heavy attack of rice mealy bug (5-8/plant) under scenario 4 (S4) due to severe infestation of grassy weeds like *Brachiaria* spp. Hence, it was necessary to go far conventional puddling and transplanting which yielded maximum (7.97 t/ha) followed by UPTR (6.73 t/ha), CT DSR (4.5 t/ha), ZT DSR (3.58 t/ha) (Fig.15.4). Continuous zero tillage in rice (ZTDSR) in S3 and S4 resulted in severe infesta-

Fig 15.3. Field view of rice during 8th year of continuous ZT DSR (left) and PTR after continuous ZTDSR for 7 years.

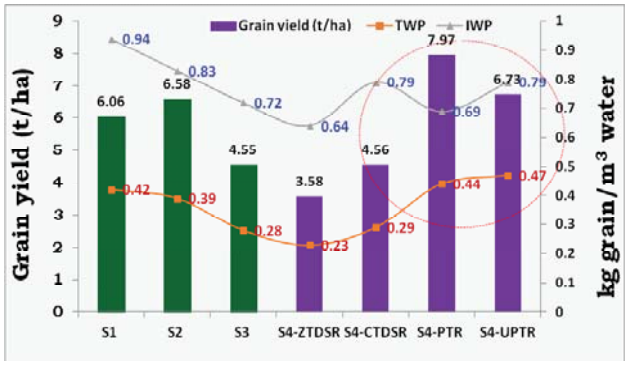

Fig 15.4. Effect of crop establishment methods on grain yield and water productivity of rice

tion of grassy weeds. Scenario 3 was dominated by *Echinichloa colona, Digitaria sanduinalis* and *Leptochloa chinensis* and S4 with *Digitaria sanguinalis*. Whereas the broadleaved weeds like *Alternanthera sessilis* and *Caesulia axillaris* were relatively higher in S1 and S2, but less in number.

Soil weed seed bank studies revealed that maximum number of total weed seeds/kg soil (based on seedling emergence) were observed in S4 (62.00) followed by S2 (47.67), S3 (46.33) and S1 (31.00). Total weed seeds were maximum on 0-10 cm depth (69.5/kg soil) that 10-20 cm (24/kg soil). Among different species, *Braciaria* spp, *Cyperus iria* and total grasses were maximum in S4, where as the total broad-leaved weeds dominated by *Trianthema portulacastrum* was higher in S2 (Table 15.3). Earthworm population studies indicated that maximum population was recorded under S2 (133 nos/cubic feet), closely followed by S4 (117/cft). Conventional tillage of rice-wheat system (S1) produced the lowest (54/cft) followed by S3 (61).

Table 15.3. Soil weed seed bank (no./kg soil) in different scenarios and soil depths

Scenario	Total	BLW	Grasses	Sedges	*Mollugo*	*Oldenlandia*	*Trianthema*	Other BLW
S1	31.00	9.83	15.83	5.33	0.00	1.5	5.00	3.33
S2	47.67	31.67	31.67	0.83	0.17	0.5	28.5	2.8
S3	46.33	17.00	17.00	2.67	8.17	5.33	0.83	2.67
S4	62.00	10.83	10.83	21.67	0.83	0.67	1.00	8.17
LSD (P=0.05)	17.46	12.91	12.12	4.48	—	0.88	10.32	1.28
D1	69.5	26.17	32.33	11.00	3.67	3.25	13.08	6.08
D2	24.00	8.50	11.25	4.25	0.92	0.75	4.58	2.25
LSD (P=0.05)	12.6	4.51	4.19	3.65	—	0.68	2.39	1.16

D1: 0-10 cm depth, D2: 10-20 cm depth

In another long-term experiment on crop establishment methods in rice-wheat greengram system, SRI system of rice establishment produced the maximum grain yield (6.99 t/ha), and was at par with CTDSR (6.94 t/ha) and ZTDSR (6.7 t/ha). Studies on weed shift due to crop establishment revealed that during 3rd year, the population of *T. portulacastrum* in ZT DSR-ZT wheat-ZT greengram (complete CA) system was drastically reduced to 11/m^2 as compared to 120/m^2 in conventional DSR (Fig 15.5).

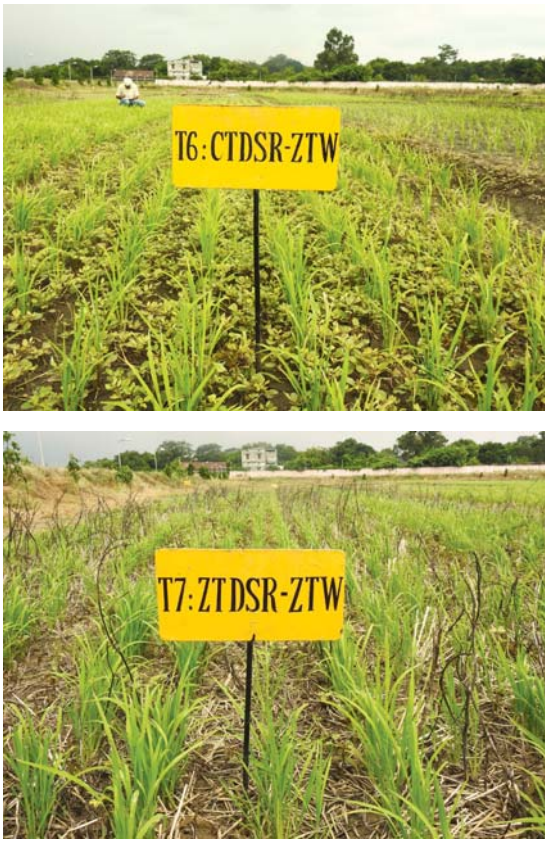

Fig. 15.5. Weed shift in rice (3rd year) due to crop establishment methods

Sustainable and Resilient Farming System Intensification in the Eastern Gangetic Plains

Analysis of wheat data (2016-17) of 32 farmers' fields in Madhubani revealed that maximum wheat yield (3.52 t/ha) was obtained in ZT wheat grown after ZT DSR (Fig 15.6). It was closely followed by the yield of wheat (3.48/ha) obtained in ZT wheat preceded by unpuddled transplanted rice. Minimum wheat yield (3.21 t/ha) was obtained

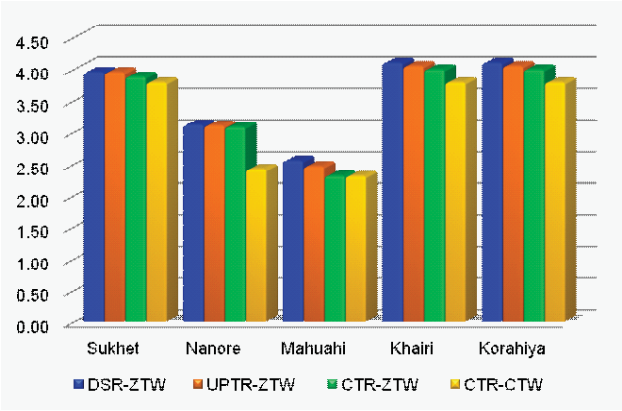

Fig 15.6. Node wise wheat yield (t/ha)under different establishment methods during 2016-17 in Madhubani

in conventional transplanted rice followed by CT wheat. Node-wise analysis revealed that average grain yield of Zero till wheat was the highest (4.10 t/ha) in Korahia and Khairi and the lowest (2.30 t/ha) in Mauahi.

In rice, ZTDSR followed by zero tillage wheat system produced maximum grain and biomass yields (3.66 t/ha and 10.2 t/ha, respectively), and maximum net profit and B:C ratio (Table 15.4). Unpuddled transplanted rice after ZT wheat produced higher grain yield by 0. 8 t/ha as compared to conventional transplanted rice. Among different establishment methods maximum system productivity (7.18 t/ha) and profits were recorded with ZTDSR-ZTW.

Table 15.4. Productivity and economics of rice-wheat systems in Madhubani (N= 29)

Treatment	Grain yield	Biomass yield	Harvest index	Total variable cost	Gross returns	Net profit	Benefit: cost ratio
	(t/ha)			Rs/ha			
Rice 2017							
CTR -CTW	3.56	9.7	0.37	53,299	67,638	14,339	1.27
CTR -ZTW	3.56	9.8	0.36	53,239	68,612	15,373	1.29
ZTDSR -ZTW	3.66	10.2	0.36	33,950	62,468	28,518	1.84
UPTR -ZTW	3.64	10.2	0.36	36,096	63,668	27,572	1.76
Wheat 2016-17							
CTR -CTW	3.21	7.39	0.43	55,694	75,650	19,956	1.36
CTR -ZTW	3.4	7.82	0.43	47,564	79,774	32,210	1.67
ZTDSR- ZTW	3.52	8.63	0.41	47,476	85,994	38,518	1.81
UPTR -ZTW	3.48	7.93	0.44	47,372	81,602	34,230	1.72
Rice-Wheat 2016-17							
CTR -CTW	6.77	7.39	0.80	1,08,993	1,43,288	34,295	1.31
CTR -ZTW	6.96	7.82	0.79	1,00,803	1,48,386	47,583	1.47
ZTDSR -ZTW	7.18	8.63	0.77	81,426	1,48,462	67,036	1.82
UPTR- ZTW	7.12	7.93	0.8	83,468	1,45,270	61,802	1.74

CTR: conventional transplanted rice, CTW: conventional wheat, ZTW: Zero tillage wheat
ZTDSR: Zero tillage direct sown rice, UPTR: Unpuddled transplanted rice

16. Solar Energy Application

Groundwater Pumping and Irrigation

The Eastern region is blessed with intense solar radiation with 250 - 280 bright sunshine days in a year. The incident solar radiation in Bihar has been found maximum (6.9 kWh/m^2/day) in the month April and minimum (3.4 kWh/m^2/day) in the month of December (Fig 16.1). Therefore, Bihar has an immense scope for solar energy use in agriculture. In Bihar the average groundwater depth ranges between 2-10 m in pre-monsoon period and 2-5 m in post-monsoon period. For dry season agriculture smallholders depend on ecosystem services. A solar submersible pump of 2 hp capacities was installed at Bharatpura village of Patna district under the project Agri-CRP on Water to improve dry season agriculture productivity along with fish farming by storing the extracted groundwater in to a pond (Figs. 16.2 & 16.3). The groundwater regime in Bharatpura ranges between 2-9 m in pre-monsoon period and 2-6 m in post-monsoon period. The performance curve of the installed solar pump is shown in Fig 16.4. The shutoff head of the pump is 20 m and operated by 1800 Wp solar array. The available solar radiation, the volume of abstracted groundwater per day and estimated irrigable area per day are reported in Table 16.1.

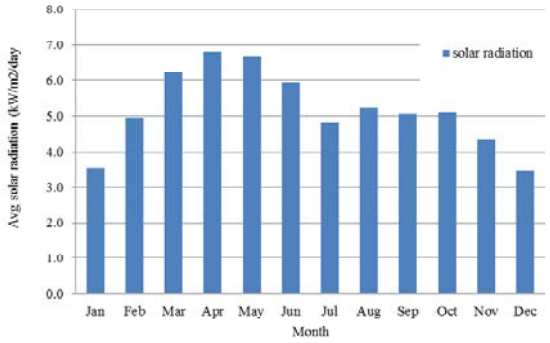

Fig.16.1. Mean monthly average solar radiation per day in Bihar

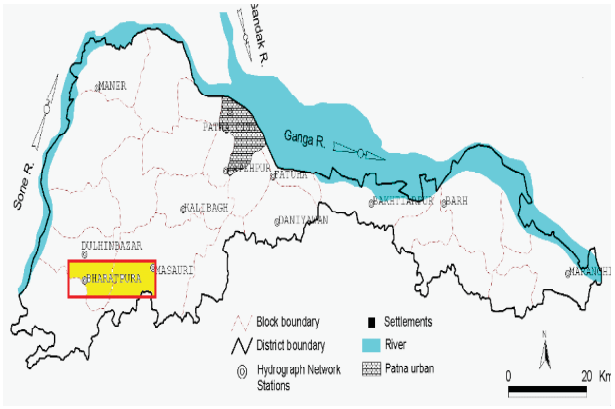

Fig. 16.2. Solar pump site, Bharatpura village, Patna. *Source:* CGWB, Patna

Fig. 16.3. Solar pump at Bharatpura village, Patna

Table 16.1. Groundwater output and irrigable area per day by 2 hp solar submersible at Bharatpura, Patna

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sol radiation Patna district (kWh/m^2 /day)	3.6	4.7	6.3	6.5	6.3	5.6	4.8	5.3	5.1	5.2	4.3	3.4
Water output (m^3/day)	40-45	60-65	80-85	80-85	80-85	75-80	60-65	60-65	60-65	60-65	50-55	40-45
Area irrigable (m ^{2}/day)	700	1100	1400	1400	1300	1200	1100	1100	1100	1100	900	700

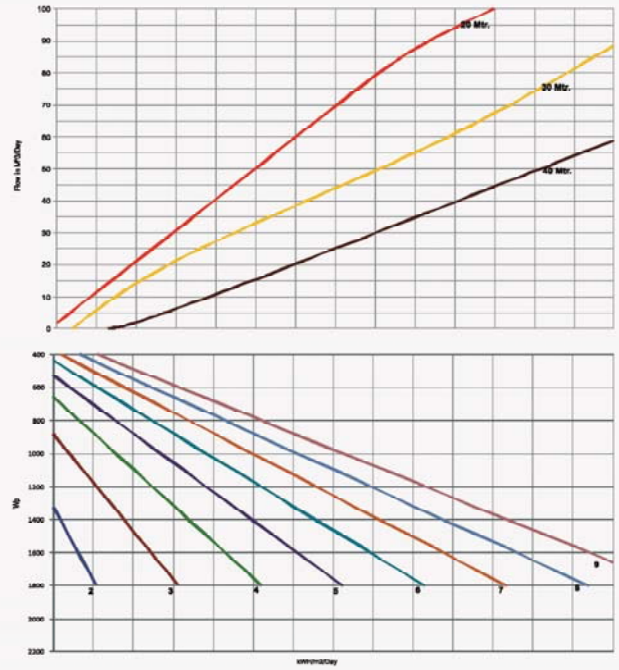

Fig 16.4. Performance curve of the installed 2 hp solar

Hydraulic Efficiency of Solar pump in Eastern region

The hydraulic efficiency of a submersible solar pump of motor rating 2.25 kW, energized by 3000 W_p solar array was evaluated for its hydraulic efficiency at Patna (25.65° N, 85.08° E) (Fig. 16.5). Solar radiation, groundwater yield, total dynamic head (TDH), ambient temperature and the efficiency of solar modules were recorded. The hydraulic efficiency of this solar pump was in the range of 58–71% (Fig.16.6). The efficiency of the solar pump was maximum (71%) in the month of April as the solar radiation was maximum (6.5 kWh/m^2 /day). The efficiency was minimum (58%) in the month of December when solar radiation was minimum (3.4 kWh/m^2 /day).

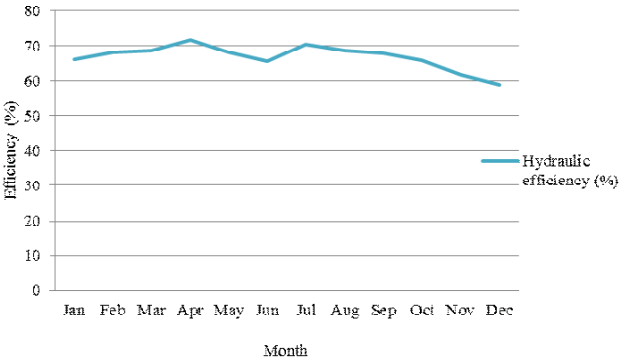

Fig. 16.6. Hydraulic efficiency of solar pump in Eastern region of India

Solar Aerator for Fish-pond

A spray type solar aerator was developed with 900 Wp solar array and 750W induction motor pump and installed in the fish pond (30 m x 40 m with 1.5 m of water depth) (Fig. 16.7). The solar aerator sprays water over the pond surface and diffuses air oxygen into the pond water. It not only increases dissolved oxygen concentration but also breaks thermal stratifications of water column by blending top oxygen saturated water layers with lesser concentrated oxygenated sub surface layers. There was an increase of 23–285 in dissolve oxygen over the controlled value (4.0–4.4 ppm) in middle water layer after 6–7 hours of operation during day time. In bottom layers the increase in dissolved oxygen was more sustained, i.e., up to 40-46% over controlled value of 3.2–3.6 ppm. This increase in dissolved oxygen (DO) was effective up to 12.0 m from the aerator and then diminished over 20.0 m from the aerator. The impact of aeration on fish growth was also evaluated in terms of their weight gain. With initial weight, (50–75g), the final weight was in the range of 150–175 g compared to the controlled condition of 100–125g over one month (Fig 16.8).

Fig. 16.5. Solar water pumping system installed at Patna

Fig. 16.7. A spray type solar aerator installed in fish pond at ICAR RCER, Patna

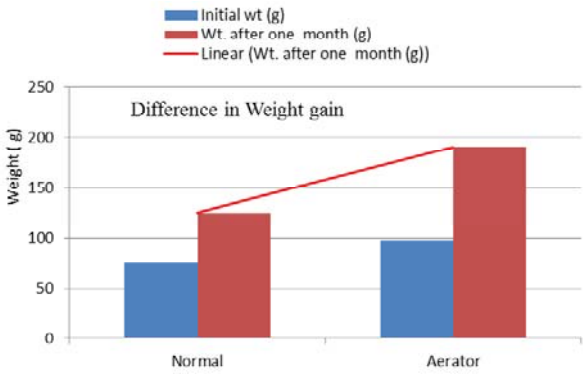

Fig 16.8. Impact of solar aerator on weight gains in fishes

Solar Energy use for Dry Season Agriculture in Madhubani District of Bihar

To improve the livelihood of marginal and tenant farmers in the Eastern Gangetic Plains through improved water use and increased dry season agricultural production two solar submersible pumps each of 2.25 kW motor rating energized by 3000 Wp solar array, were installed at Bhagwatipur village of Madhubani district of Bihar (Fig 16.9). Performance curve of the pump is shown in Fig. 16.10. The depth of ground water level ranges from 5.0-6.0 m bgl at the village location. The rate of pump discharge as well as delivery head were 4.5 to 5.5 lps and 1.4-1.8 kg/cm^2, respectively during 8 AM to 2:30 PM. This pattern is seen from the months of April to October with only slight variation in discharge due to variation in solar intensity. This much availability of delivery head facilitates a pressured irrigation by the use of drip or micro sprinklers. The total groundwater yield per day during April to October is lying in the range of 140–160 m^3. A cropped area of 3000–2500 m^2 can be irrigated per day if flood method of irrigation is followed. The weekly irrigation command area of this system is between 2.0–2.5 ha.

Fig 16.9. Solar groundwater pumping systems at village Bhagwatipur in Madhubani district of Bihar.

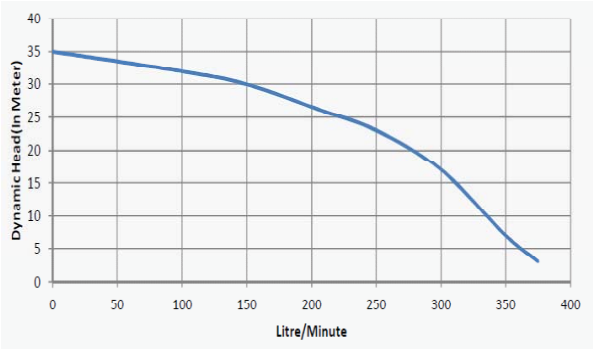

Fig 16.10. Performance curve of 3HP submersible pump

During low intensity solar radiation months the available discharge per day and the delivery head was in the range of 100–120 m^3 and 1.2 –1.4 kg/cm^2, respectively. Therefore, system is capable to operate drip and mini sprinklers round the year and farmers are able to grow cereal crops using flood or sprinkler irrigation and vegetables by drip irrigation methods. Scientist from ICAR Research Complex for Eastern Region, Patna, are also providing technical supports to the farmers in getting quality seeds, appropriate dose of fertilizers and trainings for soil and crop management. These interventions enhanced the income of marginal and tenant farmers under cooperative use of the system.

17. Farm Machinery

Ergonomic Study of Farm Women by use of different Concavity of Sickles during Paddy Harvesting

An ergonomic study was carried out using five sickles with different concavity for harvesting paddy. The different sickles were selected from Bihar, Eastern UP and Jharkhand (Fig. 17.1). Five farm women were selected for the study. The mean age of the selected farm women was 34.7±4.14 years with the average height of 151.05±3.48 cm and gross body weight of 46.7±4.84 kg. The mean body mass index was 20.48. Physiological stress of farm women during paddy harvesting was determined based on the parameters like average heart rate during work and rest period, energy expenditure and cardiac cost of work while performing the activity. The highest efficiency of 33.83% was recorded in sickle with 30 mm concavity of (Bihar), followed by 32.96% (Eastern UP-30 mm). The comparative analysis among five different designs of sickles showed that the concavity of 30 mm sickle (Bihar 30 mm) was more effective and resulted in maximum output (35.44 m^2) with minimum cardiac cost 48.96 beats/m^2 (Table 17.1).

Fig. 17.1. Sickles with different concavity (1-30 mm, 2-40 mm, 3-50 mm (Bihar), 4-30 mm (Jharkhand) and 30 mm (Eastern UP)

Eco-energetic Analysis of different Cropping System in Eastern India

The study was conducted during 2016-17 at ICAR-RCER and ICAR- CPRS, Patna. During the study, eight crop, i.e., rice, wheat, maize, potato, lentil, mung, chickpea, and mustard were taken into account to estimate input-output energy values. Inputs used in calculation of agricultural energy are human labor, machinery, electricity, chemicals, diesel, water, fertilizers, and seeds. Energy output arises mainly from the main product and byproducts. Energy output from main product as well as byproducts is calculated by multiplying production and their corresponding energy equivalent. The

Table 17.1. Effect of concavity of sickles on change in heart rate, energy expenditure and output by use during paddy harvesting (N=5)

Parameters	Concavity				
	Bihar (30 mm)	Bihar (40 mm)	Bihar (50 mm)	Eastern UP (30 mm)	Jharkhand (30 mm)
Output (m^2 /hr)	35.44	33.76	32.08	34.98	23.45
Average heart rate during rest (beats/min)	91.29±2.18	85.83±3.97	91.08±4.72	92.58±2.38	97.25±11.69
Average working heart rate (beats/min)	120.21±2.84	117.92±3.33	121.00±8.92	121.25±1.40	128.17±4.41
Δ HR, beats/min	28.92	32.09	29.92	28.67	30.92
Energy expenditure (kJ/min)	8.09	7.48	8.14	8.28	9.20
Cardiac cost (beats/m^2 area) covered	48.96	57.03	55.96	49.18	79.11
Reduction in drudgery (%)	38.11	27.91	29.26	37.83	-
Increase in efficiency (%)	33.83	30.53	26.90	32.96	-

total energy requirement from different sources of producing rice, wheat, maize, potato, lentil, mung, chickpea and mustard crop were 26331.33, 28649.63, 44592.70, 53355.79, 13602.50, 14204.70, 8681.40 and 15972.45 MJ/ha, respectively (Table 17.1). Yields of the rice, wheat, maize, potato, lentil, mung, chickpea and mustard were determined at 4300, 4900, 8000, 36603, 2020, 969, 3000 and 3730 kg/ha, respectively. It was found that the energy ratio had the highest value of the mustard production followed by chickpea, maize, rice, wheat, lentil, mung, and potato crops. These values were calculated at 10.62, 10.54, 7.96, 6.86, 6.65, 5.62, 2.80, and 2.46, respectively (Table 17.2).

Performance Evaluation of Line and Rotary Marker in SRI

A performance study was conducted with two manually operated markers, i.e., line and rolling in System of Rice Intensificatio (Fig. 17.2). The output of rolling marker was recorded 40 m^2/hr whereas, line marker recorded 40.72 m^2/hr. However, rolling marker recorded lowest energy expenditure of 4.71 kJ/s and cardiac cost 5.62 beats/m^2 as compared to line marker. The result indicated that rolling marker was able to save 19% drudgery, and increased efficiency by 16 % (Table 17.3).

Table 17.3. Field parameters and ergonomic evaluation of rolling and line markers

Parameters	Rolling marker	Line marker
Field capacity (ha/hr)	0.02	0.013
Field efficiency (%)	66	81
Cost of operation (Rs./ha)	1562.2	2403
Average heart rate during working (beats/min)	84.5	91.5
Average heart rate during rest (beats/min)	62	72
Δ HR (beats/min)	22.5	19.5
Output (m^2/hr)	40	40.72
Energy expenditure (kJ/min)	4.71	5.82
Cardiac cost (beats/m^2 area covered)	5.62	6.70
Reduction in drudgery (%)	19	-
Increase in efficiency (%)	16	-

Ergonomics Study of Manual Weeders in System of Wheat Intensification (SWI) under Indo Middle Gangetic Plains

A comparative study of two manual weeders, i.e., Star and SRI was evaluated in field of System of Wheat Intensification (Fig. 17.3). The field capacity of star weeder and SRI weeder were 172.8 m^2/hr and 142.08 m^2/hr, respectively. During

Line markers Rotary markers

Fig. 17.2. Line and rotary markers in paddy field

Star weeder SRI weeder

Fig.17.3. Field evaluation of star weeder and SRI weeder

Table 17.2. Energy consumption for raising various crops.

Item	Rice	Wheat	Maize	Potato	Lentil	Mung	Chick Pea	Mustard
Average total energy input (MJ/ha)	26331.33	28649.63	44592.70	53355.79	13602.50	14204.70	8681.40	15972.45
Average grain yield (kg/ha)	4300.00	4900.00	8000.00	36603.00	2020.00	969.00	3000.00	3730.00
Average straw yield (kg/ha)	9400.00	9500.00	19000.00	0.00	3750.00	2045.32	3790.00	6790.00
Average total energy output (MJ/ha)	180710	190780	355100	131770.8	76569.00	39810.89	91475.00	169620.6
Output–input energy ratio	6.86	6.65	7.96	2.46	5.62	2.80	10.54	10.62

weeding operation the physiological stress, i.e., ΔHR, energy expenditure and cardiac cost were recorded between 33, 6.54 kJ/s and 11.45 beats/m^2, respectively for star weeder. But in case of SRI weeder it was 37.5 beats/min, 6.46 kJ/s and 15.83 beats/min, respectively. The result indicated that working efficiency was increased by 27.66% by using the Star weeder when compared with SRI weeder.

Establishment of Custom Hiring Centre

The Custom hiring centre (CHC) was established at KVK, Buxar (Fig. 17.4) and equipped with tractor (45 hp), disc plough, rotavator, multi-crop thresher, seed cum fertilizer drill (9 rows), post hole digger (18″) diameter, power harrow (4') and cage wheel (Iron), Planker (wooden), battery operated power sprayer with 15 litre tank, water lifting pump (3.5 hp) to provide services to the farmers of Buxar district.

Fig. 17.4. Custom Hiring Centre at KVK, Buxar

18. Livestock and Fisheries

LIVESTOCK

Network Project on Buffalo Improvement

In order to select genetically superior Murrah bulls for improving the performance of non–descript buffalo in terms of production and reproduction traits; a network project on 'Buffalo Improvement' has been implemented. (Fig. 18.1) The total herd strength of Murrah buffaloes is presently 79 which includes 45 breedable females. The average lactation yield, lactation length, service period and calving interval of Murrah buffaloes were recorded at 1486.25±10.82 kg, 276.44±5.34 days, 212.83±9.18 days and 487.18±5.88 days, respectively. The wet average, herd average and average peak yield were found to be 6.07, 4.93 and 9.01 kg/d. respectively. However, individual peak yield was recorded to be 20.9 kg/d. All the animals in the herd were vaccinated against FMD, HS and BQ and dewormed periodically.

The buffaloes were fed green fodder (sorghum, berseem, oat, cowpea, hybrid napier) round the year and chopped paddy and wheat straw as dry fodder. Besides, the buffaloes were offered balanced pelleted feed apart from 50 g of mineral mixture every day. Postpartum anestrous is observed as a major reproductive problem in the herd. Therapeutic effect of hormonal and non–hormonal drugs in postpartum anoestrus buffaloes has been undertaken to address this problem. The conception rate has been recorded at 58.40%.

Fig. 18.1. Murrah buffalo

Characterization of lesser known Farm Animals in Eastern India

Ghungroo pig

A field study was undertaken in 14 villages under Alipurduar I and Alipurduar II blocks of Alipurduar district of West Bengal to evaluate the performance of Ghungroo pigs (Figs. 18.2–18.4),

Fig. 18.2. Ghungroo gilt

Fig. 18.3. Ghungroo boar

Fig. 18.4. Ghungroo piglet

one of the indigenous breeds of pigs in West Bengal, and to analyze their socio–economic status. The study indicated that the average body weights of Ghungroo pigs at 1, 3, 6, 9 and 12 months of ages were found to be 7.12±0.12 kg, 18.20±0.23 kg, 45.67±0.28 kg, 81.04±0.33 kg and 92.58±0.68 kg, respectively. The average litter size was 11.18 at birth and 10.56 during weaning. Age at sexual maturity was 11.36 months whereas interval between two parturition was 5.12 months. The average herd size of the pigs available with the farmers was 1.7. With the major part of feeding being managed from household resources, Ghungroo pigs played a vital part in the tribal economy as they contribute 22 per cent in the Gross Household Income.

Gangatiri cattle

The data collected from the breeding tract on the production and reproduction traits of Gangatiri cattle were analyzed and the results are depicted in Table 18.1. It was found that Gangatiri was a reasonably good milker with milk yield ranging from 2.0 to 9.0 l/d (Fig. 18.5).

Fig. 18.5. Gangatiri cattle in breeding tract

Table 18.1. Production and reproduction characteristics of Gangatiri cattle

Traits	Mean	Range
Lactation length (days)	230.24±7.44 (42)	167 to 315
Peak yield (litre.)	4.52±0.31 (42)	02 to 09
Age at sexual maturity in males (years)	3.07±0.10 (14)	2.5 to 3.5
Age at sexual maturity in females (years)	3.97±0.04 (72)	3.5 to 4.5
Age at 1st calving (months)	56.63±0.63 (48)	51 to 63
Service period (days)	129.45±3.63 (44)	92 to 170
Dry period (days)	169.26±10.18 (42)	90 to 270
Lifetime number of calving	6.45±0.71 (11)	3 to 10

Regression of different independent variables on the income generated from Gangatiri cattle was studied and the results are presented in Fig 18.6. Number of cattle and the quantity of concentrate fed by the farmers had positive regression whereas the occurrence of diseases had negative regression on the income generated by Gangatiri owners. Though the differences in regression coefficients among small, medium and large farmers were very marginal, the dependency of income on various independent variables was larger among medium and large farmers rather than small farmers. Probably better care and management provided by medium and large farmers might be the reason for their substantial income from Gangatiri cattle.

Experimental Dairy Unit

Comparative performance of Sahiwal, Crossbred cattle and Murrah buffalo

Comparative evaluation of Sahiwal, crossbred cattle and Murrah buffaloes in terms of production

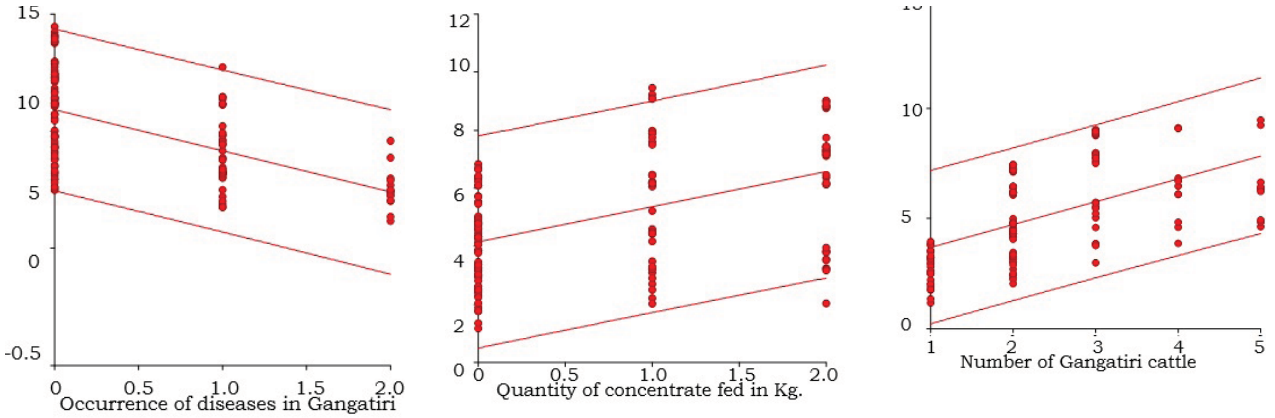

Fig. 18.6: Regression of different independent variables on the income generated from Gangatiri cattle

and reproduction parameters and occurrence of disease was carried out (Fig.18.7) and the results showed that the crossbred animals frequently suffered from different diseases though their milk production was marginally better than Sahiwal cattle (Table 18.2). Sahiwal may be considered better suited dairy animal for climatic conditions of eastern region having comparable production with crossbred cattle and lower disease susceptibility

Fig 18.7. Sahiwal cattle

Table 18.2. Performance of Sahiwal, Crossbred cattle and Murrah buffalo in climatic conditions of Bihar

Trait	Sahiwal cattle	Crossbred cattle	Murrah buffaloes
Lactation yield (kg)	2358.4	3104.5	1486.3
Lactation length (days)	312.8	324.2	276.4
Conception rate (%)	40.4	39.6	27.8
% animals suffered from mastitis	Nil	14.7	4.2
% occurrence of other diseases	11.2	28.3	17.6

Assessing Stocking Density of Livestock under different Land use System of Fodder Production

Evaluation of different maize variety as green fodder during winter season

A study was undertaken to evaluate different cultivars of winter maize as green fodder. Two varieties of maize *viz.* African Tall and Lakshmi White were evaluated **(Fig. 18.8)**. The fodder was harvested at 100th day of crop duration. The fodder yield of African Tall and Lakshmi White was recorded at 43.75±0.72 and 42.33±0.58 t/ha, respectively which is sufficient to meet up the fodder requirements of 56 –58 adult cattle unit for 30 days @ 25 kg/d/unit.

Fig. 18.8. Evaluation of winter maize cultivars for fodder

Evaluation of berseem varieties for fodder and seed production

Three varieties of berseem *viz.* JHB–146, Wardan and Hybrid were sown to assess the simultaneous production of green fodder and seed (Fig. 18.9). The fodder was harvested either three (55, 90, 110 day) or four cuts (55, 90, 110, 130 day) in all varieties and finally crop was harvested at

Fig. 18.9. Evaluation of different varieties of berseem for fodder

160 days crop duration for total biomass and seed yield (Table 18.3). Maximum fodder yield was recorded from Wardan irrespective of number of cuttings. However, the highest seed yield was recorded in three cuts fodder of all varieties than four cuts. Almost, 19–21 adult cattle unit per ha can be maintained with this productivity for 90 days during winter by providing green fodder @ 25 kg/d/unit.

Table 18.3. Fodder, seed and biomass yield of different berseem varieties

Particulars	Berseem varieties					
	JHB–146		Wardan		Hybrid	
	3 cuts	4 cuts	3 cuts	4 cuts	3 cuts	4 cuts
Total fodder yield (t/ha)	29.40	39.20	36.00	48.00	32.80	42.30
Total DM yield (t/ha)	3.97	5.29	5.19	6.93	4.78	6.17
Seed yield (kg/ha)	140	90	270	200	100	90
Total biomass yield (t/ha)	5.57	6.06	7.23	8.02	6.81	7.35

Assessment of different fodder crop rotation for round the year production with carrying capacity and soil nutrient dynamics

The initial soil nutrients status was analyzed at N:138, P:26 and K:157 kg/ha with organic carbon content of 0.62%. Hence, land was prepared with addition of DAP @ 60 kg/ha. Further, N was added @ 240 and 120 kg/ha during cropping period in multi–cut sorghum–berseem and multi–cut sorghum–oat crop rotation, respectively. Annual fodder crops *viz.* multicut sorghum and cowpea was sown during rainy season and annual rye, berseem and oat during winter season (Fig.18.10) in different combination to assess the fodder yield round the year with carrying capacity (Table 18.4).

Table 18.4 : Greeen fodder yield of different crops

Crop rotation (*Kharif – Rabi*)	Cowpea – Annual rye	Cowpea – berseem	Multi–cut sorghum –berseem	Multi–cut sorghum – oat
Kharif fodder yield (t/ha)	26.50	27.15	65.90	67.30
Winter fodder yield (t/ha)	34.58	45.23	42.63	26.95
Annual fodder yield (t/ha)	61.08	72.38	108.53	94.25
Total DM yield (t/ha)	9.56	10.63	16.80	15.04
Total protein yield (t/ha)	1.46	1.64	1.98	1.39
Carrying capacity/ha (Nos. ACU; considering 7.3t fodder/yr/ head)	8.37	9.91	14.87	12.91
N–Net balance in soil (kg/ha)	—	—	– 43.62	– 10.84

Maximum annual fodder yield was recorded in multi–cut sorghum and berseem rotation that could sustain almost 15 adult cattle unit/ha round the year. The N content in soil drastically reduced to 63 and 69 kg/ha in multi–cut sorghum–berseem and multi–cut sorghum– oat rotation after one year, respectively with net N–balance in soil of 43.62 and 10.84 kg/ha. The experiment under acidic (pH 4.66) soil condition (N: 140; P: 35 and K: 386 kg/ha and organic carbon 0.45%) conducted at regional centre of ICAR–RCER Ranchi in different fodder crop rotations revealed the highest fodder yield in baby corn–oat rotation followed by cowpea–annual rye (Table 18.5)

Fig.18.10 Round the year production of fodder crops

Table 18.5. Forage yield and soil nutrient balance under acidic soil condition

Crop combinations	Multi–cut Sorghum–berseem	Cow-pea– annual rye	Baby corn–oat	Hybrid Napier
Kharif fodder yield (t/ha)	7.66	16.41	9.62	32.38
Rabi fodder yield (t/ha)	0.35	8.02	15.75	
Annual fodder yield (t/ha)	8.01	24.43	25.37	32.38
Carrying capacity/ha (Nos. ACU; considering 7.3 t fodder/yr/head)	1.10	3.35	3.47	4.43
N balance in soil (kg/ha)	–15	–17	–21	–16
P balance in soil (kg/ha)	–11	–6	–10	–8

Development of Area Specific Mineral Mixture based on Soil–Plant–Animal Continuum in Bihar and Jharkhand

Feed & fodder, soil, water and bovine serum were collected from Hazaribagh, Ramgarh, Ranchi, Khunti, Lohardaga and Saraikela districts of Jharkhand and subjected to analysis of macro and micro minerals. Two villages from each district were randomly selected for taking representative samples. All fodder samples contained Ca level above the critical limits except the concentrate feeds (maize, wheat, rice grain, oil cakes and pulses by–product) (Table 18.6). Straw and concentrate feed were deficient in phosphorus. Zn was deficient in all the feeds and fodder samples analysed.

Management of Heat Stress in Buffalo

Amplification of HSP 70 gene

Complete HSP 70 gene of Diara and Murrah buffalo (2561 bp) was amplified by polymerase chain reaction to study its association with heat stress in murrah buffalo (Fig. 18.11). Amplifications were performed in 25 µl reactions containing 150–200 ng of genomic DNA, 10 pmol of each primer, 200 µM dNTPs, 1.5 mM MgCl2, and 1 U of Taq DNA polymerase. The thermal cycle profile was 95°C for 2 min, followed by 30 cycles at 95°C for 60 s, 57°C for 60s and 72°C for 2.30 min with a final extension at 72°C for 10 min.

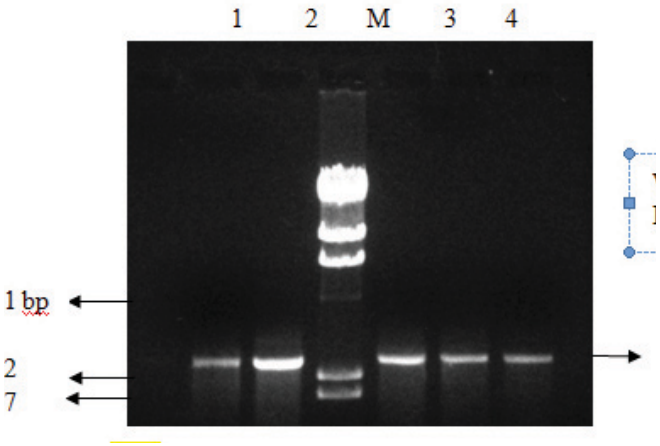

Fig. 18.11: Amplified HSP gene fragment

Effect of mustard oil supplementation in summer on milk yield in buffalo

Eight lactating buffalo (462.7± 36.8 kg body wt, 3–4 months lactation length, 2–3 parity) were selected and divided into two groups. Group 1 was fed standard diet whereas group 2 were fed standard diet with supplementation of Mustard oil @ 150 ml /d for a period of 45 days. This study revealed that mustard oil supplementation (150 ml/d) has significant effect ($P \leq 0.05$) on milk yield at summer. Treatment group had higher milk yield (6.16 ± 2.87 kg/d) than the control group (5.12 ± 1.87 kg/d)

Table 18.6. Mineral content of feeds and fodder in Jharkhand

	Ca (%)	P (%)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Critical level	<0.30	0.25	<8.0	<50.0	40.0	30.0
Straw	0.31 ± 0.02	0.06 ± 0.001	23.4 ± 1.65	829 ± 81	469 ± 52	25.62 ± 1.92
Tree leaves	1.05 ± 0.25	0.38 ± 0.09	10.73 ± 1,11	898 ± 72	105± 16	25.8 ± 2.8
Local grass	0.76 ± 0.09	0.29 ± 0.03	9.87 ± 0.78	2120 ± 531	182 ± 42	18.46 ± 2.07
Cultivated fodder	0.55 ± 0.06	0.34 ± 0.03	8.29 ± 1.02	1009.52 ± 34	201 ± 16	18.1 ± 1.1
Concentrate	0.09 ± 0.001	0.25 ± 0.01	541 ± 0.52	189 ± 42	101.0 ± 0.36	23.47 ± 0.41

Characterization and Evaluation of Duck Germplasm in Eastern Region

A study was conducted to compare carcass characteristics in six different desi duck germplasm raised under identical feeding and rearing conditions (Fig.18.12).

Fig. 18.12. Khaki Campbell ducks

The live body weight at 150 days of age, dressed weight, eviscerated weight, weight of head, skin & feather, gizzard, drumstick, thigh, shank, wing, breast, back, neck and intestine of White Pekin ducks was significantly higher ($p < 0.01$) than that of Khaki Campbell and desi duck germplasm collected from West Bengal, Odisha, Bihar and Jharkhand. There was no significant difference ($p < 0.01$) in liver weight among the breeds. However, other carcass parameters differed significantly ($p < 0.01$) among the breeds being highest in White Pekin and Bihar desi.

Multiplication and Production Profiling of Improved Poultry Germplasm Under Backyard Farming System

Carcass traits of Vanraja and Kadaknath breed reared in deep litter and cage system have been compared (Fig. 18.13). The dressing percentage was

Fig. 18.13. Kadaknath poultry

significantly higher in Vanraja. Similarly, weight of offals and cut of parts were also observed higher in Vanraja. Cage system of rearing was better than the deep litter system in both the varieties of backyard poultry based on carcass traits (Table 18.7).

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

Eight animal health camps were organized in different villages of Bihar and Jharkhand. Pre–tested questionnaire were used to collect and record secondary data from farmers. Survey and health camps were organized in two villages each from Khagaria (Zone II) and Seikhpura (Zone III) districts in Bihar. In Jharkhand, one village each from Ranchi, Ramgarh and Dumka district was selected and provided health intervention. More than 500 cows, buffaloes were given general health care and reproductive health care. Vaccination, deworming, pregnancy diagnosis were carried out in reported animals. Specific cases of mastitis, theileriosis, Surra and abortion were also investi-

Table 18.7. Carcass traits (Mean ± SE) in Kadaknath and Vanaraja reared under cage and deep litter system at 20 weeks of age

	Kadaknath		Vanaraja	
Traits	Cage	Deep litter	Cage	Deep litter
Live weight (g)	2071.2^{a} ±46.624	1749.40^{b} ±29.19	2294.20^{A} ±41.86	1949.40^{B} ±30.03
Dressed weight (g)	1407.4^{a}±43.387	1185.56^{b} ±28.35	1623.04^{A} ±30.92	1393.86^{B} ±24.64
Dressing (%)	67.90	67.74	70.74	71.48
Liver weight (g)	20.2^{a}±1.92	9.61^{b} ±0.45	67.40^{A} ±0.46	60.45^{B} ±0.57
Heart weight (g)	10.16^{a} ±0.79	20.76^{b} ±0.41	11.71^{A} ±0.24	11.36^{A} ±0.43
Gizzard weight (g)	39.44^{a} ±1.08	40.38^{a} ±0.37	69.34^{A} ±0.32	60.14^{B} ±0.38
Drumstick weight (g)	139.68^{a} ±1.66	105.59^{b} ±1.01	258.81^{A1} ±0.92	214.09^{B} ±1.37
Thigh weight (g)	149.764^{a} ±2.17	119.08^{b} ±0.71	293.03^{A} ±0.71	242.75^{B} ±1.20
Breast weight (g)	191.9^{a} ±1.53	154.04^{b} ±0.48	408.27^{A} ±1.04	330.49^{B} ±0.99

gated. Non–infectious infertility was treated with suitable medicines. More than 300 goats were vaccinated against PPR and dewormed. Technology of California Mastitis Test (CMT) and dry cow therapy were demonstrated.

Isolation and morphological characterization of *Fusarium* species from Degnala disease affected region

Identification of species of *Fusarium* by sequencing

A total of three isolates were identified as Fusarium species based on PCR using forward primer: 5′– ATGGGTAAGGARGACAAGAC–3′ and reverse primer: 5′– GGARGTACCAGTSATCATGTT–3′. The primers used for amplification were specific for translation elongation factor–1 alpha (TEF–1α) gene which is a useful genetic region to distinguish between species of *Fusarium*. The amplified product was sequenced by out sourcing. The obtained sequences were thus aligned to see homology among the isolates. In order to determine the species similarity of fusarium, the sequence of isolates were compared with global database by BLAST at NCBI site. The BLAST study of three isolates reveals the similarity of the two isolates with *Fusarium proliferatum* and one isolate with *Fusarium verticillioides*. The above study reveal that there are two different species of fusarium namely *Fusarium proliferatum* and *Fusarium verticillioides* have been recovered from the degnala affected region in Bihar.

Epidemiological study of Respiratory Viral Diseases in Calves

Pattern of disease incidence was studied in bovine calves up to 1 year of age. During the study period the type of illnesses encountered in calves were diarrhoea, respiratory distress, scabies, congenital or partial blindness, naval ill, pyrexia of unknown origin, injury related illness and hernia. Diarrhoea was found to be the most common illness in young calves (< 4 months age). Respiratory diseases and pyrexia of unknown origin were common in older calves (> 4 months age). Out of 82 calves examined during the study period, 27 (32.93%) calves were affected with diarrhoea, 15 (18.29%) calves were affected with respiratory disease, 14 17.07%) with naval ill and joint ill, 9 with scabies (10.9%) and 12 with pyrexia of unknown origin (14.63%), three (3.66%) with partial blindness (hypo–vitaminosis A) and one calf (1.21%) each was affected with injury and umbilical hernia. Nasal swab samples were collected from calves showing signs such as nasal discharge, coughing and respiratory distress. PCR technique was standardized for detection of paramyxoviruses using Pan– paramyxovirus primers PAR F1, PAR F2 and PAR R (Fig.). The collected samples were negative for bovine paramyxo and corona viruses. Histologically, the most prominent signs were present in lungs characterized by bronchopneumonia, congestion of blood vessels, peribronchial infilteration of neutrophils and lymphocytes, bronchioles were plugged with neutroplilic and lymphocytic exudate, alveolar oedema, and necrosis of lung parenchyma with infiltration of inflammatory cells (Fig.18.14 & 18.15).

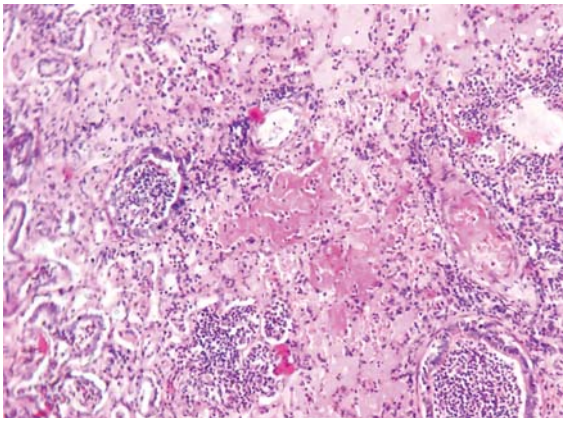

Fig 18.14. Gel electrophoresis: Lane 1, 2 and 3 PAR F1 &PAR R, Lane 5, 6 & 7 PAR F2 &PAR R Lane M: Marker, Lane 3 & 7: negative controls

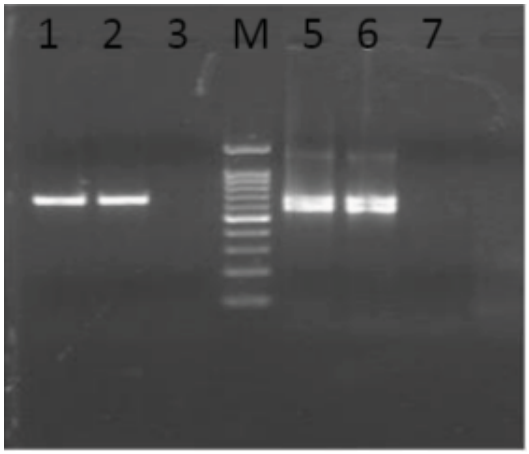

Fig 18.15. Lungs showing bronchopneumonia with infiltration of inflammatory cells and oedema

Effect of Glucosamine Supplementation on Reproductive Efficiency in Poultry

The effect of glucosamine supplementation (10 and 20 mg per kg body weight) on age of first laying was studied in the Vanaraja poultry. It was 161.15 and 165.61 days in 10 and 20 mg/kg body weight doses groups, respectively as compared to 166.84 days in control group. The growth rate of birds did not differ significantly among the groups. The mean plasma glucose level were 101,103 and 104 mg/dl, total protein level were 6.68,6.32 and 6.24 gm/dl and plasma albumin level were 3.98, 4.70 and 4.30 gm/dl in control group, 10 mg group and 20 mg group, respectively at 15 weeks of age.

FISHERIES

Optimization of Production Efficiency in Livestock–Fish Integrated Farming System

The recycling of animal wastes in fish ponds for natural fish food production is important for viable aquaculture and to reduce expenditure on feed and fertilizers which is accounted for more than 50% of the total input cost. Six integrated livestock–fish models have been developed involving cattle, buffalo, goat, pig, poultry and duck.

Plankton analysis

The current investigation have shown that the annual average plankton density was recorded to be highest in fish–pig intigration (1152.08 no./lit) followed by fish–duck (830.21 no./lit.) and fish–poultry (741.67 no./lit.) integrations etc. The lowest plankton population (639.58 no./lit) was recorded in fish–cattle integration (Fig. 18.16). The monthly variation in plankton density is shown in Fig. 18.17. Lowest plankton density was observed in the month of January among all integration system due to peak winter.

Occurrence of fish food organisms

The most abundant and frequently recorded planktonic organisms were Rotifers, Copepods, Cladocerans, Diatoms, Blue–Green algae, Chlorophytes, and Euglenoids etc. Abundance of plankton is generally associated with application

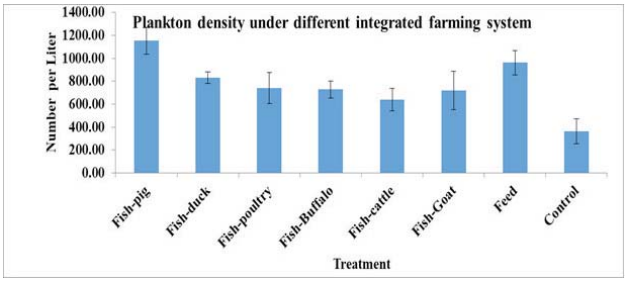

Fig.18.16. Annual average plankton density under different fish–livestock based integrated fish farming system

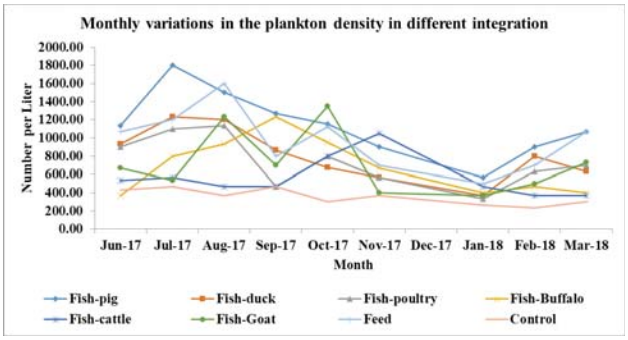

Fig. 18.17. Monthly variation in plankton density in different fish–livestock based integrated farming system

of organic manure. Rotifers, Copepods are the best natural fish food organism in freshwater fish pond. Availability of these fish food organisms indicates healthy environment for the fishes to grow. Following are some of the representative species of plankton recorded during sampling (Fig. 18.18).

Primary productivity and water quality parameters

Primary productivity and water quality of a fish pond play vital role in integrated aquaculture system (Fig 18.19). illustrates the primary productivity of pond water under different integrations. Gross primary productivity (GPP), Net primary productivity (NPP) and Respiratory quotient (RQ) was estimated to be highest in fish–cattle integration (0.36, 0.17 and 0.18 g $C/m^3/h$) followed by the fish–buffalo (0.29, 0.14 and 0.16 g $C/m^3/h$) and fish–goat (0.23, 0.14 and 0.1 g $C/m^3/h$).

Water quality parameters in different fish–livestock based integrated farming systems are depicted in Fig. 18.20. From the present investigations the water quality parameters like total ammonium nitrogen, nitrite and phosphate contents were estimated to be maximum in fish–cattle pond, i.e., 0.58 ppm, 0.018 ppm and 0.65 ppm,

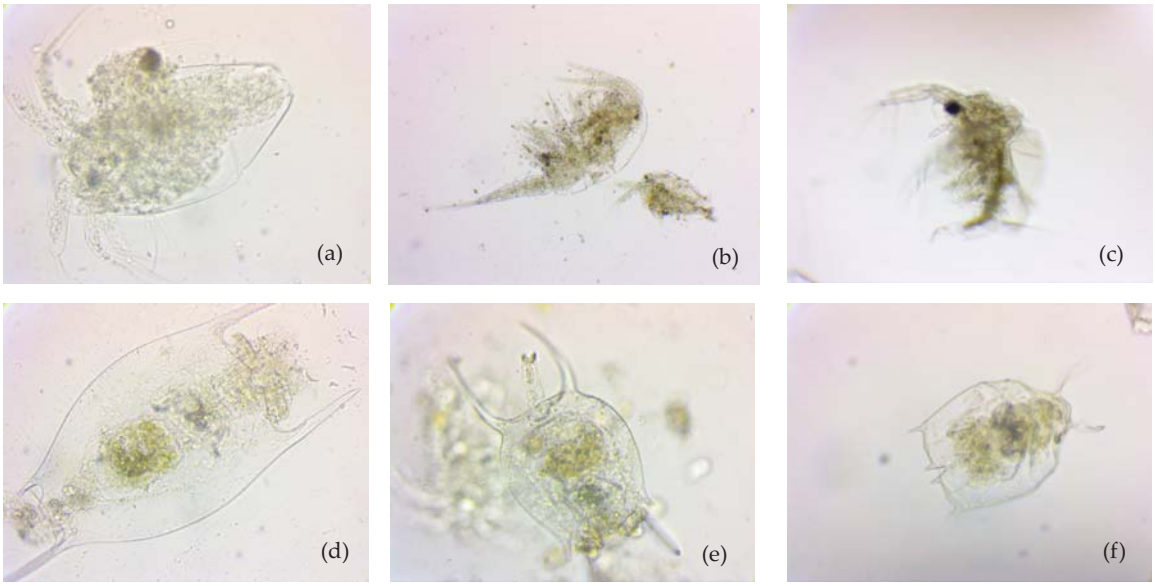

Fig 18.18. Groups of Cladocerans (a, b, c) and Copepods (d, e, f)

respectively. Moreover, in all other integrations these parameters optimum required for freshwater aquaculture system.

Alkalinity and hardness were within the acceptable limit in all the ponds (Fig.18.21). However, both parameters were maximum in fish–pig (155.22, 171.44 ppm) and minimum in fish–duck (116, 144.44 ppm). Therefore, it can be concluded that livestock–based integration did not deteriorate water quality parameters.

The temperature and pH of pond water in all the integrations ranged between 27.6–28.06 and 7.25–8.05 (Fig. 18.22.) and no abrupt changes in pH have been recorded so far. Dissolved oxygen was almost maintained between 5.83 – 6.93 ppm which is ideal for fish survival and growth.

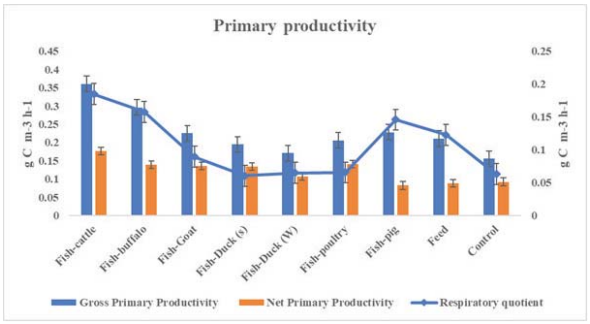

Fig. 18.19 . GPP, NPP and RQ in different livestock–fish based integrated farming systems

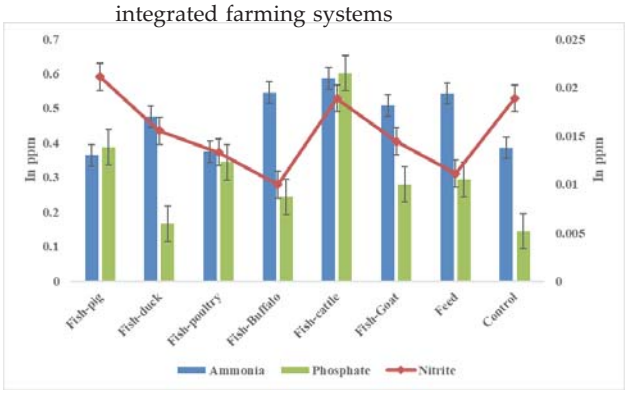

Fig.18.20. Nitrite, ammonia, nitrate and phosphate content (in ppm) in different livestock–fish based integrated farming systems

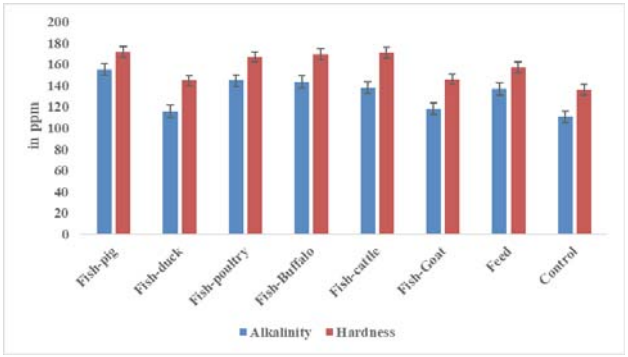

Fig. 18.21. Alkalinity and hardness level (ppm) in different livestock–fish based integrated farming systems

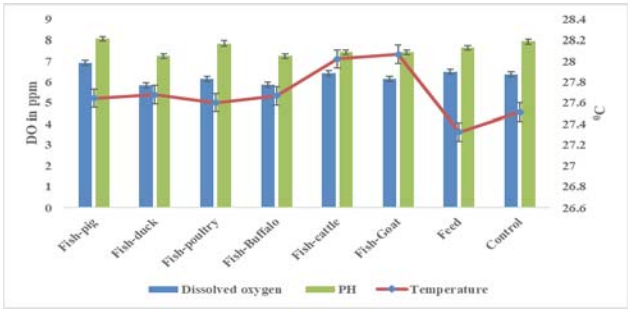

Fig. 18.22. Temperature, pH and DO in different livestock–fish based integrated farming systems

Formulation of Mineral Mixture for Indian Major Carp (IMC) based on Soil-Water-Fish Continuum

Under this project, 25 farms were selected for from Patna, Vaishali, Samastipur, Darbhanga, Motihari and Madhubani districts of Bihar. Fish tissues, gill, liver, soil, and water samples from farmer's field were collected. The micro mineral concentration of Catla, Rohu and Mrigal were estimated from Patna district (Table 18.8). From the present study Mn was observed to be little deficient in all three species as compare to previous report. The micro mineral concentration of water from different district of Bihar depicted in Table 18.9.

Table 18.8. Micro mineral concentration of different organs of Catla, Rohu and Mrigal collected from Patna district

Micro minerals	Fe (µg/g)	Mn (µg/g)	Zn (µg/g)	Cu (µg/g)
Catla				
Gill	944.05	45.79	184.06	10.19
Liver	767.59	13.75	225.86	15.30
Muscle	166.39	3.16	40.76	6.17
Rohu				
Gill	505.15	45.34	181.58	7.96
Liver	404.17	3.32	169.73	18.69
Muscle	158.21	3.90	31.19	5.73
Mrigal				
Gill	299.35	42.18	65.98	6.92
Liver	525.84	4.47	100.50	5.57
Muscle	58.27	3.20	27.41	3.92

Table. 18.9. Micro mineral concentration of water collected from different districts of Bihar

Districts	Fe (µg/g)	Mn (µg/g)	Zn (µg/g)	Cu (µg/g)
Patna	0.80	0.04	0.27	0.11
Samastipur	0.42	0.04	0.17	0.02
Darbhanga	0.82	0.08	0.28	0.01
Motihari	1.02	0.26	0.53	0.04
Madhubani	0.46	0.06	0.14	0.02

National Surveillance Programme for Aquatic Animal Diseases in Bihar component

Under this project, 10 farms from each five districts namely, Patna, Vaishali, Samastipur, Darbhanga and Madhubani were selected after extensive survey in collaboration with State Fisheries Department, Govt. of Bihar. Two awareness programmes in Motihari and Madhubani districts of Bihar with special focus on fish disease management were undertaken.

Brood Stock Upgradation through Cryopreservation Technique

In the present study short term preserved milt from quality brood fish was bought from CIFA, Bhubaneswar, and was used for the fish stock upgradation programme in Bihar (Fig. 18.23). All the three species of IMC *viz.* Rohu (2–2.5 kg) of 9 numbers, Catla (2.5–5 kg) of 5 numbers and mrigal (1.5 kg) were attempted in four hatcheries. The dry striping method was employed. Stripping was done at 9.45– 10.10 pm at ICAR RCER, Patna, 1.30 – 2.50 am at Banasur Matsya Hatchery, Karisath, Ara and 2.45–3.30 am at Chaudhary Matsya Bij Kendra, Jandaha. Overall fertilization rate was around 80% and hatching rate was 60–70%. Three days old spawn were harvested, and 2.25 lakh, 1.5 lakh and 5.5 l spawn were collected from these hatcheries.

Fig. 18.23. Hatching of fish through cryopreservation technique

19. Transfer of Technology

Growth and Instability in Production of Principal Crops in Bihar

The basic objective of the project was to study the growth and instability in production of principal food grain crops in different agro-climatic zones of Bihar during the last 30 years (1984 to 2014). There has been growth in production of food grains during the period, however, maize and wheat recorded the steady growth during the period. Pulses production got setback in all the agro-climatic zones, particularly during 1984-94. Agro-climatic zone II had an edge over other three agro-climatic zones with respect to increase in food grain production mainly due to lower food grain production during the base year (TE 1984). Food grain production got a boost during 2004-14. Instability in production of all food grains was high, but higher instability in production was observed in rice and lower in wheat. The instability in food grain production was mainly due to frequent floods in north Bihar and drought in south Bihar. Also, the growth and instability had positive relationship across all the zones. However, the sustainable increase in food grain production was made possible due to improved farmers' access to inputs and technology. All the three critical inputs (irrigation, fertilizers and HYV seeds) played a significant role in increasing food grain production in Bihar.

For flood-prone water congested ecology of north Bihar, separate analysis was carried out. North Bihar is dominated by cereal crops. Among the cereals, wheat has emerged as the second most important cereal crop during period under study whereas rice experienced deceleration in area. Maize also gained in area due to adoption of winter maize at large scale in post seventies period. Winter maize is now preferred crop due to its higher yield potential. There has been significant change in cropping pattern during last four decades in north Bihar. All the principal crops recorded growth in production but performance of rice – the most important staple food crop in the area, has not been impressive during the period under study. Research priority should be assigned for innovation and spread of appropriate technology of rice production for unfavourable ecology of north Bihar. Pulses and oilseeds production witnessed a setback due to decline in area and almost stagnant productivity of most of pulses and oilseeds. Special efforts are needed to evolve the varieties of pulses and oilseeds for increasing their production to meet the requirement.

Water and Weed Management in System of Rice Intensification

Water and weed management techniques were evaluated in system of rice intensification in Dohari and Chiraila villages, Manpur Block, Gaya (Bihar) (Fig. 19.1). The highest grain yield (5.42 t/ha) of rice was recorded through saturation all throughout followed by saturation till panicle initiation stage and 2.5 cm standing water till dough stage (5.30 t/ha). Conoweeder when used at 15, 25 & 35 DAT produced maximum grain yield (5.94 t/ha) which was 32% higher than the farmers' practice (4.5 t/ha).

Fig. 19.1. Water management in system of rice intensification in Manpur Block, Gaya

Mera Gaon Mera Gaurav

The different activities (Fig. 19.2-19.4) undertaken under the MGMG programme are listed below:

Block	Beneficiary farmers	Activities
Tamar	331	• Training in seed treatment, nursery raising, lime application, use of drip irrigation system.
Ramgarh	452	• Layout of multi-tier system. • Distribution of fruit plants namely mango, guava, pomegranate, jackfruit, litchi and lemon among farmers. • Pit digging and planting of fruit crops.
Namkum	298	• Cultivation of leguminous and solanaceaous vegetables. • Trained selected women in mushroom seasonal and off-season cultivation of solanaceaous and leguminous vegetables. • Insect pest management • Distribution of quality seeds of leguminous vegetables. • Cultivation of oyster mushroom.

Animal Health Camps Organized

Venue	No.	Animals	Date
Ekrama village, Sheikhpura district, Bihar	1	Bovine: 78 Goat: 15	12.6.2017
Badshapur village, Sheikhpura district, Bihar	1	Bovine: 42 Goat: 20	13.6.2017
Badhuwa parari village, Khagaria district, Bihar	1	Bovine: 56 Horse: 01 Goat: 06	10.08.2017
Tellauchh village, Khagaria district, Bihar	1	Bovine:75 Goat: 52	11.08.2017
Saraitoli village, Namkum block, Ranchi district, Jharkhand	1	Goat: 80 Bovine:38	13.10.2017
Gargali village, Mandu block, Ramgarh district, Jharkhand	1	Goat: 72 Bovine : 42	14.10.2017
Pashu Arogya Mela in village Chintamanpur and Chandrahiya, East Champaran, Bihar	2	250	24-25 Nov 2017
Pashu Arogya Mela in Village Govindganj, Areraj block, East Champaran, Bihar	1	500	6-7 Nov 2017
Pashu Arogya Mela in village Semuapur, Keshariya block, East Champaran, Bihar	1	300	28-29 Oct 2017.
Dumaria village, Dumka district, Jharkhand	1	Bovine : 60 Goat : 81	2.11.2017
Deogarh, Jharkhand	1	Bovine : 110 Goat : 150	3.11.2017
Jogla village, Ramgarh, Jharkhand	1	Bovine and goat 175	23.1.2018
Digwara village, Ramgarh, Jharkhand	1	Bovine and goat 101	24.1.2018

Fig. 19.2. Distribution of fruit plants

Fig. 19.3. Dobha preparation at Semra village, Ramgarh

Fig. 19.4. Plantation of fruit based multi-tier system in Jobla (2 ha)

Venue	No.	Animals	Date
Pundi, village, Mandu block, Ramgarh, Jharkhand	1	Caprine: > 300 Bovine: > 110 treated and vaccinated	14.02.2018
Dagdagia village, Mandu Block, Ramgarh district, Jharkhand	1	Caprine: > 150 Bovine: > 45 treated and vaccinated	15.02.2018
Govindganj village, Areraj block, East Champaran district, Bihar	2		5-6 Nov. 2017.

Workshop, Seminar, Meetings Farmer's days etc. Organized

- Organized 03 days training program sponsored by World Vision India and acted as Course Director on "Climate Resilient Practices for Productivity Enhancement in Agriculture and Allied Sectors" (IRCER/TRG/17-18/51) during 7-9th March 2018 at Farmers Hostel, ICAR- Research Complex for Eastern Region Patna.
- Inter-state Travelling Seminar for Participatory Learning on Climate Smart Agriculture: On 24 -27th Feb. 2018 a four day "Inter-state Travelling Seminar for Participatory Learning on Climate Smart Agriculture" was organised by CIMMYT, ICAR–RCER Patna, BISA under aegis of CGIAR Research Program on CCAFS & RKVY (Bihar Govt.). In which, 13 farmers (6 farmers from Baghakol, Bikram, Patna & 7 farmers from 4 different villages from Vaishali district) participated to understand and exposure of climate smart agriculture intervention and share their learning under Climate smart villages (CSVs) of Haryana & Punjab.

Training Programmes

Name of Training Program	Duration	Sponsored by
Livestock and Fishery Management	21-25 Nov. 2017 (30 participants)	ATMA, Madhubani
Poultry rearing and disease prevention: technology information	16-18 Feb. 2017, (30 participants)	ICAR NRC, Litchi
Modern techniques in poultry farming under rural backdrop	15-17 March 2017, (30 participants)	ICAR NRC, Litchi
Recent Advances in Livestock Fish Integrated Farming sponsored by ATMA, Govt. of Bihar	14-23 Sep. 2017, 12-21 Dec. 2017 and 19-28 Mar., 2018 (90 participants)	ATMA, Govt. of Bihar
Climate Resilient Practices for Productivity Enhancement in Agriculture and Allied Sectors"	25-27 Apr. 2017 (27 farmers, Bhojpur Bihar) 02-04 May, 2017 (33 farmers Muzaffarpur, Bihar) 11-13,May 2017 (30 farmers Vaishali, Bihar)	World Vision, India, Patna
Improved practices of vegetable cultivation	11-13 Apr., 2017 (24 participants)	ATMA, Muzzafarpur
Vegetable cultivation techniques	16-18 May, 2017 (25 participants)	ATMA, Khunti
Water management in horticultural crops	22-26 May, 2017 (24 participants)	ATMA, Latehar
Water management in horticultural crops	29 May-1 June, 2017 (25 participants)	ATMA, Latehar
Water management in horticultural crops	5-9 June, 2017 (25 participants)	ATMA, Latehar
Organic cultivation of horticultural crops	9-13 Oct., 2017 (25 participants)	ATMA Purnea
Scientific cultivation of vegetable crops	5-9 Mar., 2018 (21 participants)	ATMA, Koderma
Improved practices of vegetable and fruit crop cultivation	30 Oct. -03 Nov., 2017 (24 participants)	JTDS, Jharkhand
Improved practices of vegetable and fruit crop cultivation	6-10 Nov., 2017 (24 participants)	JTDS, Jharkhand
Fruit based production system and management practices	20-24 Nov., 2017 (24 participants)	JTDS, Jharkhand
Vegetable and mango cultivation practices	27 Nov-01 Dec., 2017 (21 participants)	JTDS, Jharkhand

Name of Training Program	Duration	Sponsored by
Recent advances in management of horticultural crops	14-16 Mar., 2018 (15 participants)	ICAR RCER & AAU, Jorhat
Use and operation of improved farm Implements (Batch-I)	21-23 Dec. 2017 (40 participants)	CRP on FM, ICAR
Operation and maintenance of tillage and sowing equipments (Batch-II).	07-09 Feb. 2018 (40 participants)	CRP on FM, ICAR
Operation and maintenance of tillage and sowing equipments (Batch-III).	12-14th Mar. 2018 (26 participants)	CRP on FM, ICAR

Linkages

Besides having linkages with leading ICAR institutions, SAUs and State Govt. of various eastern states, the details of other linkages is mentioned 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 pigeonpea for 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, IIFSR, Modipuram 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.

20. Trainings and Capacity Building

Following employees of the institute has undergone training during 2017-18 (Table 20.1)

Table 20.1 List of employees undergone training

Category	Total employees (No.)	Total nos. of training planned for 2017-18 as per ATP	Employees undergone training (No.)	% employees undergone training
Scientist	67	16	10	62.5
Technical	50	14	0	0
Administration	21	6	4	66.67
Skilled Supporting Staff	24	0	0	0
Total	162	36	14	—

Feedback of trainees were collected, consolidated and sent to ICAR, New Delhi. Annual Training Plan 2018-19 for all categories of staff of the institute has been prepared and being implemented.

HRD Activities

Details of the educations and training attended by the scientists are given below:

Bhavana, P., attended International training programme on 'Plant Variety Protection' under NFP Fellowship at Wageningen Centre for Development Innovation, Wageningen University and Research, Wageningen, Netherlands from 19th - 30th June 2017.

Bhavana, P., completed the distance learning course "DL-205: Introduction to the UPOV system of Plant Variety Protection under the UPOV Convention" jointly run by International Union for the Protection of New Varieties of Plants (UPOV) and WIPO Academy 08th May - 11th June, 2017

Choudhary, J.S., attended 21 days CAFT training programme on "Recent developments in statistical modelling and forecasting in agriculture" at ICAR-Indian Agricultural Statistical Research Institute (IASRI), New Delhi from 28th Dec., 2017 to 17th January, 2018.

Seth, T. attended 21 days Winter School on "Molecular breeding for higher productivity, quality, food colorants, nutraceutical and bioactive health compounds in vegetable crops" at ICAR-IARI, New Delhi from February 13th - March 5th, 2018.

Singh, A.K. attended training programme on "Stress management" at ICAR NAARM, Hyderabad during 12th - 15th July, 2017

Chandran, P.C. attended 5-days training program on "Animal Breeding Data Analysis and Genomics Prediction" conducted by ILRI and organized by ICAR-CIRB from 20th -24th, November, 2017.

HRD Fund Allocation and Utilization

S. No.	RE 2017-18 for HRD (Rs. in Lakh)	Actual expenditure 2017-18 for HRD (Rs. in Lakh)	% Utilization
1	3.50	2.57	73.43

21. Events Organized

Policy Dialogue Workshop on Flood Index Insurance and Drought Management for Agricultural Development in Bihar

One day Policy Dialogue Workshop on 'Flood Index Insurance and Drought Management for Agricultural Development in Bihar' was organized by International Institute of Water Management (IWMI), New Delhi and ICAR-Research Complex for Eastern Region (RCER), Patna at ICAR – RCER Patna on 7th June, 2017. Professor Chandrashekhar, Hon'ble Minister for Disaster Management, Government of Bihar, graced the occasion as Chief Guest, and Sri Alok Kumar Mehta, Hon'ble Minister for Co-operative, Government of Bihar was the Guest of Honour. The purpose of this workshop was to present the results of Index Based Flood Insurance (IBFI) product development and evaluation in Bihar, to discuss strategies for implementation in 2017 monsoon season and to develop and recommend protocols for drought monitoring and mitigation with inbuilt contingency measures including capacity development. The Chief Guest stated that Bihar is facing consequences of climate change due to global warming and it is very difficult to assess the losses caused by flood and drought. In this scenario, satellite based technology flood index insurance will be very useful for assessing damage and helping sufferer. Research report on "Mapping multiple climate-related hazards in South Asia" was released by the dignitaries on this occasion. About 50 dignitaries from IWMI, New Delhi, ICAR-RCER, Patna, ICAR-CRIDA, Hyderabad, ICAR-IIWM, Bhubaneswar, ICAR-IARI, New Delhi, representatives of Panchayati Raj Institutions, NGOs, Agriculture Insurance Companies, State officials from Department of Agriculture, and Disaster Management Department, etc. participated in the workshop.

Fig. 21.1 (a) Welcome address by Director, ICAR-RCER, Patna, (b) Hon'ble Minister for Disaster Management, GoB resleasing research report .

International Yoga Day

International Yoga Day was celebrated on 21st June, 2017 at ICAR Research Complex for Eastern Region, Patna, and its Regional Centres and KVKs. All the scientists and staff of the institute performed Yoga under the instruction of Dr J.J. Gupta, Principal Scientist, ICAR RCER, Patna, followed by the programme of Rural Development Wing of Rajyoga Education and Research Foundation, Patna which offered all round development strategies on social, behaviour, moral and cultural characters through spiritual revolution.

Fig. 21.2 International Yoga Day celebration at ICAR-RCER, Patna

Visit of Additional Secretary, DARE & Secretary, ICAR

Shri Chhabilendra Roul, Additional Secretary, DARE & Secretary ICAR visited ICAR Research Complex for Eastern Region, Patna on 17th July, 2017. He emphasized on validation of the technologies developed by the institute and also suggested to study socio- cultural limitations for the adaptation of the technologies developed by ICAR. He advised to co-opt the farmers in on-campus research programme and in budgeting the research proposals. Sri Roul also visited institute farms and interacted with scientists and other staff members.

Fig. 21.3. Shri Chhabilendra Roul, Additional Secretary, DARE & Secretary ICAR interacting with scientists

XVth Annual Review Meeting on Network Project on Buffalo Improvement

XVth Annual Review Meeting on Network Project on Buffalo Improvement was held at ICAR Research Complex for Eastern Region, Patna during 21-22nd July, 2017 under the Chairmanship of Dr J.K. Jena, Deputy Director General (AS), ICAR, New Delhi. Dr Rameshwar Singh, Vice-Chancellor, Bihar Animal Sciences University and Dr B.P. Bhatt, Director, ICAR-RCER, Patna were also present in the meeting. The Chairman in his inaugural address emphasized the need to produce tangible results from the project and stressed that the outcome from the projects should directly benefit the farmers across the country. He also asked the scientists to evaluate the generation wise milk yield improvement of buffalo inseminated with elite semen and emphasized the need of establishing the centre of elite buffalo germplasm in different parts of the country.

Fig. 21.4. Annual review meeting chaired by Dr. J.K.Jena DDG (Animal Science), ICAR

Visit of Secretary, DARE and Director General, ICAR

Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR, New Delhi visited the State of Jharkhand during July 22-23, 2017. He laid down the Foundation stone of Farmers' Hostel of the KVK, Ramgarh on 22nd July, 2017. While addressing the farmers, he appreciated the pace of progress made by the KVK in a short period since its inception in 2014. He made an appeal to the farmers to adopt the technologies being promoted by the KVK for doubling their income.

On 23rd July, the Hon'ble Secretary DARE & DG visited ICAR RCER Research Centre Ranchi and laid down the Foundation stone of Hi-Tech Nursery and visited the experimental farms. He emphasized on generation of adequate and intensive research data under each of the experiments for improving the scientific validity of the findings. He also advised scientists to identify the gap of seed supply in the state and plan accordingly with state department of agriculture and horticulture to overcome those gaps.

Fig. 21.5. Hon'ble DG (ICAR) Dr. T. Mohapatra laying the foundation stone of farmers' hostel at KVK, Ramgarh

Master Training on Vegetables and Mango

Four master trainings of five days each on vegetables and mango were organized from 30th Oct. to 1st Dec., 2017 at ICAR Research Complex for Eastern Region, Research Centre, Ranchi. These trainings were sponsored by the Jharkhand Tribal Development Society (JTDS). During the training total 93 master trainers from 14 districts of Jharkhand were trained for the improved cultivation of vegetables and mango.

Fig. 21.6. Participants for the Master training programme at ICAR-RCER Research Centre, Ranchi

ICAR Zonal Sports Tournament 2017 (Eastern Zone)

ICAR Zonal Sports Tournament 2017 (Eastern Zone) was organized by ICAR Research Complex for Eastern Region, Patna, during 13 - 16 November 2017. The tournament was inaugurated by Dr. R. C. Srivastava, Hon'ble Vice Chancellor, Dr. Rajendra Prasad Central Agril. University, Pusa, Samastipur on 16th Nov. 2017 at the Patliputra Sports Complex, Kankarbagh, Patna. The Sport Complex is a modern state-of-the-art complex, having facilities for both indoor and outdoor games. A total of 16 institutes participated in various events and around 430 participants were present. There were 12 athletics and track events, 4 indoor events and 5 outdoor events and all together 21 events were conducted during 4 days. ICAR-National Rice Research Institute (NRRI), Cuttack was declared as the Overall Team Champion followed by ICAR-Indian Veterinary Research Institute, Izatnagar. In individual performance, Sandhya K. M., CIFRI, Barrackpore and Pradip Kumar Parida, NRRI, Cuttack were declared best athlete in women and men category, respectively. ICAR Research Complex for Eastern Region, Patna also participated in various events during the tournament. Dr T.L Bhutia clinched the gold medal in table tennis (women category). Dr. Bhutia and Ms Kirti Saurabh were the runner up in bad minton women's double category. Dr. J.S. Chaudhary and his team were also runner up in badminton team (men category) event. The prize were awarded by Shri Pramod Kumar, Hon'ble Tourism Minister, GoB, who was the Chief Guest for the closing ceremony of the sports tournament on 16th Nov. 2017.

Fig. 21.7. Inauguration of ICAR Zonal Sports Tournament (2017) by Dr. R.C. Srivastava, Hon'ble Vice-Chancellor, Dr. RPCAU, Pusa, Samastipur

Fig. 21.8. Best athlete in women category Ms. Sanehya K.M., CIFRI, Barrackpore receiving the award by Shri Pramod Kumar, Hon'ble Minister, GoB.

Fig. 21.9. Dr T.L Bhutia, Scientit - ICARRCER, Patna receiving the Gold Medal in table tennis (women category) by Dr. Rameshwar Singh, Hon'ble Vice Chancellor, BASU, Patna.

Institute Research Council Meeting

The Institute Research Council Meeting was held on 29th July, 2017 under the Chairmanship of the Director, ICAR RCER, Patna to review the ongoing projects, to discuss the progress and to approve new projects to be taken up by the scientists. The Chairman in his opening remarks emphasized that our mission should be 'research for total agricultural development with practical implications'. All the scientists of the institute and NRCIF, Motihari participated in the meeting.

Fig. 21.10. Institute Research Council meeting chaired by Dr. B.P. Bhatt, Director, ICAR-RCER, Patna

Workshop on Status of Seed sector in Jharkhand

Workshop on status of Seed sector in Jharkhand was organized at ICAR RCER Research Centre, Ranchi on 8th August, 2017 in which representatives from all the 23 KVKs of the Jharkhand state and the concerned experts of Birsa Agricultural University, Ranchi, Officials from Departments of Agriculture, Horticulture, Fisheries and Animal Husbandry, Govt. of Jharkhand participated. Deliberations were made on the demand and availability of seed in Jharkhand.

Fig. 21.11. Workshop on status of seed sector in Jharkhand organised at ICAR-RCER Research Centre, Ranchi

Sankalp Se Siddhi Programme

ICAR-Research Complex for Eastern Region, Patna in collaboration with Agricultural Technology Application Research Institute (ATARI), Patna and Krishi Vigyan Kendra, Barh organized one-day programme on "New India Manthan - *Sankalp se Siddhi*" at Bihar Agricultural Management & Extension Training Institute (BAMETI), Patna on 26th August, 2017. Hon'ble Union Minister of Agriculture and Farmers' Welfare, Govt. of India, Sri Radha Mohan Singh graced the occasion as the Chief Guest and administrated oath to all participants for making new India and doubling farmers' income by 2022. Other dignitaries present were; Dr Prem Kumar, Hon'ble Agriculture Minister, Govt. of Bihar, Mr. Sanjeev Chaurasia, Hon'ble MLA, Digha constituency, Bihar, Vice Chancellor, BAU, Sabour, Director, NRC, Litchi, officials from ICAR institutes, State Department of Agriculture, Animal Husbandry, Fisheries, Coconut Board, Central Integrated Pest Management Centre, Patna. Around 800 farmers participated in the programme. Scientist-farmers' interaction was also organized on this occasion.

Fig. 21.12. Hon'ble Union Minister of Agriculture & Farmers' Welfare Sh. Radha Mohan Singh administrating oath to the participants

Hindi Chetna Mas

14 सितम्बर से 13 अक्टूबर 2017 के दौरान "हिंदी चेतना मास–2017 का सफल आयोजन किया गया, हिंदी चेतना मास–2017 के दौरान विभिन्न वर्गों के कर्मचारियों के लिए कुल 17 प्रतियोगिताओ एवं कार्यक्रमों का आयोजन किया गया जिसमे सभी वर्गों के अधिकारियों एवं कर्मचारियों ने उत्साहपूर्वक भाग लिया और आयोजन को सफल बनाया।

25 से 27 सितंबर, 2017 के दौरान "हिंदी में वैज्ञानिक लेखन" के लिए तीन दिवसीय कार्यशाला का सफल आयोजन हुआ। 3 से 5 अक्टूबर, 2017 के दौरान तकनीकी एवं प्रशासनिक वर्ग के लिए तीन दिवसीय हिंदी कार्यशाला का आयोजन भी किया गया।

7 अक्टूबर, 2017 को हिन्दी की छाँव मे कृषक एवं वैज्ञानिक नामक कार्यक्रम का आयोजन अकबरपुर, पटना मे किया गया।

चित्र 21.13. हिन्दी चेतना मास 2017 के अवसर पर मुख्य अतिथि का सम्बोधन

चित्र 21.14. हिन्दी की छाँव मे कृषक एवं वैज्ञानिक – कार्यक्रम का आयोजन अकबरपुर, पटना मे किया गया।

Model Training Course on Market Led Extension

An eight-day Model Training Course (MTC) on "Market Led Agricultural Extension-Concept and Practices" was organized during 4-11 October, 2017 at ICAR Research Complex for Eastern Region, Patna. The training course was sponsored by Directorate of Extension, Ministry of Agriculture and Farmers Welfare, Govt. of India. This MTC was designed for the extension functionaries and officials working for field level for improving their knowledge, skills and understanding of production of quality agricultural produce for effective marketing as well as dissemination of market related information to different stakeholders for better price realization of agricultural produce, and thus increase the income of farmers.

Twenty one officials from different development departments (Agriculture, Horticulture, Animal Husbandry, Fisheries, Bhumi Sudhar Nigam, ATMA, etc) of Bihar, Karnataka, Madhya Pradesh, Odisha and Uttar Pradesh participated in the MTC. Field visits and interactive session with Farmers Producer Company and Milk Cooperative Union (Sudha Dairy) were also organized during the

Fig. 21.15. Participants in the model training course

training programme. Resource persons from different ICAR institutes, SAUs, Kaushalya Foundation and High-tech dairy shared their experiences and gave interactive lecture during the programme.

Rashtriya Mahila Kisan Diwas

Rashtriya Mahila Kisan Diwas was organized on 15th Oct, 2017 at ICAR Research Complex for Eastern Region, Patna. The Chief Guest of the function was Dr. Prem Kumar, State Agriculture Minister, Govt. of Bihar. Other dignitaries present were Shri Sanjeev Chaurasia, MLA, Digha, Shri Nityananda Rai, Member of Parliament, Dr. Rameshwar Singh, Vice Chancellor, BASU, Bihar, Shri N. Vijayalaxmi, Secretary, Animal and Fisheries Resource Dept. and Dr. B.P. Bhatt, Director, ICAR RCER, Patna. The Chief Guest in his address emphasized the role of women in agriculture and their importance. Around 160 women farmers participated in the function from different districts, and six women farmers were felicitated for their contributions in the various fields of agriculture.

Fig. 21.16. Falicitation of women farmers on *Rashtriya Mahila Kisan Diwas* at ICAR-RCER, Patna

Pashu Arogya Mela

Pashu Arogya Mela 2017 was organized by ICAR Research Complex for Eastern Region, Patna in collaboration with Bihar State Milk Co-operative Federation Ltd.(COMFED) at Village- Semuapur, Kesaria, East Champaran during 28 – 29th October, 2017. Honb'le Union Agriculture and Farmers Welfare Minister, Shri Radha Mohan Singh graced the occasion as Chief Guest. Hon'ble Minister emphasized that livestock is the most important income generating enterprise in Indian agricultural economy and plays a multifaceted role in providing livelihood support to even landless farmers. He stressed upon the importance of indigenous breeds of cattle, buffalo and goat, and their superiority over exotic breeds in climate change scenarios. Attention should be given upon selection of local breeds of dairy animals who can adapt in adverse climatic condition, he added. Hon'ble Minister advised the farmers to adopt diversified farming like fisheries, poultry, piggery and goat farming which provide good alternative options in social development. He suggested the farmers that they can take assistance from different centrally sponsored schemes including National Gokul Mission.

Fig. 21.17. Hon'ble Union Minister of Agriculture & Farmers' Welfare Sh. Radha Mohan Singh addressing the farmers on Pashu Arogya Mela at East Champaran

Vigilance Awareness Week

Vigilance Awareness Week was celebrated from 30th Oct 2017 to 4th Nov, 2017 at ICAR RCER, Patna, its centres and KVKs. Integrity pledge was taken in various schools, villages and office of the respective areas. Various events like a lecture on procurement through GeM was also delivered at ICAR RCER Patna and Group discussion, round table discussion on vigilance, easy competition for students were carried out during the week.

Visit of Deputy Director General (NRM)

Dr. K Alagusundaram, Deputy Director General, Natural Resource Management visited ICAR-Research Complex for Eastern Region, Patna on 31st October, 2017. He visited the research farm of the institute and interacted with scientists. Dr B.P. Bhatt made a brief presentation about the activities, research, new initiatives and other activities carried by the institute. DDG emphasized on the huge natural resources present in the eastern region. He advised scientists to work for betterment of the farmers. He quoted examples of agricultural development with scarce natural resources in Israel. The DDG pointed out limited facilities for processing, value addition of agro-produce and marketing in Bihar without which it is not possible to increasing farmers' income. He also advocated for system diversification to achieve the goal of doubling farmers' income.

Fig. 21.18. Hon'ble DDG (NRM) Dr. K. Alagusundaram addressing scientist of ICAR-RCER, Patna

Agriculture Education Day

Agricultural Education Day was celebrated at ICAR Research Complex for Eastern Region, Patna on 3rd December, 2017. 126 students participated in the programme from two different schools of Patna. Field visit was carried out to the experimental farms of the institute, creating awareness regarding the importance of agriculture with a audio-video short films followed by debate competition.

Fig. 21.19. Agricultural Education Day observed at ICAR-RCER, Patna

World Soil Day Programme

World Soil Day programme was organized on 5th December, 2017 at ICAR Research Complex for Eastern Region, Patna. Smt. Asha Sinha, Hon'ble, MLA of Danapur was the Chief Guest of the programme. On this occasion, a Video Film on soil health containing message from Hon'ble Prime Minister of India (*Man ki Baat* on soil health), and from Hon'ble Minister of Agriculture & Farmers' Welfare, Govt. of India, was shown to the participants along with the distribution of Soil Health Cards prepared by the institute and a *kisan gosthi*. Around 60 farmers from Simra, Wadipur and Baghakole villages of Patna district attended the programme.

Fig. 21.20. Health card distribution on World Soil Day programme at ICAR-RCER, Patna

Mushroom Day

Mushroom Day was celebrated on 23rd December, 2017 at ICAR-Research Complex for Eastern Region, Research Centre, Ranchi, Jharkhand. The programme was inaugurated by Dr A. K. Singh, Head, ICAR-RCER RC Ranchi. Four successful Mushroom entrepreneurs of Jharkhand, Mr. Dinesh Prasad, Mycelia Labs, Mrs. Seema Sandesh, Basidia Labs, Ranchi, Mr. Shubham Modi, Ranchi and Mr. Sanjeev Mathur, Jamshedpur shared their experiences to start-up mushroom and its spawn production as an enterprise, quality mushroom spawn in enhancing its productivity, compost preparation and post harvest management of mushroom. On the occasion hands on training on

Fig. 21.21. Mushroom enterpreneurs sharing their experience on mushroom start-up

oyster mushroom was also conducted. Around 70 participants from Ranchi, Bokaro (Jharkhand), Bhagalpur (Bihar) and Dehradoon (Uttarkhand) participated in the programme.

Field Day at Sukhet and Korahia (Madhubani) under SRFSI project

Field day at Sukhet and Korahia was organized by ICAR-RCER, Patna on 2nd November, 2017 and 3rd November, 2017 respectively to see the performance of rice crops under different establishment methods (Zero till direct seeded, unpuddle transplanted and puddle transplanted). Ninety one farmers including field staff of JEEViKA and State Govt. officials participated in the programme.

Research Advisory Committee Meeting

XVth Research Advisory Committee Meeting of the Institute was held during 22th-23th March, 2018 at ICAR RCER, Patna under the Chairmanship of Dr. A. N. Mukhopadhyay, Ex-Vice Chancellor, AAU, Jorhat and members Dr. S. Bhaskar, ADG (Agronomy, Agroforestry & Climate Change), ICAR, (Dr. Ashwani Kumar, Ex-Director of Indian Institute of Water Management, Bhubaneswar, Dr. Gopal Nath Tiwari, Professor, Centre of Energy Studies, I.I.T, New Delhi, Dr. K.P. Sampath, Ex- Director, ICAR-NIANP, Bengaluru and Dr. Shivendra Kumar, Ex-Head, ICAR RCER Research Centre, Ranchi. All the Scientists of ICAR RCER, Patna, Research Centre, Ranchi, Research Centre, Makhana, KVK Buxar and KVK, Ramgarh participated in the meeting and presented the achievements of their respective divisions, centers and projects. The RAC also visited the experimental farms and laboratories of the institute and made valuable suggestions for improvement.

Fig. 21.25. Chairman of RAC interacting with scientists

Fig. 21.22. Field day at Korahia (Madhubani)

Fig. 21.23. Field day at Sukhet (Madhubani)

Field day at Sukhet (Madhubani)

Fig. 21.24. Farmers training programme on plant nutrient management at Sukhet, Madhubani

22. Krishi Vigyan Kendra

KRISHI VIGYAN KENDRA, BUXAR

Cluster Demonstration on Oil Seeds and Pulses under NFSM and NMOOP

Krishi Vigyan Kendra, Buxar organized a Cluster Demonstration on Oilseed and pulses crops during *kharif* and *rabi* season of 2017-18 under National Food Security Mission (NFSM) and National Mission on Oilseed and Oil palm (NMOOP) by Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation, Govt. of India. All demonstrations were laid in cluster approach emphasizing on rice fallow and new released varieties (upto 15 years). Farmers were advised to adopt the good agronomic practices, balanced fertilization and IPM practice to reduce the cost of cultivation to get better economic returns. KVK also demonstrated the cafeteria of each crop at their farm to popularize the varieties and production technologies of pulse and oilseeds among the farmers Buxar. Farmers were also trained for seed production and primary processing activities. The details of crops, varieties, area, beneficiaries and demo sites are given bellow:

Details of cluster front line demonstration

Pulses

Crop	Area	Variety	No of beneficiaries	Technology used	Place (Village)
Kharif					
Pigeon pea	10 ha	Narendra Arhar-2	33	Seed treatment with rhizobium culture + application of micronutrient (Mo and B @ 1ml/lit water) before flowering and management of Legume pod borer (*Maruca testulalis*) by application of emamectin benzoate @ 250 ml/ha	Ahirouli, Sarenja, Balua, Balirampur, Dakaich, Pavni and Milki.
Rabi					
Chickpea	20 ha	BGM-547	69	IPM (FIR+ Neem oil 1%) and foliar spray of (Mo and B) @ 1ml/lit of water before flowering	Hata, Chotki Basouli, Dumraon, Navadera, Vishrampur, Kathrai, Mahdah, Bocsara, Kusrupa, Pandeypatti, Sahiyar, Dafadihri and Lalganj
Lentil	20 ha	HUL-57	61	FIR+ Spray of *Trichoderma harzianum* @ 10 g/ lit water for controlling the wilt	Hata, Hukha, Kukurah, Chotki basouli, Dumraon, Chougai, Bocsa, Kusrupa, Pandey patti, Sahiyar, Barri, Lalganj, Kulariya and Dalsagar
Field pea	20 ha	Vikash	53	Seed treatment with *Rhizobium* culture + foliar Spray of micronutrient (Mo+B) @ 1 ml/lit of water	Hukha, Dhansoi, Jaipur, Sondhila, Bocsa, Mangolpur, Mahuari, Dafadehri, Chakrahasi, Jigna and Bocsara
Summer					
Green gram	10 ha	IPM 2-3	25	Seed treatment with *Rhizobium* culture +foliar Spray of micronutrient (Mo+B) @ 1 ml/lit of water	Chotka rajpur, sikti, mangolpur, turkpurva, Hukha, Kukurah, Bijhora, sughar, Lalganj and Barri

Oilseeds

Mustard	50 ha	Pusa Mustard-28	125	Application of sulphur @20 kg/ha+ management of aphid through spray of imidachloprid 1 ml/3 lit of water	Rahtua, Suroudha, Kukurah, Kusrupa, Bocsara, Gurudas Mathiya, Chotki Basouli, Bharchakiya, Denudhia, Chotka rajpur, Milki, Pavni, Chunni, Uttampur, Lalganj and Pandeypatti
Sunflower	20 ha	KBSH-53	52	Sulphur 20 kg/ha+ 1 kg/ha Micronutrient (B+Mo)	Bharchakiya, Parasia, Pavni, Vishrampur

Seed hub programme

During the year 2016, Ministry of Agriculture and Farmers welfare started programme "Creation of seed hubs for increasing indigenous production of pulses in India" under National Food Security Mission. In this project quality seed of different pulse crops has to be produced by each seed hub for supplying quality seed to the farmers. KVK, Buxar have started the seed production of chickpea under seed hub programme. Under participatory seed production mode chickpea seed production was done at farmers field in *rabi* season covering 19.42 ha area and 24 farmers. It was also taken up in 4.015 ha at KVK, Farm using chickpea variety GNG 1581.

Training Programmes Organized

Following training were conducted for practicing farmers, rural youth and extension functionaries

Off-campus training

Topic	Date	No of beneficiaries
Best Management practices for rice production	18-19/08/17	20
Good agronomic practices for pigeonpea production	22-23/09/17	20
Integrated crop management for sustainable rice production	15-16/09/17	20
Production technology of direct - seeded rice	18-19/09/17	20
Crop production techniques of pearl millet and sorghum	20-21/09/17	20
Integrated crop management for *rabi* pulse production	24-25/01/18	20
Integrated nutrient management in rapeseed and mustard production	2-3/02/18	20
Resource conservation techniques in rice-wheat cropping system	5-6/02/18	20
Integrated crop management for wheat production	12-13/02/18	22
Production technology of berseem and oat	14-15/02/18	20
Organic farming and crop production	23-24/02/18	20
Weed management in *rabi* season crops	26-27/02/18	20
Water management in *rabi* season crops	1-2/03/18	20
Production technology of *rabi* season oilseed	28-29/11/17	20
Production technology of *rabi* season pulses	6-7/11/18	20
Production technology of summer moong	20-21/03/18	20
Micro nutrient management in *rabi* pulses	5-6/12/18	20
Integrated crop management in pigeonpea	6-7/09/17	20
Quality Seed production of paddy	31/8/17 to 1/9/17	21
Weed management in paddy	18-19/09/17	22
Quality seed production technique of okra	22-23/9/17	21
Quality Seed production techniques of pigeonpea	25-26/9/17/	22
Seed production techniques of pearl millet	27-28/9/17	24
Quality seed production of onion	14-15/3/18	20
Seed production techniques of fieldpea	19-20/1/18	20
Quality seed production of chickpea	21-23/2/18	20
Seed production of *rabi* pulses	26-27/2/18	20
Quality seed production of wheat	6-7/3/18	21
Quality seed production of oat	19-20/2/18	24
Crop residue management for sustainable soil health.	18-19/08/17	20
Method of soil and water testing	15-16/09/17	20
Method of bunding and its importance	18-19/09/17	22
Method & importance of deep summer plough	22-23/09/17	23
Rain water harvesting method and their role in life saving irrigation	25-26.09.17	20
Use of bio-fertilizer in cereal and pulses	27-28/09/17	23
INM in paddy	06-07/10/17	23
INM in potato	10-11/10/17	20
Use of bio-fertilizer in *rabi* pulses	27-28/11/17	27
Crop residue management for sustainable soil health.	29-30/11/17	20
Application of sulphur in pulses and oilseed .	19-20/01/18	21
INM in cauliflower	24-25/01/18	23
INM in wheat	02-03/02/18	23

Topic	Date	No of beneficiaries
Method of foliar application of micro- nutrients in fruits plant.	05-06/02/18	20
Nitrogen management in wheat by the leaf colour chart (LCC).	19-20/02/18	20
Water management in *rabi* pulses .	27-28.02.18	20
INM in Onion	6- 7/03/18	22
Foliar application of urea and micro-nutrients in pulses.	19-20/03/18	22

On-campus training

Topic	Date	No of beneficiaries
Seed production techniques of maize	20-21/9/17	25
Seed production of pigeonpea	30-31/10/17	22
Seed production of mustard	9-10/3/18	20

Training for rural youth

Topic	Date	No of beneficiaries
Integrated farming system	20-24/11/2017	20
Crop diversification through high value crops	13-17/03/2018	20
Quality seed production of *Kharif* cereal crops	29/11/17 to 2/12/17	15
Seed production techniques of *Rabi* pulses	24-27/3/18	19
Use and operation of Improved agriculture implements	21-23/12/17	40
Operation and maintenance of ploughing and sowing implements	7-9/02/18	40

Training for extension functionaries

Topic	Date	No of beneficiaries
Method of in-situ crop residue management.	21, 24 and 25 /03/2017	15
Organic farming	8-9/11/2017	20
Resource conservation techniques in rice-wheat cropping system	5-6/03/2018	20
Seed production of paddy	25-26/11/17	20
Seed production of chickpea & lentil	1213/3/18	20

On-farm trials

Topic	Area (ha)	No of beneficiaries	Place
To assess the yield performance of garden pea	0.5	10	Dalsagar
Evaluation of conservation agricultural practices under rice-fallow system of eastern region	1.0	10	Chotki Basouli, Mahdah, Bocsa
Effect of water and boron management on terminal heat of late sown wheat	1.0	10	Rajapur, Mahdah, Geruabandh
Effect of nutrient management practice on yield attributes and yield of lentil	0.75	10	Bharchakia, Jagdishpur, Pawni and Turk Purawa
Effect of nutrient management (through nutrient expert) on yield of wheat.	1.0	05	Kukurha, Mahda
Effect of micro nutrients zinc on rice- wheat cropping system	1.0	10	Kukurha, Surondha
Effect of nutrient management practice on yield attributing character and yield of lentil	1.0	12	Pawani, Kukurha

Front line demonstration

Topic	Area (ha/ unit)	Total beneficiaries	Place
Demonstration of scented rice variety *Rajendra Kasturi*	20.0	55	Pavni, Bocsa, Mahdah, Sondhila, Rajapur, Jagdishpur, Rahtua, Karahasi, Nihalpur
Demonstration of pearl millet (JKBH 676)	10.0	25	Simri, Chotka Rajpur, Pavni, Surodha
Demonstration of zero tillage sowing wheat	10.0	25	Kukurah, Pavni, Sonpa, Kathrai, Basoli, Dhansoi, kanoli, Chousa, Jogiya, Bhatwalia
Demonstration of timely sown high yielding variety HD 2967	10.0	25	Kathrai, Kukurah, Kuchriya, Fatehpur, Atrouna, Jagdishpur, Maniya, Mahdah, Barri
Demonstration of Oyster mushroom	10	10	Kamarpur, Kukurah, Kusrupa, Dullahpur, Kathar khurd

Topic	Area (ha/ unit)	Total benefi-ciaries	Place
Demonstration of plastic based vermin compost unit	10	10	Rajapur, Sondhila, Suroudha
Demonstration of rice straw decom-poser	300 ml	3	Mahdah, Kukurah, Geruabandh
Role of *Rhizobium* culture on yield of lentil	4.15	24	Pawni, Surandha, Majhariya and Mukunddera
Demonstration of pegionpea 'IPA 203'	1.0	04	Balwa, Chhotka Dhakaich
Role of *Rhizo-bium* culture on yield of chickpea. 'JAKI 9218'	3.0	13	Dhansoi, Rampur dera, Mahda, Kathrai

Station trials

Topic	Area (ha)	No of replica-tion	Place
Evaluation of aerobic and drought tolerant rice geno-types	0.1	3	KVK Farm
Participatory varietal selective trial in DSR & transplanted paddy	0.2	3	KVK Farm
Evaluation of promising geno-types of wheat	0.1	3	KVK Farm
Evaluation of conservation agricultural practices for rice-fallow system of eastern region	0.2	3	KVK Farm

Training of trainers (ToTs)

Two training programmes on "Application of farm machinery and production technology of rice" was organized at KVK, Buxar during June 1-2, 2017 and July 1-2, 2017 for 30 employees of JEEVIKA, Buxar (Fig. 22.1A-C) . The Social Development Manager, Livelihood Manager, Training officers, Block Project Manager, Community coordinator and Village Resource Person of JEEVIKA were participated and trained for effective use of farm machinery, production of community rice nursery, direct- seeded rice, weed management in rice and system of rice intensification (SRI).

Fig. 22.1 (A) Training for JEEVIKA (B) on use of sprayers and (C) on seed treatment at KVK Buxer

Community Rice Nursery

Rice transplanting in Buxar district is normally done in the month of August, which is late for optimal crop production and results in low paddy yields. KVK along with CSISA developed a schedule for the timely production of healthy rice seedlings. Awareness among the farmers was created by KVK, Buxar by growing the rice nursery in two acres of land and supplying 21 to 25 days old rice seedlings to 60 farmers for transplanting in 64 acres of land (Fig. 22.2). The total cost of production for one acre was Rs 14227 with a net returns of Rs 11373 in one month. This prompted timely transplanting of paddy with yields, and also facilitated timely sowing of wheat.

Fig. 22.2. Field view of young seedling transplanted field (above) and Training on community rice nursery production (below)

Technology week

Technology week was organized in KVK, Buxar from 01-06th August, 2017. The main aim was to delivers the latest agricultural technologies to the farming communities. Agriculture and allied activities, i.e., crop production, horticulture, nutrient management, livestock and fisheries, farm mechanization and women empowerment were covered in the technology week (Fig. 22.3). A total of 360 farmers were trained in this programme.

Fig. 22.3. Lecture delivered by Dr R K Malik, CSISA-CIMMYT during Technology week

New India Manthan: *Sankalp se Sidhi*

KVK Buxar organized the "*Sankalp se Siddhi*"-New India Movement (2017-22) on 30th August 2017 with a pleadge of building a new India by doubling farmers income by year 2022 based on seven point strategies. Hon'ble M.P. Buxar Sh. Ashwini Kumar Chaubey graced the occasion as Chief Guest. Sh. Sanjay Kumar Tiwari, MLA Buxar Sadar and Dr. Anjani Kumar, Director ATARI, Patna were also present as Special Guests (Fig. 22.4). The Chief guest stressed up on the challenges of farming and encouraged the farmers and young participants to become successful agripreneurs. A total of 778 participants attended the programme.

Fig. 22.4. KVK Buxar organized the "*Sankalp se Siddhi*"-New India Movement

Scientific Advisory Committee Meeting

The 8th Scientific Advisory Committee (SAC) Meeting of KVK Buxar was held on 12th October, 2017 at Training Hall of KVK, Buxar under the Chairmanship of the Director, ATARI, Patna Dr Anjani Kumar Singh. The meeting was also attended by Dr Ujjwal Kumar, Head DSEE, ICAR RCER, Patna. Sri Ranbeer Singh, District Agricul-

ture Officer (Buxar), Sh. Devnandan Ram, Project Director (ATMA, Buxar), Dr. Trivedi Prakash Narayan, Mobile Van Veterinary Officer (Buxar), Ms Gudiya Kumari, DDM, NABARD, PC and SMS/ Staffs of KVK Buxar, Progressive famrers/member of this meeting and Officials from State Agriculture Department/other department (Fig. 22.5).

Fig. 22.5. 8th Scientific Advisory Committee (SAC) Meeting of KVK Buxar

Vigilance Awareness Week

Vigilance Awareness Week was celebrated from 30th Oct 2017 to 4th Nov, 2017 (Fig. 22.5). Awareness was created among school children in Foundation school Buxar and DAV Public School Buxar on 3rd Nov 2017.

Fig. 22.4. Vigilance Awarness Week celebrated.

Mahila Kisan Diwas

Kisan Mahila Diwas was organized by KVK, Buxar on 15th October 2017. Member Zila Parisad Smt. Basanti Devi was the Chief guest (Fig. 22.6). SAC members Smt Juhi Pandey and Smt. Meera Devi were also present on the occasion. The Chief guest urged farm women to come forward for their upliftment, and shared new agricultural technology for doubling the farmers income. A total of 70 farm women participated in the programme.

Fig. 22.6. *Kisan Mahila Diwas* was organized by KVK, Buxar

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

KVK Buxar celebrated World Soil Health Day-cum-Kisan Gosthi on 5th Dec, 2017 in its campus. Sh. Sanjay Kumar Tiwari, MLA Buxar Sadar was the Chief Guest (Fig. 22.7). He stressed up on the need to take the advantage of the Govt. schemes

Fig. 22.7. Glimpses of World Soil Health Day

and take all the possible measures for improving soil health. He narrated the advantages of soil health card and he distributed 200 soil health cards to the farmers. A total of 525 farmers attended the programme.

Zonal Monitoring Committee Review Meeting of NICRA Project

Zonal Monitoring Committee (ZMC) review meeting of NICRA project was held on 13th December, 2017. Dr A. K. Mehta, Ex ADG (Extension) ICAR, New Delhi was the Chairman of the meeting. Dr. Anjani Kumar Singh, Director ATARI, Patna, Dr D.V.B Ramana, Pr. Scientist, and Dr S. K. Bal, Pr. Scientist from CRIDA and Dr N. Bhakta, Pr. Scientist, ICAR RCER, Patna were also present. ZMC visit the NICRA project adopted village "Kukurah" and appreciated the on-going climate resilient activities of the project.

Fig. 22.8. A view of Zonal Monitoring Committee review meeting (above) and the Members of the commeettee visited the NICRA project adopted village

Mukhyamantri Bagwani Mission

Two training programmes under Mukhyamantri Bagvani Mission, Bihar were organized in KVK, Buxar on 15/12/2017 and 20/12/2017 (Fig. 22.9). Total 50 farmers participated and trained for mushroom production and bee keeping and

Fig. 22.9. A view of training programme under Mukhyamantri Bagvani Mission

different production technology of horticultural crops.

Training on Improved Agricultural Implements

Three days training programme on 'Use and Operation of Improved Agriculture implements' was organized from 21st to 23rd Dec, 2017 at KVK Buxar. The programme was inaugurated by SDM Buxar Sh. Gautam Kumar and SDPO Buxar Sh. Shaishav Yadav (Fig. 22.10). Kisan Diwas and National Mushroom day were also celebrated on 23rd Dec, 2017.

Fig. 22.10. A view of training programme on use and operation of improved agricultural implements

Live Telecast of Prime Minister's Address

On the occasion of biennial conference of KVKs and *Krishi Unnati Mela* at IARI, Pusa New Delhi Hon'ble Prime Minister, Sri Narendra Modi **Jee** addressed the farmers and scientist on 17th March 2018. The live telecast of the programme and *Krishak Vaigyanik Vartalap* was arranged by KVK, Buxar at Nagar Bhawan Sabhagar, Buxar. The total number of 1086 farmers participated in the programme covering each Block and Panchayat of the District (Fig. 22.11) . District Development Commissioner, Buxar Sri Arvind Kumar was chief guest of the programme. Other officers of Line Department like District Agriculture Officer, District Animal Husbandry Officer, District Fisheries Officer, and Project Director ATMA were present in the programme. The Extension officials like Agriculture Coordinators, Kisan Salahkar, Block Technology Manager, Assistant Technology Officer, NGO workers and Farmers Producer Groups were also present in the programme. In *Krishak Vaigyanik Vartalap* major focus was given on farm mechanization, crop residue management, organic farming, protective cultivation, micro irrigation and vegetable cultivation.

Fig. 22.11. Viewing of the live telecast of the Krishak Vaigyanik Vartalap was arranged by KVK, Buxar

Technology Demonstration Fair

Technology demonstration fair was organized by KVK, Buxar under the project CRP on FM& PF on 16th February, 2018. The programme was inaugurated by District Magistrate Buxar Shri. Arvind Kumar Verma. Total numbers of 224 farmers were participated in the programme (Fig. 22.12). Major focus was showcasing the modern hi-tech agricultural machinery viz. happy seeder, zero tillage, multicrop thresher, tractor mounted power sprayer, seed drill, raised bed planter, MB plough, disc plough, seed drill, rotavator etc.

Fig. 22.12. Showcasing of farm implements and DM, Buxar Mr A K Verma interacting with KVK experts

Operation and Maintenance of Ploughing and Sowing Implements

Three days training programme on Operation and maintenance of ploughing and sowing implements was organized from 7th to 9th February, 2018 (Fig. 22.14). The programme was inaugurated by SDM Buxar Sh. Gautam Kumar and SDPO Buxar, Sh. Shaishav Yadav. Total number of 40 young rural youth participated in the programme.

Fig. 22.13. A view of training programme on operation and maintenance of ploughing and sowing implements

Celebration of International Women's Day

International Women's Day was celebrated by KVK, Buxar on 8th March 2018. SAC, member Smt Juhi Pandey was chief guest of the programme (Fig. 22.14) . She encouraged women for strengthening the society. A total of 41 women participated in the programme.

Fig. 22.14. International Women's Day was celebrated by KVK, Buxar

Training on Seed Production and Certification

One day training programme was organized on 18th March, 2018 in collaboration with Bihar State Seed and Organic Certification Agency, Patna. Shri Kamlesh Kumar Sub Divisional Agriculture Officer was chief guest of the programme (Fig. 22.15). Main focus of the programme was to create awareness among farmers about seed production and certification. Farmers were also trained for organic farming and certification of organic produce to get better market for organic produce. Total numbers of 72 farmers were present in the programme.

Fig. 22.15. One day training programme on Seed Production and Certification

Visit of Seed Certification Team

Mr. Bankatesh Narayan Singh, Director, Bihar State Seed and Organic Certification Agency, Patna, seed inspector and organic certification inspector visited the seed production plot of the KVK, Buxar on 19th March 2018 (Fig. 22.16).

Fig. 22.16. Certification team visited to the seed production plot of the Kendra

Monitoring of CFLD and Seed Hub Programme

Dr Virendra Kumar, Director, Directorate of Rice Development, Ministery of Agriculture &

Farmers Welfare, GOI visited the CFLD and Seed Hub plots at Basouli, Bocsa and Ahirouli village of Buxar district on 7th December 2017 (Fig. 22.17). He expressed satisfaction over the effort made by KVK, Buxar.

Fig. 22.17. Dr Virendra Kumar, Director, Directorate of Rice Development has visited to the CFLD and Seed Hub plots

Training on Mushroom Production

One day training programme on mushroom production was jointly organized by Dr. RPCAU, Pusa, Samastipur and KVK, Buxar at adopted village Rahtua in Brahmpur Block of Buxar district. Dr. P. S. Pandey, ADG (Education) ICAR, New Delhi was the Chief guest of the occasion. Total number of 210 farmers participated in the programme.

Fig. 22.18. Dr. P. S. Pandey, ADG (Education) ICAR addressing the participants

Seed Production

Quality seed (Foundation/certified and TL) of different varieties of paddy (8.8 tones), wheat (4.5 t), pigeonpea (0.25 t), chickpea (4.0 t) and field pea (0.5 t) was produced at KVK Buxar (Table).

Crop/Variety	Quantity (kg)	Type of seed
Paddy		
Rajendra Kasturi	1200	CS
Rajendra Sweta	3500	FS
MTU 7029	2500	TL
BPT 5204	1400	CS
Swarna Shreya	200	TL
Pigeon pea		
Narendra Arhar 2	150	TL
IPA 203	100	TL
Wheat		
HD 2967	4000	CS
HD 3118	500	TL
Chickpea		
GNG 1581	4000	FS
Field pea		
Vikash	500	TL

CS: Certified seed, FS: Foundation seed, TL: Truthful seed

Custom Hiring Centre

One custom hiring centre (CHC) was established at KVK Buxar under CRP on FM & Consortia Project. In CHC, one tractor, multicrop thresher, seed drill, rotavator, cultivator disc plough, cage wheel, post hole digger, water lifting pump are available. These implements are provided to the farmers with nominal charges for promotion of farm mechanization and popularized the newly introduced efficient farm implements.

Fig. 22.19. Shri A. K. Verma DM, Buxar visiting CHS

Summary of NICRA, Technology Demonstration Component, and Interventions Conducted at Adopted Village: Kukurha, Buxar

	Intervention/ Technology	Crop/ Variety	No of farmers covered	No/ area (ha)
NRM	Deep summer ploughing cum wheat residue management	MB Plough	09	11
	Raising bund height around the rice field	MTU 7029	33	10
	Direct seeded rice	BPT 5204	07	6.40
	Construction of earthen check dam for controlling runoff water and its used for rice cultivation	Check dam/ Sahbhagidhan	35	10
	Paddy crop residue management through happy seeder for wheat sowing	HD 2967	07	2.0
	Sowing of chickpea by ZT	BGM547	24	6.25
	Renovation and de-silting of rain water harvesting structure	-	13	04
	Renovation and de-silting of drainage cum irrigation channel (total length 1100 mt.)	-	41	01/ 29
	Renovation and de-silting of drainage cum irrigation channel (total length 1400 mt.)	-	35	01/ 22
	Bunding (1000 x 1.1 x 0.90 mt)		16	9.25
	Demonstration of vermin compost unit	HD Poly bag	08	1.25
Crop production	Soil test based nutrient application paddy.	BPT5204	45	12
		HD-2967	42	8.0
	Demonstration drought tolerant varieties	Sahbhagi Dhan	11	03
		Swarn Shreya	06	1.5
	Demonstration flood tolerant variety	Swarna sub 1	04	01
	Intercropping (mango Var. Dusheri with chickpea)	Chickpea Var. BGM 547	01	03
	Demonstration of short duration of mustard	Var, Pusa 28	18	4.0
	Sowing of lentil through ZT by using residual moisture of paddy field.	Var HUL57	15	7.5
	Demonstration of lathyrus in rainfed area .	Var. Ratna	04	1.6
	Demonstration of field pea	Var. Prakash	15	2.25
	Demonstration of spring-summer moong bean followed by potato	Var. IPM 2-3	08	2.5
	Demonstration of late sown wheat	Var 3118	04	1.0
Livestock and fisheries	Quality fodder production	MP chari	22	4.50
	Hay making	Sorghum	18	3.5
	Rural backyard poultry	Kuroiler Birds Vanraja	44	1250 (Chicks)
	Animal health camp	Medicines	26	86 Animals treated
	De-worming	Medicines	60	115 Animals treated
	Survey of dairy farmers to collect data of management of feed, fodder, milking status, shade and health status of dairy animal.	-	20	105
	Fish farming in water harvesting structure cum secondary reservoir	Poly-culture Rohu, Katla and Mrigal	04	27x 27 x1.75 m
				35 x 22 x 1.75 m
				27 x 27 x 1.75 m
Institutional interventions	Seed Bank	Rice-Drought tolerant Var. Swarna Shreya , & Sahbhagi Dhan	1.6 ton	04 Unit
		Rice Flood tolerant Swarna Sub 1	1.10	02

		Wheat Var.HD 3118	04 ton	03
		Chick pea Var. Pusa 372	05 ton	04
	Custom hiring of farm implement.	MB Plough, Rotavator, Happy seeder, ZT Power weeder, Power sprayer & Leveller	29	16

KRISHI VIGYAN KENDRA, RAMGARH

Training Programme for Practising Farmers (on campus) Duration: 2 days

S. No.	Topics	Total beneficiaries
1	Use of weedicide for weed management in *kharif* season crops	25
2	Importance of trap crop as intercropping in pest management	25
3	Community approach for seedling raising of vegetable and cereals	25
4	Importance of macronutrients in vegetables cultivation	25
5	Oyster mushroom cultivation and its marketing strategy by SHG	50
6	Storage pest management in cereals & pulses crop	25
7	Green fodder cultivation and Animal nutrition	25
8	Awareness of mushroom cultivation with lac cultivation for doubling farmers' income	50
9	Contingent planning for *kharif* season crops	25
10	Awareness about seed replacement	25
11	Role of information and communication technology in agriculture	25
12	Importance of group farming for rainfed area	25
13	Awareness about the cashless economy	25
14	Seed treatment of pulse crop	25
15	Soil fertility management through composting	25
16	Enhancing income through integrated farming by SHG	25
17	Improved technologies for cultivation of rose	25
18	Techniques for planning, layout and establishment of fruit orchard	25
19	Improved technologies for cultivation of pointed gourd	25
20	Improved techniques for kitchen garden development	25
21	Improved technologies for cultivation of watermelon	25
22	Improved technologies for cultivation of muskmelon	25
23	Improved technologies of orchard establishment with silviculture	25
24	Improved technologies of multitier fruit orchard establishment	25
Total		650

Training Programme for Practising Farmers (Off-campus) Duration: 2 days

S. No.	Topics	Total beneficiaries
1	Summer vegetables' cultivation in rice fellow area	25
2	How to grow mushroom cultivation in winter season by Woman SHG	25
3	Papaya cultivation in naxal area village	25
4	Disease and pest management in oyster mushroom cultivation	25
5	Weeds management in paddy	25
6	Disease and pest management of *kharif* season crops	50
7	Use of bio fertilizer for seed treatment in *kharif* pulses and cereals	25
8	Identification of disease and pest of rainy season vegetables cultivation	25

S. No.	Topics	Total beneficiaries
9	Community approach for seedling raising of vegetable and cereals	25
10	Awareness of lac cultivation on ber, palas and kusum trees by SHG.	50
11	Management of stored pest in cereals and pulses of grain and seeds	50
12	Importance of group farming for rainfed areas	25
13	Enhancing income through I.F.S.	25
14	Introduction of agriculture	25
15	Awareness for rural youth towards agriculture	25
16	Awareness about production technology of oilseed and pulse crop	50
17	Awareness about credit linkage for higher production	25
18	Employment generation through goatry management	25
19	Importance on backyard poultry and agroforestry	25
20	Capacity building on SHG on community nursery	25
21	Strategy and planning for contingent crop	25
22	Importance of SHG for livelihood security	25
23	Use of agro-forest in rain fed area	25
24	Improved technologies for cultivation of cowpea	25
25	Techniques for propagation of mango plant	25
26	Improved technologies for cultivation of sweet potato	25
27	Improved technologies for cultivation of ginger	25
28	Improved technologies for cultivation of broccoli	25
29	Improved technologies for cultivation of cucumber	25
30	Improved technologies for cultivation of off season vegetables	25
31	Improved techniques for soil and water conservation through mulching	25
32	Improved techniques for vegetable cultivation on rice fallow land	25
33	Techniques of intercropping in fruit crops	25
Total		925

Training Programme for Rural Youth and Practicing Farmer as Skill Development

S. No.	Topics	Duration (Days)	Venue	Total beneficiaries
1	Oyster mushroom cultivation and post harvest management	5	On campus	25
2	Oyster mushroom cultivation and post harvest management	5	On campus	25
3	Integrated farming of oyster mushroom cultivation and lac cultivation for income doubling of farmers	5	On campus	25
4	Soil fertility management in situ crop residue management through green manuring	5	On campus	50
5	Production technology of vermi-compost and vermi-wash	5	On campus	25
6	Improved techniques for nursery raising of vegetables in pro-tray	5	On campus	25
7	Improved technologies of fruit nursery establishment	5	Off campus	25

Extension Activities

Nature of Extension Activity	No. of activities	Total no. of participants
Field Day	6	423
Kisan Mela cum Exhibition	3	1154
Kisan Ghosthi	6	236
Farmers Seminar	3	166
Workshop	1	165
Lectures delivered	26	1167
Advisory Services	386	744
Scientific visit to farmers field	96	906
Farmers visit to KVK	567	784
Diagnostic visits	58	457
Exposure visits	1	45
Soil health Camp	1	252
Animal Health Camp	6	205
Self Help Group Conveners meetings	10	184

On farm trials (OFT)

Thematic area	Title	Treatments	No. of farmers
IPM	Evaluation of different IPM component against pest complex in pigeon pea	Farmers practices.(two spray of Cypermethrin 18% SC @ 0.400 ml/ha) TO1: 1st spray of NSKE @2.5 ltr before flowering, IInd spray of profenophos @650 ml/ha after flowering TO2: 1st spray of NSKE @2.5 ltr before flowering, IInd spray of profenophos @650 ml/ha after flowering with intercropping of maize(6:1)	10
Agricultural Extension	To study suitable short duration hybrid paddy variety for medium land (Don III) or bunded upland for better yield and productivity	Farmers option (IET 6444) T_1: Hybrid paddy cv. PAC 801 T_2: Hybrid paddy PAC "TEJ"	10
	Integrated Nutrient management in Cabbage	T_1: FYM@2t/ha + $N_{80}P_{40}K_0$) T_2 : $N_{100}P_{40}K_{20}$)+ vermi-compost (1 t/ha) T_3: RDF($N_{120}P_{60}K_{60}$) +vermi-compost(1 t/ha)	10
Horticulture	Performance and evaluation of bacterial wilt resistant varieties of brinjal	TO1: Farmers practice TO2:SwarnaShyamali TO3: SwarnaPratibha TO4: SwarnaShakti	10
	Assessment of plastic mulching technology for reducing weeds and increase water use efficiency in chilli	TO1: Farmer practice- Seedling raised in nursery & transplanted without the use of mulch at 30 x 30 cm distance (Plant to plant and row to row) TO2: Seedling raised in protray and transplanted with use of poly mulch at 45 x 60 cm distance (Plant to plant and row to row) TO3: Seedling raised in protray and transplanted with use of bio mulch at 30 x 45 cm distance (Plant to plant and row to row)	10

Frontline Demonstration (FLD)

S. No.	Topic / crop	Technology	Area / unit	No. of farmers	Results
1	FLD on Pheromone trap for cabbage diamond backmoth	Management of Diamond Back Moth in Cauliflower / Cabbage by installation of DBM lure @15/ha at 25 days crop	5.0ha	35	18% reduction in infestation and 20% increase in profit over that of traditional management of DBM
2	Oyster mushroom cultivation	Oyster mushroom cultivation on paddy straw	50 bag of each unit (total 15 unit)	10	Production: 85 kg /unit Profit : 6500/- unit
3	Use of Pheromone lure for fruit fly management in summer season cucurbits	Installation of Cue lure @ 20/ ha at the 25 days old crop	5.0 ha	30	Reduction of 65% fruit damage
4	Tomato	Introduction of Swarn Sampada	0.5 ha	10	Yield (q/ha):380.00; B:C Ratio: 1:2.77
5	Sponge gourd	Introduction of Swarn Prabha	0.5 ha	10	Yield (q/ha):90.00; B:C Ratio: 1:1.31
6	Ridge gourd	Introduction of Swarn Sawani	0.5 ha	10	Yield (q/ha):80.00; B:C Ratio: 1:1.17
7	Dolichos bean	Introduction of HADB-119	0.5 ha	10	Yield (q/ha):1:145.00; B:C Ratio: 1:2.76
8	Vegetable pea	Introduction of Azad pea-3	0.5 ha	10	Yield (q/ha):81.50; B:C Ratio: 1:1.6
9	Cowpea	Introduction of Swarn Mukut	0.5 ha	10	Yield (q/ha):50.00; B:C Ratio: 1:1.2
10	Potato	Introduction of Kufri kanchan	0.5 ha	10	Yield (q/ha):130.50; B:C Ratio: 1:1.33

CFLD during *Kharif* 2017-18

Crop	Area	Variety	No. of Demonstration	No. of cluster	No. of villages
Pigeonpea	30.0	NDA-2	105	10	8
Horsegram	20.0	Birsa Kulthi -1	50	5	6
Technology intervention : Seed treatment (Carbendazim+ Chloropyriphos + Rhizobium culture); Line sowing; Installation of pheromone trap for monitoring of pod borer and management; and Need based spray					

CFLD in *Rabi* 2017-18

Crop	Area	Variety	No. of Demonstration	No. of cluster	No. of villages
Chick pea	10.0	Pusa -547	28	5	5
Lentil	10.0	HUL-57	35	4	4
Mustard	30.0	Pusa-30 RC 45-05-02	86	10	8
Technology intervention for pulses : Seed treatment; Line sowing; Foliar spray of soluble fertilizer and micro nutrient; Installation of pheromone trap for monitoring of pod borer and management; and Need based spray					
Technology intervention for oil seed : Seed treatment; Line sowing; Foliar spray of soluble fertilizer during vegetative growth; Need based spray for pest and disease management					

Seed Production through Farmers Participatory Approach

No of seed villages : 10					
Area (ha)		No. of farmers	Expected seed production (q)		Seed procured (q)
92.36 Paddy	7.6 Pigeonpea	292	Paddy: 2309	Pigeonpea: 64	423

Delivered Training Lectures as Resource person: (19 Nos)

Sl No.	Lecture topic	Venue	Organizer
1	Oyster Mushroom cultivation	ICAR-RCER, RC Ranchi	ICAR-RCER, RC Ranchi
2	Disease management and beneficial insect in vegetable	ATMA, Ramgarh	P.D. ATMA
3	Pulse crop pest and disease management	ATMA, Ramgarh	P.D. ATMA, Ramgarh
4	Weed management in kharif season crops	ATMA, Ramgarh	P.D. ATMA, Ramgarh
5	Symptoms of nutrient deficiency in crop and vegetables	ATMA, Ramgarh	P.D. ATMA, Ramgarh
6	Diagnosis of disease in vegetables	ATMA, Ramgarh	P.D. ATMA, Ramgarh
7	IPM in Vegetables cultivation	ATMA, Ramgarh	P.D. ATMA, Ramgarh
8	Use of fungicide and Insecticide in crop production	DVC, Hazaribag	Director, DVC (Soil Conservation), Hazaribag
9	Use of N.P.K. and bio-fertilizer in vegetables crops	Bhalu Village	NRLM
10	Nutrients management in rabi crops.	Burakhap	SRIJAN foundation Ramgarh
11	Strengthening of SHG	Gargali	ATMA Ramgarh
12	Formation of Self Help Group and Kharif planning for seed village	Jameera	NRLM
13	Production and nutrients Management of onion crop.	Burakhap	SRIJAN Foundation
14	Production of wheat crop	Bumari at Gola	NRLM, Ramgarh
15	Forecasting of weather of Jharkhand	ATMA Ramgarh	ATMA, Ramgarh
16	Nutrient management in pulses	Marangmarcha, Chitarpur	ATMA, Ramgarh
17	Cultivation of summer vegetables	Hahua	ATMA Ramgarh
18	Grading's of vegetables	Fanikpur	ATMA Ramgarh
19	Good agricultural practices for vegetable farming	Jobla	ATMA Ramgarh

Details of Event/Activities organized by KVK

S.N.	Date	Venue	Activity	Guest/VIP	Farmers
1.	22/07/17	KVK	Foundation stone laying of farmers hostel	D.G. ICAR and Secratory DARE New Delhi	600
2.	30/08/17	KVK	Sankalp SE Siddhi	D.C. Ramgarh	600
3.	14/09/17	KVK	National Farmers Day		
4.	27/11/17	KVK	Scientific Advisory Meeting	Director, ICARRCER, Director, IINRG, Director IIAB etc	50
5.	23/01/18	Jobla	Farmers Scientist Interaction	Dr Pankaj Kumar Patna	250
6.	23/01/18	Jobla	Animal Health Camp and Vaccination camp	Dr Pankaj Kumar Patna	250
7.	24/01/18	Digwar	Farmers Scientist Interaction	Dr Pankaj Kumar Patna	250
8.	24/01/18	Digwar	Animal Health Camp and Vaccination camp	Dr Pankaj Kumar Patna	250
9.	26/01/18	KVK	Flag hosting	Dr D.K. Raghav	250
10.	03/02/18	KVK	One day workshop on IFS for existing agriculture in Ramgarh	PD ATMA	60
11.	12/02/18	Gola	One day workshop on IFS for existing agriculture in Ramgarh	Program Incharge PRADAN Ramgarh	150
12	14/02/18	Pundi	Animal Health Camp and Vaccination camp	Dr Ray , Patna	150
13.	15/02/18	K.K. Basodi	Animal Health Camp and Vaccination camp	Dr Ray , Patna	150
14.	05/12/17	KVK	World Soil Day	BDO Mandu	800
15.	17/03/18	KVK	Live telecast of Honble PM's address during *Krishi Unnati Mela* at IARI New Delhi	BDO, Mandu	500

23. Awards and Recognitions

A.K. Singh **Dr. Biswajeet Choudhary Memorial Award** for Outstanding Vegetable Scientist 2017 conferred by Indian Society of Vegetable Sciences, Varanasi

B. Das **Certificate of Appreciation** at ICAR-NRC for Litchi, Muzaffarpur, Bihar on the Occasion of 17th Foundation Day of the institute held on 6th June, 2017.

B. Das **Distinguish Scientist Award** in International Conference on Food and Agriculture during March 29th -31st 2018 at Dhanbad.

B.P. Bhatt **Dr. Rajendra Prasad Puraskar-2016** for Technical Book Writing in Agricultural & Allied Sciences, conferred by ICAR New Delhi, 2016.

Dr. B.P. Bhatt receiving 'Dr. Rajendra Prasad Puraskar' from the Hon'ble Minister of Agriculture and Farmers' Welfare, Govt. of India

B.P. Bhatt **Lifetime Achievement Award** for recognition of research quality, novelty and significance, conferred by Endling Conferences, Pune, Maharashtra in the International Conference on Food & Agriculture (ICFA- 2018) held at Dhanbad, Jharkhand during 29th-31st March, 2018.

B.P. Bhatt **Outstanding Achievement Award** for Excellence in Research, conferred by Society for Agriculture Innovation & Development (SAID), Ranchi on the occasion of National Conference on Livelihood and Food Security (LFS-2018) held at Patna on 27th January, 2018.

Manibhushan **Senior Scientist Award** conferred by MSET-ICCB (International Consortium of Contemporary Biologist) in International Conference on "Global Scenario of Life Science, Agriculture, Nursing and Medical Research for the welfare of Rural and Urban Folk (GOSLANRUF)" during 03-05, December, 2017 at METAS Adventist College, Ranchi.

Mishra, J.S. **Distinguish Scientist Award** conferred by the Endling Conferences, Pune in the 2nd International Conference on Food & Agriculture (ICFA) 2018 held at Dhanbad during 29-31 March, 2018.

P. Bhavana **Indo Global Excellence Award** in the field of Genetics & Plant Breeding by Indo Global Chamber of Commerce Industries and Agriculture in International Conference on Advances in Environmental and Agricultural Technology 2018 during 22nd—24th February, 2018 at St Xaviers' college, Ranchi.

P.K. Sarkar **Young Scientist Award** during 2nd International Conference on Food & Agriculture 2018 (ICFA-2018) during 29th-31st, March, 2018 at Dhanbad, Jharkhand.

Pankaj Kumar **Young Scientist Award**, during 5th Academic Achievement Award, EETS, Noida

Rajni Kumari **Best Oral Presentation Award** for "Determination of sperm sex ratio in buffalo bull semen using Sybr Green based Real time PCR assay " in the International Conference on 'Recent trends in Bioinformatics and Biotechnology for Sustainable Development' organized at SKUAST, Jammu during 12th-13th October, 2017.

S.K. Dwivedi **Distinguish Scientist Award** conferred by the Endling Conferences, Pune in the 2nd International Conference on Food & Agriculture (ICFA) 2018 held at Dhanbad during 29th-31st March, 2018.

S.S. Mali **Best Oral Presentation Award** in 'International conference on water and waste water management and modelling (ICWWMM)', 16th-17th January, 2018 at Central University of Jharkhand.

S.S. Mali **Best Paper Award** for the research paper entitled 'Yield, water productivity and economics of vegetable production under drip and furrow irrigation in eastern plateau and hill regions'. Published in *International Journal of Agricultural Sciences and research*, Tran stellar Journal Publications.

S.S. Mali **Young Scientist Award** by 'Green Reap Welfare Society' for outstanding contribution in the field of Soil and water conservation engineering on the occasion of National Conference on 'Technological challenges in social, environmental and Agricultural reforms' during 9th – 10th September, 2017 at ICAR-IIRR, Hyderabad.

Santosh Kumar **Bioved Young Scientist Associate Award-2018** conferred by Bioved Research Society & Bioved Research Institute of Agriculture Technology and Sciences (BRIATS), Allahabad (U.P) in "20th Indian Agricultural Scientists and Farmers Congress (IASFC 2018) during 17th-18th February, 2018 at Allahabad.

Surbhi Kumari, Sahana Basu, S.K. Dwivedi, Santosh Kumar and Gautam Kumar **Outstanding Poster Award** entitled "*Responses of high yielding rice genotype to multiple environmental drivers under climate change*" in International Conference on Novel Applications of Biotechnology in Agricultural Sectors: Towards Achieving Sustainable Development Goal- 2018 (INABASDG-2018)" during 20th-21st March, 2018.

T.K. Koley **Young Scientist Award** conferred by the Endling Conferences, Pune in the 2nd International Conference on Food & Agriculture (ICFA) 2018 held at Dhanbad during 29th-31st March, 2018.

Mohammad Monobrullah, **Distinguished Scientist Award** for contribution in the field of Entomology by the Society for Agriculture Innovation & Development (SAID), Ranchi for the Year 2018 during National Conference on Livelihood and Food Security held during 27th-28th January, 2018 at Bihar Veterinary College, Patna.

24. Seminars and Symposia

Participation in Conferences/Seminars/ Workshops/ Symposia/ Meetings

Bhavana, P. International conference on advances in environmental and agricultural technology 2018, held at St Xaviers' college, Ranchi during 22nd to 24th February, 2018.

Bhavana, P. Seminar on 'Biodiversity and sustainable tourism on International day for biodiversity organized by Jharkhand Biodiversity Board, Ranchi on 22nd May, 2017

Chaudhary, A.K. Annual review meeting of "creation of seed hubs for increasing indigenous production of pulses in India" at ICAR-IIPR, Kanpur on 7th November, 2017.

Chaudhary, A.K. International conference on "Sustainability of smallholder agriculture in developing countries under changing climatic scenario" at CSAUAT, Kanpur during 14th-17th February, 2018.

Chaudhary, A.K. Workshop of working group for finalizing "Seed policy draft and farm mechanization policy draft" at BAMETI, Patna on 6th February, 2018.

Choudhary, J.S. and Pan, R.S. Review meeting of horticultural institutes by expert committee at ICAR-IIHR, Bengaluru organized by ICAR-CRIDA, Hyderabad under NICRA project on 24th March, 2018.

Choudhary, J.S.; Bhavana, P.; Mali, S.S.; Chakrabarty, A.; Das, B.; Singh, A.K.; Maurya, S.; Sarkar, P.K. and Jha, B.K. 2nd meeting of technical advisory committee (TAC) for S & T communication programme "Mission Eco-Next" & regional consultation youth meet & Eco Next lab on youth for scientific temper & eco solutions" organized by DST, Govt. of India at ICAR RCER, Research Centre, Ranchi during 17th-19th June, 2017.

Das, B. and Dhakar, M.K. 5th Group discussion of ICAR-AICRP fruits, held at ICAR NRC for Banana, Trichy, Tamil Nadu from 15th - 18th February, 2018.

Das, B. Meeting on finalization of technical program under NICRA (Horticulture Institutes) for next three years, held at ICAR-IIVR, Varanasi on 17th June, 2017.

Das, B. Pre-QRT meeting and follow up action on the future needs meet of ICAR-AICRP on fruits, held at ICAR-IIHR, Bengaluru, 30th to 31st August, 2017.

Das, B. National conference on Perspective of challenges and options in litchi production and utilization, held at ICAR-NRC for Litchi, Muzaffarpur during 6th-7th June, 2017.

Dayal, S. Workshop on "Pro-poor livestock policy formulation" organized by GLAVmed, South Asia and Bihar Government at Hotel Gargee Grand, Patna during 13th-14th June, 2017.

Dwivedi, S.K. 56th All India wheat and Barley Research Workers Meet" during 25th-28th August, 2017 at BHU, Varanasi.

Dwivedi, S.K. International conference on novel applications of biotechnology in agricultural sectors: towards achieving sustainable development goal-2018 (INABASDG-2018)" during 20th-21st March 2018 at BHU, Varanasi.

Koley, T.K. 2nd International conference on food and agriculture-2018, at Dhanbad, Jharkhand from 29th-31st March, 2018.

Kumar, Ajay 9th meeting of the core group on benchmarking of irrigation systems in India at CWC, Sewa Bhawan, R. K. Puram, New Delhi on 12th December, 2017.

Kumar, Ajay and Sarkar B. Annual review-cum-planning meet under SRI project at the Hotel New Marrion, Bhubaneswar during 15th -16th July, 2017.

Kumar Ujjwal International conference on "advances in potassium research for efficient soil & crop management" at NASC, New Delhi, from 28th-29th August, 2017.

Kumar, Santosh 52nd Annual rice research group meeting at Assam Agricultural University (AAU), Jorhat, Assam during 08th-11th April 2017.

Kumar, Santosh Annual review and planning workshop, stress-tolerant rice for Africa and South Asia (STRASA Phase 3) at NASC, New Delhi during from 30th April – 03rd May, 2017.

Kumar, Ujjwal National conference on "Climate change and agricultural production" at BAU, Sabour during 06th-08th April, 2017.

Mali, S.S. International conference on Water and waste water management and modelling (ICWWMM)' held at Central University of Jharkhand, Ranchi during 16th - 17th January, 2018th.

Maurya, S. IXXth AICRP workshop on Mushroom at Directorate of Mushroom Research (DMR), Solan, HP during 25th-26th April, 2017.

Mishra, J.S. CSISA-India Phase III-*Kharif* 2017 planning meeting, 03th-04th April, 2017, Jaypee Siddhrth, New Delhi.

Mishra, J.S. Project finalization meeting on 11th April 2017 at IWMI, New Delhi

Mishra, J.S. ICAR Review Committee meeting on 11th April, 2017 at ICAR-NIAP, Pusa, New Delhi

Mishra, J.S. Review and planning workshop of EC-IFAD funded project on "Improved crop management and strengthened seed supply system for drought-prone rainfed lowlands in South Asia at NASC, Pusa New Delhi on 3rd May, 2017.

Mishra, J.S. Policy Dialogue Workshop on 'Flood index insurance and drought management for agricultural development in Bihar' organized by the International Institute of Water Management (IWMI), New Delhi and ICAR-Research Complex for Eastern Region (RCER), Patna on 7th June, 2017.

Mishra, J.S. Workshop on Strategizing pulse production in rice -fallows in Eastern India' on 23rd September 2017, Ranchi.

Mishra, J.S. Review meeting regarding finalization of the document on 'Doubling Farmers' Income by 2022' on 10th October, 2017, Krishi Bhawan, New Delhi.

Mishra, J.S. Vice Chancellors and ICAR Directors conference during 8th-9th March, 2018 at NASC Complex, New Delhi.

Mishra, J.S. 2nd International conference on food & agriculture 2018 held during 29th-31th March, 2018, Dhanbad.

Naik, S.K. Workshop on "Amrut Krushi" organized by business planning and development, Birsa Agricultural University Society, Ranchi on 21st December, 2017.

Naik, S. K. Workshop on "Fertilizer policy with special reference to DBT, GST and balance fertilization" organized by Fertilizer Associations of India, Kolkata at Rama Krishna Mission, Morabadi, Ranchi on 27th July, 2017.

Rahman, A. Review meeting of account officers & vigilance officers of ICAR at CIFRI, Barrakpore on October 10, 2017.

Santosh Kumar 3rd ARRW International symposium at ICAR-NRRI, Cuttack, Odisha during February on 6th September, 2017.

Sarkar, B. Annual review-cum-planning meet under SRI project at the Hotel New Marrion, Bhubaneswar during 15th -16th July 2017.

Sarkar, B. QRT meeting of AICRPs on FIM, ESA, UAE, EAAI and CRPs on FM &PF, EA at IIT Kharagpur, West Bengal during 27th-28th June 2017.

Singh A.K. National Conference on "Food and nutritional security through vegetable crops in relation to climate change" at ICAR IIVR, Varanasi from 9-11th December, 2017.

Singh, A.K. 35th AICRP(VC) group meeting at ICAR IIHR, Banglore during 24th-27th June, 2017.

Singh, I.S.; Choudhary, A.K. and Thakur, A.K. National conference on livelihood and food security, organized by Society for Agriculture Innovation and Development, Ranchi at Bihar Veterinary College, Patna during 27th-28th January, 2018.

Singh, SK State level consultation workshop on Formulating heat action plan-2017 for Bihar' at Hotel Patliputra Ashok on 5th May, 2017.

Research Papers Presented in Conferences/Seminars/Symposia

Aishwath, O.P.; Dubey, P.N.; Yadav, R.K.; Meena, R.L. and Jha, B.K. (2017). Performance of dill (*Anethum graveolens*) with sodic irrigation water in Typic Haplustepts. Paper presented in *National Seminar on "Developments in Soil Science-2017" and 82nd Annual Convention of the Indian Society of Soil Science* held at Amity University, Kolkata during 11th -14th December, 2017.

Aishwath, O.P.; Dubey, P.N.; Yadav, R.K.; Meena R.L. and Jha, B.K. (2017). Abiotic and edaphic stresses: proving causes of reddening and non-pathogenic mortality in cumin seedlings. Paper presented in *26th National Conference on Natural Resource Management for Climate Smart Sustainable Agriculture*, 11th -13th September, 2017.

Bhavana, P.; Prema, S. Soreng.; Shinde, R.; Prajapathi, G.K. and Bishnoi, S.K. (2018). Genetic diversity and principal component analysis for nutritional characters of rice landraces of Eastern India. Paper presented in *International Conference on Advances in Environmental and Agricultural Technology 2018* organised by Indo Global Chamber of Commerce Industries and Agriculture at St Xaviers' college, Ranchi during 22nd - 24th February, 2018.

Choudhary, A.K.; Mishra, J.S.; Kumar, Ujjwal; Singh, I.S. and Bhatt, B.P. (2018). Sustainable crop intensification through grain legumes for nutritional security in Eastern Gangetic Plains. Lead paper presented in the International Conference on "*Sustainability of Smallholder Agriculture in Developing Countries under Changing Climatic Scenario*" held at CSAUAT, Kanpur during 14th-17th February, 2018.

Das B. (2017). Genetic resource management in litchi- Three decades of accomplishment at ICAR RCER, Research Centre, Ranchi. Paper presented in National *conference on perspective of challenges and options in litchi production and utilization*, held at ICAR-NRC for Litchi, Muzaffarpur during 6th-7th June, 2017.

Das, B. (2017). Genetic resource management of fruit crops in Jharkhand. Paper presented in *State level workshop on "Implementation of biodiversity act 2002"* organized by Jharkhand Biodiversity Board at Ranchi on 1st June 2017.

Das, B. (2017). Shoot nutrient and hormonal balance for regulating fruiting in litchi" at *National conference on perspective of challenges and options in litchi production and utilization*, held at ICAR-NRC for Litchi, Muzaffarpur during 6th-7th June, 2017.

Dhakar, M.K. and Das, B. (2017). Standardization of grafting technique in litchi. Paper presented in *National conference on perspective of challenges and options in litchi production and utilization*, held at ICAR-NRC for Litchi, Muzaffarpur during 6th-7th June, 2017.

Dwivedi, S.K.; Kumar, S.; Basu, S.; Kumar, G.; Koley, T.K.; Mishra, J.S. and Bhatt, B.P. (2018). Exploration of mechanism behind heat tolerance in wheat: photosynthesis, antioxidants activity, assimilate mobilization, pollen viability and grain yield. Paper presented in the *International conference on novel applications of biotechnology in agricultural sectors: towards achieving sustainable development goal-2018* (INABASDG-2018)" at BHU, Varanasi during 20th-21st March, 2018.

Jha, B.K.; Mali, S.S. and Naik, S. K. (2017). Evaluation of mulching and different irrigation practices on yield and water productivity of vegetables grown in acid soils of Eastern Plateau and Hill Region of India. Paper presented in *International symposium on horticulture: priorities and emerging trends* held at ICAR-IIHR, Bengaluru during 5th-8th September, 2017.

Jha, B.K.; Mali, S.S. and Naik, S.K. (2018). Efficacy of irrigation method and bicolour polyethylene mulch on growth, yield and water productivity of cole crops in Eastern Plateau Hill Region of India". Paper presented in *International conference on "water and wastewater management and modelling (ICWWMM-2018)"* held at Centre for Water Engineering and Management, Central University of Jharkhand, Ranchi, during 16th-17th January, 2018.

Kumar, Rakesh, Mishra, J.S.; Rao, K.K.; Kumar, Ravikant; Singh, SK; and Bhatt, B.P. (2017). Evaluation of crop establishment techniques in rice-fallows of Eastern Indo-Gangetic Plains. Paper presented in the

National seminar on organic waste management for food and environmental security organized by ICAR- Indian Institute of Soil Science & Indian Society of Soil Science (Bhopal Chapter), Bhopal during 8th-10th February 2017,

Kumar, Santosh; Dwivedi, S.K; Bhakta, N.; Mishra, J.S.; Bhatt, B.P., Singh, O.N., and Kumar, A. (2018). Effect of multi-stages drought on yield and yield components of rice genotypes grown under rainfed lowland drought prone ecosystem of eastern India". Paper presented in *3rd ARRW International symposium -2018* held at ICAR-NRRI, Cuttack Odisha during 06th-09th February, 2018.

Mali, S.S.; Jha, B.K.; Naik, S.K.; Kumar, A. and Singh, A.K. (2018). Response of broccoli to planting geometry and growth stage based fertigation patterns in hot and semi arid region of India. Paper presented in *International conference on "Water and waste water management and modelling (ICWWMM-2018)* held at Centre for Water Engineering and Management, Central University of Jharkhand,Ranchi, Jharkhand during 16th-17th January, 2018.

Mali, S.S.; Naik, S.K.; Jha, B.K. (2018). Response of broccoli to planting geometry and growth stage based fertigation patterns in hot and semi-arid region of India. Paper presented in '*International conference on water and waste water management and modelling (ICWWMM 2018)'*, held at Central University of Jharkhand, Ranchi during 16th to 17th January, 2018.

Manibhushan (2017). An integrated Approach of GIS and data mining techniques in spatial data of water resources". Paper presented in the *International conference on "global scenario of life science, agriculture, nursing and medical research for the welfare of rural and urban folk (GOSLANRUF)* at METAS Adventist College, Ranchi during 3rd-5th December, 2017.

Naik, S.K. (2017). Doubling Farmer's Income by 2022-ways and means in *Workshop on "Fertilizer policy with special reference to DBT, GST and Balance fertilization"* organized by Fertilizer Associations of India, Kolkata at Rama Krishna Mission, Morabadi, Ranchi, Jharkhand on 27th July, 2017.

Naik, S.K. (2017). Nutrient management in Amrit Krushi in *Workshop on "Amrut Krushi"* organized by Business Planning and Development, Birsa Agricultural University Society, Ranchi, Jharkhand on 21st December, 2017.

Rajesha, G.; Bendangsenla; Kumar, Rakesh and Ngachan, S.V. (2017). First report of rust caused by *Uromyces Vicia-faba* on fababean (*Vicia faba* L.) in North East India". Paper presented in the *National conference on "emerging and re-emerging plant diseases in north east India: challenges and strategies"* at the ICAR RC for NEH Region, Manipur Centre, Imphal during October 10th-11th, 2017.

Sarkar, B.; Reddy, R.B; Singh, S.K.; Kumar, A.; Kumar, Rakesh and Bhatt, B.P. (2018). Ergonomics of manual weeders in SRI under Indo Middle Gangetic Plains". Paper presented in the *National seminar on sustainable rice production technology for increasing the farmers income (NSRT-2018)* at IGKV Raipur, during 20-21 January, 2018.

Singh, A.K. (2017). Development of bacterial wilt resistant varieties of brinjal and tomato – a saga of two decades. Paper presented at *National conference on "Food and nutritional security through vegetable crops in relation to climate change"* organized by ICAR IIVR, Varanasi during 9th -11th December, 2017.

Singh, I.S. (2017). Management of bearing in subtropical fruits through INM and soil management practices. Delivered lecture in Winter School on "Understanding flowering mechanism and management of bearing in sub-tropical fruit crops" organized by ICAR-NRC on Litchi, Muzaffarpur from 1st-21st December, 2017.

Zeliang, P.K.; Kumar, M.; Kumar, Rakesh; Meena, KL and Rajkhowa, D.J. (2018). Productivity assessment of rice cultivars under the *jhum* areas of Nagaland". Paper presented in the National Conference on *"Improving income of farmers through agriculture and aquaculture through development interventions"* held at the ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha from 5th-7th Jan.2018.

25. Publications

Research Papers

Ahirwal, S.K.; Jaiswar, A.K. and Chakrborty, S.K. (2017). Biometric analysis of oil sardine, *Sardinella longiceps* (Valenciennes, 1847) from Mumbai coast of Maharashtra, India. *Indian Journal of Geo-Marine Science*, **46** (09) 1810-1817.

Arora, Sheetal, Mahato, A.K.; Singh, Sangeeta; Mandal, Paritra; Bhutani, Shefali; Dutta, Sutapa; Kumawat, Giriraj; Singh, Bikram Pratap; Choudhary, A.K.; Yadav, Rekha; Gaikwad, K.; Sevanthi, Amitha Mithra; Datta, Subhojit; Raje, Ranjeet S.; Sharma, T. R. and Singh, Nagendra Kumar (2017). A high-density intraspecific SNP linkage map of pigeonpea (*Cajanus cajan* L. Millsp.). *PLoS ONE*. DOI: https://doi.org/10.1371/journal.pone.0179747.

Arumugam, M.; Pillai, M.A.; Jayapradha, C.; Chaudhary, S.; Mishra, B.K.; Velayutham, G.; Verma, N.; Singh. N.; Vanniyarajan. C.; Thangahemavathy, Nagaraja A.; Singh, A.K. and Yasin, J.K. (2018). DG (RG) 55-High yielding short duration dwarf line of pigeonpea. *Journal of AgriSearch,* **5**(1): 5-7.

Barman, D. and Naik, S.K. (2017). Effect of substrate, nutrition and growth regulator on productivity and mineral composition of leaf and pseudobulb of Cymbidium hybrid "Baltic Glacier Mint Ice". *Journal of Plant Nutrition*, **40**(6): 784-794.

Basu, Sahana; Giri, R.K.; Benazir, Ibtesham; Kumar, Santosh; Rajwanshi, Ravi; Dwivedi, S.K. and Kumar, Gautam (2017). Comprehensive physiological analyses and reactive oxygen species profiling in drought tolerant rice genotypes under salinity stress. *Physiology and Molecular Biology of Plants,* **23**(4): 837-850.

Bharati, R.C.; Chaudhary, K.K.; Singh, A.K.; Kumar, A.; Kumar, U. and Chandra, N. (2017). Efficiency of optimum plot size using information of previous experiments conducted in split plot design, *Journal of AgriSearch*, **4**(1):60-67.

Bharti, P.K.; Dutt, T.; Patel, B.H.M.; Pandey, H.O.; Gaur, G.K.; Singh, M.; Kamal, R.; Verma, K.K. and Upadhyay, D. (2017). Impact of weaning age on post-partum reproductive performance and stress level in Murrah buffaloes. *Indian Journal of Animal Sciences,* **87**(4): 432–434.

Bhatt, B.P.; Gupta, V.K.; Kumar, L.; Singh, I.S. and Sarkar, B. (2017). *Euryale ferox* (Salisb): Promising aquatic food crop of eastern Indo-Gangetic plains. *Internation Journal of Current Microbioly and Applied Sciences,* **6**(6): 1914-1921.

Bhavana P. and Singh A.K. (2017). Effect of grafting in tomato to control bacterial wilt (*Ralstonia solanacearum* Yubuuchi). *Vegetable Science,* **44**(2): 110-113.

Bhavana, P.; Prema, S. Soreng.; Shinde, Reshma; Prajapathi, Gopal K. and Bishnoi, S.K. (2018). Genetic diversity and principal component analysis for nutritional characters of rice landraces of Eastern India. *Genius,* **6**(2): 59-67.

Bhutia, Tshering Lhamu , Shivani and Saurabh, Kirti (2017). Evaluation of different varieties of pea (*Pisum sativum* L.) for yield and quality under late sown conditions in Eastern Region. *Crop Research,* **52**(4&5): 176-179.

Bhutia, Tshering Lhamu; Munshi A. D.; Behera, Tusar Kanti and Lal, S.K. (2017). Combining ability for yield and yield related traits and its relationship with gene action in cucumber. *Indian Journal of Horticulture Science*, **74**(1):51-55.

Bhutia, Tshering Lhamu; Singh, S.H. and Reddy, K.C.S. (2017). Effect of mulching and nitrogen on growth, yield and economics of Okra (Abelmoschus esculentus). *Ecology, Environment and Conservation*, **23**(2): 826-832.

Choudhary, A.K.; Revanappa, S.B. and Vijayakumar, A.G. (2017). An analysis of yield gains through breeding high-yielding varieties in urdbean and mungbean. *Journal of AgriSearch,* **4**(3): 219-222.

Choudhary, A.K.; Sultana, Rafat; Vales, M. Isabeland Saxena, Kul Bhushan (2017). Integrated physiological and molecular approaches to improvement of abiotic stress tolerance in two pulse crops of the semiarid tropics. *The Crop Journal*, Doi:10.1016/j.cj.2017.11.002

Choudhary, J. S.; Naaz, N.; Moanaro; Das, B.; Singh, A.K.; Bhatt, B.P. and Prabhakar, C.S. (2017). Genetic analysis of *Bactrocera zonata* (Diptera: Tephritidae) populations from India based on cox1 and nad1 gene sequences. Mitochondrial DNA Part A, https://doi.org/10.1080/24701394.2017.1350952 .

Choudhary, J.S.; Dhakar, M.K.; Mukherjee, D.; Moanaro; Das, B.; Singh, A.K. and Bhatt, B.P. (2018). Influence of some fruit traits of mango, Mangifera indica L. varieties against maggot development and infestation of mango fruit fly, Bactrocera dorsalis (Hendel). *Journal of Entomology and Zoology Studies*, **6**(2): 2621-2627.

Choudhary, J.S.; Naaz, N.; Das, B.; Bhatt, B.P. and Prabhakar, C.S. (2018). Complete mitochondrial genome of Idioscopus nitidulus (Hemiptera: Cicadellidae). Mitochondrial DNA Part B, **3**(1): 191-192

Choudhary, J.S.; Rao, M.S.; Mali, S.S.; Das, B.; Kumari, A.; Mukherjee, D.; Singh, A.K. and Bhatt, B.P. (2017). Potential changes in number of generations of oriental fruit fly, *Bactrocera Dorsalis* (Diptera: Tephritidae) on mango in India in response to climate change scenarios. *Journal of Agrometeorology,* **19**(3): 200-206.

Daspute, Abhijit Arun; Kobayashi, Yuriko; Panda, S.K.; Fakrudin, Bashasab; Kobayashi, Yasufumi; Tokizawa, Mutsutomo; Iuchi, Satoshi; Choudhary, Arbind Kumar; Yoshiharu Y. Yamamoto and Hiroyuki Koyama (2017). Characterization of CcSTOP1; a C_2H_2 type transcription factor regulates Al tolerance gene in pigeonpea. *Planta*, DOI 10.1007/s00425-017-2777-6.

Dayal, S.; Dey, A.; Pandian, S. J.; Gupta, J.J.; Chandran, P.C. and Ali, I. (2017). Effect of seasonal variation on physiological parameters in Murrah buffalo. *Indian Journal of Animal Sciences,* **87**(8): 965-967.

Devi, Sarita.; Sharma, Mahesh Chandra; Singh, Rabindra Prasad; Dimri, Umesh; Patel, Arun; Kumar, Pankaj and Singh, Ratan Deep (2018). Effect of mineral supplementation on humoral immunity against rabies vaccine in dog pups. *Indian Journal Animal Research*. DOI:10.18805/ijar.B-3433.

Dey, A.; Sarma, K.; Kumar, U.; Mohanty, S.; Kumar, T. and Bhatt, B.P. (2018). Prospects of ricefish farming system for low laying areas in Bihar, India. *Organic Agriculture*. DOI: 10.1007/s13165-017-0204-8.

Dwivedi, S.K.; Kumar, S.; Kumar, Rahul; Prakash, Ved; Rao, K.K.; Samal, S.K.; Yadav, Shikha; Jaiswal, Kundan Kumar; Kumar, Shiv Shankar; Sharma, Basant Kumar and Mishra, J.S. (2017). Interactive Effect of Elevated CO_2 and Temperature on the Incidence of Brown Spot and Sheath Blight of Rice (*Oryza sativa* L.). *International Journal of Current Microbiology and Applied Sciences*, **6**(4):195-202.

Dwivedi, S.K.; Kumar, Santosh; Bhakta, N.; Singh, S.K.; Rao, K.K.; Mishra, J.S. and Singh, A.K. (2017). Improvement of submergence tolerance in rice through efficient application of potassium under submergence-prone rainfed ecology of Indo-Gangetic Plain. *Functional Plant Biology,* **44**(9): 907-916.

Gani, M.; Gupta, R.K.; Zargar, S.M.; Kour, G.; Monobrullah, M.; Thamilarasi, K. and Mohanasundaram, A, (2017). Molecular identification and phylogenetic analyses of multiple nucleopolyhedro virus isolated from *Lymantria obfuscata* (Lepidoptera: Lymantriidae) in India. *Applied Entomology and Zoology*, **52**(3): 389-399.

Jadhav, R.K., Dar, A.A., Dimri, U., Kumar, Pankaj and Sharma, M.C. (2018). Mineral profile of water buffaloes (*Bubalis bubalis*) under different physiological and production status in Western Maharashtra. *Indian Journal of Animal Sciences*, **88**(2): 186-190.

Jana, B.R.; Idris, M. and Singh, M. (2017). Physicochemical changes and pest incidence associated with Bael (*Aegale marmelos* Correa) fruit. *Advance Plants Agricultural Research*, 7(6): 277-281.

Jha, B.K and Chakraborti, A., (2017). Duck farming: A potential source of livelihood in tribal village. *Journal of Animal Health and Production*, **5**(2):1-5.

Jha, B.K.; Mali, S.S.; Naik, S.K. and Sengupta, T. (2017). Yield, water productivity and economics of vegetable production under drip and furrow irrigation in Eastern Plateau and Hill Region of India. *International Journal of Agricultural Sciences,* **7**(3): 567-573.

Jha, B.K.; Naik, S.K. and Choudhary, J.S. (2018). Efficacy of of planting methods and mulching under drip irrigation on yield, water use efficiency, water productivity and economics of cauliflower (*Brassica oleracea* var. *botrytis*). *International Journal of Agricultural Sciences,* **8**(2): 39-48.

Kamal, R.; Dey, A.; Mondal, K.G.; Chandran, P.C. (2018). Impact of environmental stressors on the performance of backyard poultry. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, **88**(1): 79-84.

Kamal, R.; Dutt, T.; Patel, M.; Dey, A.; Bharti, P.K. and Chandarn, P.C. (2018). Heat stress and effect of shade materials on hormonal and behavior response of dairy cattle: a review. *Tropical Animal Health and Production*. DOI: https://link.springer.com/ article/10.1007/s 11250-018-15426-z.

Kharumnuid, P.; Sarkar, S.; Singh, P.; Priya, S.; Tomar, B.S.; Singh, D.K; and Pandey, N.K. (2017). An assessment of contract farming system for potato seed production in Punjab-A case study, *Indian Journal of Horticulture,* **74**(3): 453-457

Koley, T.K.; Khan, Oulkar D.; Singh, B.K.; Maurya, A.; Singh, B. and Banerjee, K. (2017). High resolution LC-MS characterization of phenolic compounds and the evaluation of antioxidant properties of a tropical purple radish genotype. *Arabian Journal of Chemistry*. DOI: https://doi.org/10.1016/j. arabjc.2017.11.007.

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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 Specialists

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

New Joining

Scientists

Sh. Abhishek Kumar Dubey, Scientist w.e.f.

15.04.2017

Dr. Dhiraj Kumar Singh, Scientist w.e.f. 30.06.2017

Dr. Manoj Kumar, Scientist w.e.f. 22.07.2017

Dr. Nongmaithem Raju Singh, Scientist w.e.f. 13.10.2017

Mrs. Mridusmita Debnath, Scientist w.e.f. 13.10.2017

Ms. Manisha Tamta, Scientist w.e.f. 13.10.2017

Technical

Sh. Abhishek Kumar, Sr. Technical Officer w.e.f. 01.09.2017

Promotion

Scientists

Dr. S.S. Mali, Scientist, Soil & Water Conservation Engineering promoted from GP 6000 to 9000 w.e.f. 12.06.2012

Dr. B. K. Jha promoted from Senior Scientist to Principal Scientist w.e.f. 09.07.2012

Dr P. R. Kumar promoted from Senior Scientist to Principal Scientist w.e.f. 04.09.2014

Dr. Bikash Das promoted from Senior Scientist to Principal Scientist w.e.f. 22.06.2015

Dr S. K. Naik promoted from Senior Scientist to Principal Scientist w.e.f. 31.03.2017

Technicals

Shri Manual Lakra promoted from Technical Officer to Sr. Technical Officer w.e.f. 01.01.2016

Shri P.K Singh promoted from Technical Officer to Sr. Technical Officer w.e.f. 18.03.2017

Shri Dev Narayan promoted from Sr. Technical Assistant to Technical Officer w.e.f.28.12.2016

Shri Ashok Kumar promoted from Technical Assistant to Sr. Technical Assistant w.e.f 16.09.2015

Shri Kamlesh Mahto promoted from Sr. Technician to Technical Assistant w.e.f. 06.09.2012

Shri Prakash Khatiwada promoted from Technician to Sr. Technician w.e.f. 11.10.2016

Administrative

Sh. Dayaanand, UDC to Assistant w.e.f. 30.03.2011 (A/N)

Supportings

Shri Prem Kumar promoted from SSS to Technician w.e.f. 10.08.2017

Shri Surendra Yadav promoted from SSS to Technician w.e.f. 08.08.2017

Transfer

Dr. S.J. Pandian, Scientist transferred to CSWRI, Avikanagar w.e.f. 27.06.2017

Dr. Anuradha Srivastava, Scientist, Food Technology transferred to DMR, Solan w.e.f. 16.09.2017

Mrs Snatashree Mohanty, Scientist, Fish Health transferred to CIFA, Bhuvaneshwar w.e.f. 22.09.2017

Dr. Asit Chakraborty, Senior Scientist (LPM) transferred to Animal Resource Development Dept., Govt. of Tripura w.e.f. 16.12.2017

Retirements

Sh. Sona Ram Rajak, Assistant Administrative Officer w.e.f. 31.12.2017

Sh. Nand Kishore Ram, SSS w.e.f. 31.12.2017

Obituary

Late Baleswar Lakra, SSS, Research Centre Ranchi on 09.07.2017

Late Jibiya Oraon, SSS, Research Centre Ranchi on 28.07.2017

27. On-going Research Projects

Theme-wise Ongoing and New Institute Research Projects 2017-18

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation 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 R.K. Kamal S. Mohanty	Jun. 2010	Mar. 2018	IIFSR, AICRP (Externally funded)
1.2	ICAR-RCER/ RC Ranchi/ 2011/ **25(iii)**	Development of location specific Integrated Farming System models for rainfed eco-system of Eastern Plateau Hill Region	M.K. Dhakar P.R. Kumar	Jun. 2011	May 2018	ICAR RCER
1.3	ICAR-RCER/ DCR/2016-17/25 **(iv)**	Integrated Farming System for improving livelihood security of resource poor farmers.	T.L. Bhutia Reena K.Kamal S. Mohanty R.C. Bharati	Jul. 2016	Jun. 2019	ICAR RCER
1.4	ICAR-RCER/ DLWM/ 2016-17/ **182**	Evaluation and optimization of IFS	Manibhushan Sanjeev Kumar A. Upadhyaya R.C. Bharati	2016	2019	ICAR RCER
1.5	ICAR-RCER/ RC Makhana/ 2014-15/ **157**	Introduction of sweet flag and tuber vegetable crop under wetland ecosystem with makhana crop for north Bihar	B.R. Jana Rajvir Sharma	Jul. 2014	Jun. 2017 Extd 2018	ICAR RCER
1.6	ICAR-RCER/ DLFM/ 2014/ **143**	Multiplication and production profiling of improved poultry germplasm under Backyard farming system	Reena K. Kamal P.C. Chandran	Jul. 2014	Jun. 2019	ICAR RCER
1.7	ICAR-RCER/ RC Ranchi/ 2014/**147**	Development of multi-tier cropping system for rainfed uplands of Eastern Plateau and Hills	M. K. Dhakar Bikas Das	Sept. 2014	Sept. 2019	ICAR RCER
1.8	ICAR-RCER/ DLWM / 2016-17/	Eco-energetic analysis of different cropping system in Eastern India.	Bikash Sarkar Ajay Kumar S.S. Mali Rakesh Kumar	Jul. 2016	Jun. 2019	ICAR RCER
1.9	ICAR-RCER/ DLFM/2014/**155**	Optimization of production efficiency in Livestock Fish integrated farming system	Kamal Sarma A. Dey S.K. Gupta S. Mohanty TarkeshwarKumar	Aug, 2014	Jul., 2017 Extd 2019	ICAR RCER

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation Year	Funding agency
2	**Resource conservation technology**					
2.1		Sustainable Resilient Farming System in intensification (SRFSI) in the Eastern Gangetic Plains	Ujjwal Kumar Rajvir Sharma S.K. Singh Bikash Sarkar R. C. Bharati K. K. Rao	Oct. 2014	Jun. 2018	CIMMYT
2.2		Evaluation of Conservation Agricultural (CA) practices under Rice-fallow system of Eastern Region	J. S. Mishra K. K. Rao S. K. Singh B. K. Jha S. K. Naik S.S. Mali Rakesh Kumar	2015	2020	Consortium Research Platform on CA
2.3	ICAR-RCER/ DCR/ 2011/ **104**	Evaluation of different production system for carbon sequestration potential	S.K. Naik S. Maurya Shivani K.K. Rao	Jul. 2011	Jun. 2017 Extd 2019	ICAR RCER
2.4	ICAR-RCER/ RCR/2015/**168**	Evaluation of vegetable cropping sequences under drip irrigation with mulching in Eastern Plateau and Hill Region	B.K. Jha S.S. Mali S.K. Naik	Aug. 2015	Jul. 2018	ICAR RCER
2.5	New	Decomposition of nitrogen and carbon mineralization dynamics of rice-wheat system in EIGP	Kirti Saurabh Rakesh Kumar	Jul., 2017	Jun., 2019	ICAR RCER
2.6		Cereal Systems Initiative for South Asia (CSISA) Phase III	J.S. Mishra Md. Monobrullah K.K. Rao Rakesh Kumar S.K. Dwivedi Kirti Saurabh	2016	2020	CIMMYT
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	Bikash Das J.S. Choudhary S. Maurya S.S. Mali	Jan. 2011	Mar. 2018	NICRA (Externally funded)
3.2	ICAR-RCER/ EF/ 2011/**29**	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	N. Bhakta J.S. Mishra Kamal Sarma K.K. Rao S.K. Dwivedi	Jul. 2014		NICRA (Externally funded)
3.3	ICAR-RCER/ DCR/ 2016-17/ **181**	Diversification of rice-wheat system through climate resilient cropping in Eastern India.	Rakesh Kumar J.S. Mishra N. Chandra Kirti Saurabh R.S. Pan R. Shinde	2016	2019	ICAR RCER
3.4		Developing and defining climate smart agriculture practices portfolios in South Asia (CCAFS)	K.K. Rao Rakesh Kumar Manoj Kumar	2016	2018	CIMMYT

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation Year	Funding agency
3.5		Development of climate resilient farming system models for livelihood improvement	Md. Monobrullah B. Sarkar S.S. Mali Bikash Das P.C. Chandran Ravi Kumar S.K. Samal	Nov. 2016	Dec. 2019	NMSA, DAC&FW, Ministry of Agriculture & Farmers' Welfare, GOI
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 S. K. Dwivedi J.S. Mishra N. Bhakta K.K. Rao Rakesh Kumar Abhishek Dubey Md. Monobrullah	Apr. 2014	Feb. 2019	IRRI
4.2	ICAR-RCER / HARP/ 2001/ **03**	Plant genetic resource and improvement of fruit and ornamental crops	M.K. Dhakar Bikash Das J. S. Choudhary D. Kherwar	2001	Long term	ICAR RCER
4.3	ICAR-RCER/ RCRanchi/ 2012/**132**	Collection, characterization and evaluation of potentials wild edibles including tuber crops	R.S. Pan Reshma Shinde Tania Seth	Apr. 2013	Mar. 2018	ICAR RCER
4.4	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	Jul. 2014	Jun. 2018	ICAR RCER
4.5	ICAR-RCER/ DCR/ 2014/**160**	Breeding for submergence tolerance in rice	N. Bhakta Santosh Kumar S. K. Dwivedi	Jul. 2014	Jun. 2018	ICAR RCER
4.6	ICAR-RCER/ RC Ranchi/ 2015/**171**	Improvement of seed quality of solanaceous and cucurbitaceous vegetables	P. R. Kumar S. Maurya	Aug. 2015	Aug. 2020	ICAR RCER
4.7	ICAR-RCER/ RC Ranchi/ 2015/**172**	Genetic improvement for yield and biotic stress resistance in pigeonpea under eastern plateau and hill region	P. Bhavana A.K.Choudhary S. Maurya J.S. Chaudhary Md Monobrullah	Jul. 2015	Jun. 2019	ICAR RCER
4.8	ICAR-RCER/ RC Ranchi/ 2015/**173**	Collection, evaluation and development of bacterial wilt resistant germplasm of brinjal	P. Bhavana A. K. Singh S Maurya	Aug. 2015	Dec. 2019	ICAR RCER
4.9	New	Evaluation of different genotypes of water chestnut	Rajvir Sharma I.S. Singh B.R.Jana Md. Idris	2015	2020	ICAR RCER
4.10	New	Genetic resource management in vegetable crops	A.K. Singh P. Bhavna R. S. Pan A.K. Singh (Agronomy) V.K. Yadav	Sept. 2017	Long term project	ICAR RCER

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation Year	Funding agency
Theme- 3. Improved Production and Protection Technologies for Agri-Horti Crops						
5	**Production Technologies**					
5.1	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 system in Eastern India	A.K.Choudhary I.S. Singh	Jul. 2014	Jun. 2017 Extd 2018	ICAR RCER
5.2	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	Jul. 2014	Jun. 2017 Extd 2018	ICAR RCER
5.3	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 M.K. Dhakar	Aug. 2014	Jul. 2017 Extd 2020	ICAR RCER
5.4	ICAR-RCER/ RC Ranchi/ 2014/**152**	Nutritional characterization and value addition of potential underutilized leafy vegetables of Jharkhand	A. Srivastava R. S. Pan Tania Seth	Sept. 2014	Sept. 2017 Extd 2018	ICAR RCER
5.5	ICAR-RCER/ DCR/ 2015/	Integrated Weed Management (i) Integrated weed management in makhana	Rajvir Sharma	2015	2020	ICAR RCER
	ICAR-RCER/ DCR/ 2015/**163**	(ii) Integrated weed management in rice-wheat system.	Sanjeev Kumar	2015	2020	ICAR RCER
	ICAR-RCER/ RC Ranchi/ 2015/**169**	(iii) Phyto-sociology of weeds associated with important agricultural crops under eastern plateau and hill region of India	Jaipal S. Choudhary	2015	2018	ICAR RCER
5.6	ICAR-RCER/ DLWM/ 2016-17/	Ergonomic study of farmers' friendly farm implements in Eastern region.	Bikash Sarkar Rakesh Kumar	2016	2019	ICAR RCER
5.7	New	Diversification of rice-wheat system with vegetables	Shivani T.L. Bhutia	2017	2021	ICAR RCER
6.0	**Protection Technologies**					
6.1	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	Jul. 2015	Jun. 2018	ICAR RCER
6.2	ICAR-RCER/ RC Ranchi/ 2015/**167**	Development and evaluation of disease suppressive potting mixtures in vegetable crops.	S. Maurya	Jul. 2015	Jun. 2018	ICAR RCER
6.3	New	Identification, incidence and population dynamics of major insects pests of Gorgon nut (Makhana) and water chestnut (Singhara) in wet-land ecosystem of North Bihar	M. Idris I.S. Singh B.R. Jana	Jul., 2017		ICAR RCER

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation Year	Funding agency
Theme- 4. Integrated Land & Water Management						
7.0	**Land & Water Management**					
7.1	ICAR-RCER / DLWM/ 2015S/**178**	Development of bio-drainage in participatory mode under waterlogged area	S.K. Singh S.K. Dwivedi Ajay Kumar	Jul. 2014	Jun. 2022	ICAR RCER
7.2	ICAR-RCER / DLWM /2014/	Application of optimization techniques in planning and management of land, water and other resources	A. Upadhyaya Manibhushan A. Rahman	Jul. 2014	Jun. 2017 Extd 2018	ICAR RCER
7.3	ICAR-RCER / DLWM/ 2014/**176**	Solar energy utilization in agriculture (i) Design and assessment of solar powered aerator for fish pond (ii) Assessment of solar energy operated micro-irrigation system in mango and guava orchards (iii) Design and assessment of solar humidifier for animal shed (iv) Design and assessment of solar watering system for animal shed.	**A. Rahman** Kamal Sarma Ajay Kumar B. Sarkar	Aug. 2014	Jul., 2017	ICAR RCER
7.4	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 M.K. Dhakar	Jan. 2015	Jun. 2018	ICAR RCER
7.5	ICAR-RCER / RC Ranchi/ 2014/**150**	Rehabilitation of coal mine affected areas through agroforestry interventions	M.K. Dhakar S. S. Mali	Sept 2014	Aug 2019	ICAR RCER
7.6	ICAR-RCER/ RC Ranchi/ 2014/**145**	Farmers Participatory Evaluation of Basic slag in Acidic soils of Jharkhand under different cropping systems	S.K. Naik Reshma Shinde A.K. Singh	Jul. 2014	Jun. 2018	Tata Steel
7.7		Systemic approach to research and adoption of SRI.	S.K. Singh Ajay Kumar	Jul. 2015	Jun. 2018	TATA Trust
7.8	ICAR-RCER/ EF/ ACIAR/ 2015/**39**	Improving water for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains	S.S. Mali T.L. Bhutia Ajay Kumar A. Rahman A. Upadhyaya Manibhushan	Aug. 2015	Jul. 2018	ACIAR
Theme- 5. Livestock & Fisheries Management						
8.0	**Livestock and Avian Management**					
8.1	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 P. K. Ray	Aug. 2011	Jul. 2015 Extd Jun. 2018	ICAR RCER
8.2	ICAR-RCER / DLFM/EF/ 2011/ **31**	Buffalo improvement	P.C. Chandran A. Dey Pankaj Kumar M.K. Tripathi	Jun. 2012	Dec. 2016 Extd Dec. 2020	ICAR RCER

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation Year	Funding agency
8.3	ICAR-RCER / DLFM/ 2013/ **135**	Characterization of lesser known breeds of farm animals in Eastern India	P.C. Chandran Shanker Dayal Reena K.Kamal	Jul. 2013	Jun. 2017 Extd 2019	ICAR RCER
8.4	ICAR-RCER/ DLFM/ 2014/**141**	Management of heat stress in buffalo	S. Dayal M.K. Tripathi	Jan. 2015	Dec. 2018	ICAR RCER
8.5	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	Apr. 2015	Mar. 2019	Network project (linkage NDRI Regional Station, Kalyani)
8.6	ICAR-RCER/ DLFM/ 2015/**165**	Meso level animal health interven-tions and evaluating economic losses from animal diseases	Pankaj Kumar P.K.Ray	Aug. 2015	Aug. 2018	ICAR RCER
8.7	ICAR-RCER/ DLFM/ 2015/**166**	Isolation and characterization of *Fusarium* species responsible for Degnala like disease in animals	S.K. Gupta P.K.Ray	Aug. 2015	Aug. 2018	ICAR RCER
8.8	ICAR-RCER/ DLFM/ 2015/**175**	Characterization and evaluation of duck germplasm in Eastern region.	Reena K.Kamal S.K. Gupta	Aug. 2015	Aug. 2018	ICAR RCER
8.9	ICAR-RCER/ DLFM/ 2015/**174**	Identification, documentation and quantification of non-conventional feed resources in traditional swine husbandry practices	Asit Chakrabarti	Jul. 2015	Jul. 2018	ICAR RCER
8.10	ICAR-RCER/ DLFM/ 2015/**180**	Epidemiological study of Respira-tory viral diseases in calves.	P.K.Ray Pankaj Kumar	2016	2019	ICAR RCER
8.11	New	Effect of Glucosamine supplementa-tion on reproductive efficiency in poultry	M.K.Tripathi Reena K.Kamal	2017	2020	ICAR RCER
8.12	New	Evaluation of different tree leaves as fodder for goats	A. Chakrabarti J.J. Gupta	Aug. 2017	Jul. 2020	ICAR RCER
9.0	**Fisheries Management**					
9.1		National Surveillance Programme for Aquatic Animal Disease (NSPAAD)	Kamal Sarma	Nov. 2015	Mar. 2018	NFDB
9.2	ICAR-RCER/ DLFM/ 2016/**183**	Formulation of mineral mixture for Indian Major carps based on soil-water and fish continuum	Tarkeshwar Kr Kamal Sarma S.Mohanty Ravi Kumar S.K.Ahirwal	2016	2019	ICAR RCER
9.3	ICAR-RCER/ DLFM/ 2016/**185**	Assessment of Ichthyofaunal biodi-versity and stock assessment of the selected fish species from wetland ecosystems.	Ravi Kumar Tarkeshwar Kr S.K.Ahirwal	2016	2019	ICAR RCER
Theme- 6. Socio-Economics, Extension and Policy Research						
10.0	**Socio-economic Research**					
10.1	ICAR-RCER/ DSEE/ 2012/**125**	Impact assessment of agricultural technologies in Eastern India	N. Chandra R.C. Bharati Abhay Kumar A.K. Singh (Ranchi)	Aug. 2014	Jul. 2017 Extd 2018	ICAR RCER

Sl. No.	Project code	Project title	Name of PI & Co-PI	Start year	Com-plation Year	Funding agency
10.2	ICAR-RCER/ DSEE/ 2012/**179**	Econometric analysis of diffusion of zero tillage in wheat in eastern region.	R.C.Bharati Abhay Kumar Ujjwal Kumar N. Chandra B.Sarkar	2016	2019	ICAR RCER
10.3		Rural youth as WaSH motivators & caseworkers for watershed linked ECO-WaSH based practices in Jharkhand & Odisha	Asit Chakrabarti	Jun. 2016	Jul. 2017	DST
10.4	ICAR-RCER/ DSEE/ 2014/**184**	Growth and instability in production of principal crops in Eastern India	Abhay Kumar N. Chandra R.C. Bharati Shanker Dayal Pankaj Kumar Bikash Das P. R. Kumar Dhiraj K.Singh	Jul., 2017	Jun., 2021	ICAR RCER
10.5	New	Socioeconomic characterization of farmers in Bihar & Jharkhand	V. K. Yadav A.K. Singh Pankaj Kumar Ujjwal Kumar R. C. Bharati	2017	2020	ICAR RCER
10.6	New	Standardization of shoot bending as canopy management technique for crop regulation in guava	T. K.Koley T.L Bhutia M.K. Dhakar	2017	2020	ICAR RCER
10.7	New	Production and value chain analysis of makhana	D.K. Singh Abhay kumar N.Chandra I.S. Singh	2017	2020	ICAR RCER

Approved activities of IRC 2017

S. No.	Title of Activities	PI
1.	Development of makhana based Integrated Farming System models for low land eco-system	Rajvir Sharma
2.	Impact of elevated CO_2 and temperature on growth and yield of rice-wheat cropping system under predicted climate change scenario.	S. K. Dwivedi
3.	Genetic enhancement of tomato for nematode and bacterial wilt resistance through molecular markers	P. Bhavana
4.	Optimization of water productivity of aerobic rice-based cropping system	S. K. Singh
5.	Cultural practices (irrigation levels and different bio mulches) for intercropping mustard with potato	S. K. Singh
6.	Controlling of internal breakdown of mango using post-harvest techniques	T. K. Koley
7.	Improving rice-lentil-moong bean system productivity through water management.	A. K. Singh

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किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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