Annual Report
2016-17

ICAR

ICAR Research Complex for Eastern Region

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

Annual Report
2016-17

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

Correct Citation

Annual Report
2016-17

Guidance
B.P. Bhatt
Director

Editors
Janki Sharan Mishra
Tshering Lhamu Bhutia
Kirti Saurabh
Shivani
Santosh Kumar
Santosh Kumar Gupta
Naresh Chandra
Bikash Das
Indu Shekhar Singh

Secretarial Assistance
Sarfaraj Ahmad

Photography
Sanjay Rajput

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

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

Preface

It gives me immense pleasure to present the 16th Annual Report of ICAR Research Complex for Eastern Region, Patna for the year 2016-17. The institute is contributing immensely in technology development and dissemination through multi-commodity and multi-disciplinary research so as to enhance the productivity and profitability of agricultural production systems, and efficient management of available natural resources in diverse agro-climate zones of eastern states.

During the period under report, the institute has developed several technologies for crop production and resource conservation in the backdrop of improved natural resource management strategies to mitigate/adapt to the changing climate challenges. A large number of rice genotypes have been evaluated under drought and submergence stress conditions. In order to increase productivity and cropping intensity in rice-fallows, technologies such as zero tillage and crop residue management have been standardized and popularized. *Boro* rice has been another area of focus in the last year.

For achieving the goal of food, nutritional and livelihood security and increasing the farmers' income, emphasis has been given on management of fallow lands, conservation agriculture, variety development for stress conditions, water productivity enhancement, rainwater harvesting, diversification in cropping systems with pulses and millets, weed management, solar energy application in agriculture and restoration of degraded lands. Different models of integrated farming systems have been developed for small and marginal farmers of rainfed, irrigated, hill & plateau and waterlogged situations, which have been found ecologically and economically viable. Emphasis has also been given to improve the nutrition and livelihood security of farm women through integrated farming systems.

Germplasm of different pulses like greengram, blackgram, pigeonpea, chickpea and lentil were evaluated and promising lines were identified. Similarly a large number of germplasm of mango, litchi, jackfruit, jamun, tamarind, makhana, water chestnut have been collected from different states and evaluated. Promising lines of sweet potato, colocasia, cassava, elephant foot yam and arial yam have been identified. Further, the host-pest interaction and its dynamics in mango have been studied under climate change scenario in eastern region. For augmenting the availability of quality seeds of pluses, two pulse seed hubs have also been sanctioned to the institute.

Characterization of Gangatiri, an indigenous breed of cattle, was completed in its home tract of Bhojpur and Buxar districts. Comparative performance of Khaki campbell, White pekin and indigenous duck germplasm collected from Odisha, Jharkhand, Bihar and West Bengal was evaluated. Regarding fish health, five districts of Bihar were surveyed to detect the presence of viral diseases of Indian Major Carps through PCR.

The institute has also been providing technological support to the farmers of the eastern region of India through its extensive extension network. A total of 122 training programmes, 20 FLDs and 26 OFTs have been conducted for the farmers and state officials. Thirty four villages of four districts of Bihar and Jharkhand were covered under *Mera Gaon Mera Gaurav* to make the farmers aware of improved technologies. Scientists of the institute have also excelled in strategic and adaptive research, made good contribution in publication of quality research papers in the journal of national and international repute.

I acknowledge the consistent support, keen interest and guidance received from Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR in order to plan and implement various research and extension activities. The encouragement, valuable guidance and support rendered by Dr. K. Alagusundaram, DDG, (NRM) is duly acknowledged. All Heads of Divisions/Research Centres deserves appreciation for submitting their research findings in time. I also express my appreciation to the editorial team of this report.

(B.P. Bhatt)
Director
ICAR-RCER

Contents

1. Executive Summary

- Twenty four rice genotypes were evaluated under vegetative stage drought stress condition. Six genotypes *viz.*, IR88964-11-2-2-3, IR88964-24-2-1-4, IR84899-B-179-16-1-1-1, IR84899-B-183-CRA-19-1, IR83929-B-B-291-2-1-1-2 and IR83929-B-B-291-3-1-1 have been found promising with productivity range of 4.78 – 5.35 t/ha compared to Sahbhagi Dhan (3.70 t/ha).
- Eight rice genotypes IR84899-B-179-16-1-1-1, IR83929-B-B-291-2-1-1-2, IR88964-24-2-1-4, IR84 899-B-179-13-1-1-1, IR88964-11-2-2-3, IR83929-B-B-291-3-1-1, IR83387-B-B-27-4, IR84894-143-CRA-17-1 and IR88963-3-7-2-4 have been found promising for multi-stages drought tolerance with productivity range of 1.05-1.58 t/ha compared to check variety Sahbhagi Dhan (0.78 t/ha).
- Rice genotype IR84896-B-127-CRA-5-1-1 (6.81 t/ha), followed by IR83376-B-B-24-2 (6.58 t/ha) was found superior in terms of photosynthetic activity and produced higher yield under 25% higher CO_2 concentration (500 ppm) as compared to ambient condition (400 ppm).
- Rice genotypes 'IR09L342', 'IR10F198', 'IR11F195' and 'IR10F365' were found to have submergence tolerant for 21 days which showed the superiority over Swarna Sub-1 so far in submergence tolerance was concerned.
- Polythene covering of nursery beds in night times during December and January increased the soil temperature by 2-3^{0}C as compared to normal conditions and increased the germination and early vigour of seedlings and reduced the seedling mortality in boro rice. Application of vermicompost @ 2.0 kg/m^2 in the nursery bed after seed sowing was also equally effective.
- Wheat genotypes NW1014, WH760, Raj 3765, Halna, HD2987 and DBW14 with yield potential of 3.13 to 4.03 t/ha showed higher heat stress tolerance, and application of salicylic acid (0.5 mM) improved the grain number and test weight of wheat genotypes under heat stress condition.
- Based on the process-based climatic phenology model (ILCYM) studies, it was found that the changing climate will be more favorable for mango fruit fly (*Bactrocera zonata)* and its damage potential will progressively increase in all the mango producing regions of India where the pest already prevails.
- Among different tuber crops evaluated, sweet potato line ACC-172, colocasia genotype ACC-269, cassava line ACC-152, elephant foot yam line ACC-134, aerial yam line ACC-123 were found promising.
- Carbon mitigation potential of the litchi orchard was estimated to vary from 0.052 to 1.26 t/ha during 2–10 years of age with a sequestration potential of 0.19–4.63 ton CO_2/ha from the atmosphere.
- The highest water productivity of 14.3, 11.9 and 4.6 kg/m^3 was obtained in case of cabbage, cauliflower and broccoli, respectively under drip irrigation with polythene mulch in eastern Hill & Plateau conditions.
- The complete decomposition of wheat, maize and paddy straw was observed after 7,9 and 10 months of its placement in the field, while the complete decomposition of wheat, maize and paddy roots was observed after 5, 6 and 7 months, respectively.
- In Integrated Farming System, total C-stock was reported as 2.60 and 7.0 Mg C/ha from one and two acre IFS models, respectively after 5 years. An increasing trend was observed in case of NPK & organic carbon status of soil over a period of 5 years due to better resource recycling.
- For weed control in direct-seeded rice, pendimethalin 1.0 kg/ha as pre-em. fb halosulfuron 18 g/ha as post-em. resulted in higher weed control efficiency (84%) and grain yield (5.0 t/ha). Among varieties, hybrid rice 'Arize 6444' resulted in the highest WCE (85%) and grain yield (4.8 t/ha) due to more ground cover and higher no. of tillers.

- Rice—maize—mungbean cropping system recorded the highest rice grain equivalent yield (13.2 t/ha) and water productivity (1.11 kg/m^3), while the lowest values of 9.36 t/ha and 0.76 kg/m^3, respectively, were obtained with rice-wheat—mungbean cropping system.
- In SRI, cost effective Mandava weeder was found more efficient with higher field capacity (0.0178 ha/hr) and weeding efficiency (83-91%) as compared to Conoweeder.
- In rice—lentil—mungbean cropping system, zero till lentil produced higher grain yield (1.13 t/ha) as compared to conventional tilled lentil (1.06 t/ha). There was no advantage of irrigations on the grain yield of lentil due to sufficient residual soil moisture.
- A multiple use of a single solar array was explored for performing various operations such as groundwater pumping, aerating fishpond, supplying pressured water at 1.2-1.5 kg/cm^2 for operating pressurised irrigation system for irrigating crops and washing cattle shed, and also to operate humidifier at more than 6.0 kg/cm^2 for management of microclimate in cattle shed.
- In buffalo improvement programme, wet average, herd average and average peak milk yield of Murrah buffalo were recorded at 6.07, 4.93 and 9.01 kg, respectively with highest yield of 20.6 kg per day. Average lactation yield, lactation length, service period and inter-calving period of Murrah buffalo were observed at 1645.53 ±5.24 kg, 312.76±4.17 days, 168.35±7.17 days and 412.16±3.07 days, respectively.
- Gangatiri, an indigenous breed of cattle, was characterized in its home tract of Bhojpur and Buxar districts. Daily milk yield varied from 2-6 litres with peak yield of 8 litres. The average age at first calving was also recorded at 42 to 48 months.
- Daily milk yield of Sahiwal cattle was recorded at 9.3 kg. Average daily body weight gain of male calves upto 4 months of age was recorded at 227 g/day as compared to body weight gain of 203 g/day in case of HF x Indigenous cross-bred calves.
- Studies on blood profiles of buffalo during peak winter (temperature 2-4^oC) indicated the reduction of Hemoglobin (12.98±1.17 g/dl) and total erythrocyte counts (6.9±1.08 10^6 /µL) as compared to values (13.79±1.28 g/dl and 7.43 ± 0.94 10^6/µL) observed during pre-winter season.
- Comparative performance of Khaki Campbell, White Pekin and indigenous duck germplasm collected from Odisha, Jharkhand, Bihar and West Bengal were evaluated. Hen day egg production up to 30th week of age was recorded the highest in Khaki Campbell (45%), followed by indigenous ducks of Odisha (35 %), Jharkhand (28 %) and Bihar (27 %). Hatchability percentage was highest in Khaki Campbell (70%) followed by White Pekin (65%), Odisha Desi (60%), Jharkhand Desi (60%) and Bihar desi (55%).
- Various integrated fish farming models, developed by the institute, showed the highest fish productivity in case of cattle-fish integration (4.69 t/ha), followed by goat-fish (4.0 t/ha) integration.
- Five districts of Bihar were surveyed to detect the presence of viral diseases of Indian Major Carps through PCR. After screening of 500 samples during the year, incidence of Koi Herpes Virus (KHV) and Spring Viraemia of Carp Virus (SVCV) was observed negative.
- District wise tabular data have been extracted from the maps of three states *viz.* Bihar, Jharkhand and West Bengal related to different categories of standing water bodies with their area. The compiled information has been sent to the Govt. of Bihar for further use.
- Under the Pulse Seed Hub Project, quality seed of around 9 t lentil (HUL57 & KL125) and 40 t chickpea (Pusa 547) was produced.
- The 2nd Green Revolution cell has been established with its headquarters at ICAR-RCER, Patna to coordinate the research, and identify the development and policy issues related to agricultural development in Eastern states. The Steering Committee meeting, and States Coordination Committee meetings of all the seven states were organised.
- During the year 2016-17, thirty four villages of four districts were covered under *Mera Gaon Mera Gaurav* and 336 farmers were directly benefited through various activities like training, demonstration, availability of quality planting materials etc.
- During the year under report, the Institute published 128 nos. of research papers in the journals of national and international repute, 03 books, 02 policy documents, 35 book chapters, 04 technical bulletins, 06 extension bulletins, 02 training manuals, and 19 popular articles.
- Further, total of 122 training programmes, 20 Front Line Demonstration and 26 On Farm Trials have been conducted for the farmers and the state government officials.

2. Introduction

Historical Perspective

The Eastern region of India covering plains of Assam, West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha and eastern Uttar Pradesh, representing 21.85% of the geographical area and supporting 34% human and 31% livestock population of the country is characterized by rich natural resources but poor productivity and low income. The region has favourable climate and an abundant supply of water, however, frequent occurrence of flood and drought adversely affect the agricultural productivity and livelihood security. The small and scattered land holdings, unavailability of quality seeds and planting material, imbalance use of fertilizer, deterioration of soil health, lack of stress-tolerant crop varieties, poor extension mechanism and marketing of the agricultural products are some of the major bottlenecks to improve upon the productivity and thereby profitability of the farmers. Nevertheless, the region has great potential for crop production, besides livestock and fishery development. It is rightfully thought that the Second Green Revolution would be started in the Eastern region to ensure food security of the nation.

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. Hence, the mandate of the institute is:

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

The modalities to achieve the mandate 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 2016-2017 of the complex is presented below (Table 2.1).

Table 2.1. Financial allocation and expenditure during the year 2016-17 (Rs. in Lakhs)

Head of accounts	Budget allocation		Actual expenditure	
	Plan	Non-plan	Plan	Non-plan
Establishment charges	—	1729.50	—	1729.08
T.A.	18.50	10.75	18.50	10.75
HRD	3.15	0.00	3.15	0.00
Works	66.50	0.00	66.50	0.00
Other charges	351.85	821.04	351.84	812.71
Total	440.00	2561.29	439.99	2552.54

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

3. Weather

At Patna, weather parameters *viz.* air temperature, humidity, rainfall, sunshine hours and pan evaporation at hourly interval were recorded. The total annual rainfall in 2016 was 1053.3 mm which was little below than normal (1127.3 mm) and the year's rainfall was not deficient. The pattern of rainfall over time and intensity was erratic. The monsoon rainfall (824.4 mm) was near to normal (951.9 mm). It was the highest in month of September (375 mm) and the lowest in month of June (53.7 mm). The good amount of rainfall was received in non monsoon months (May, 124.8 mm and October, 96.6 mm). Mean monthly maximum temperature varied from 39.1 °C in April to 20.5 °C in December. Similarly, mean monthly minimum temperature varied from 26.9 °C in August to 8.72 °C in January. Weather data indicated maximum deviation of -4.1 °C from normal maximum temperature in the month of December. The average relative humidity and sunshine hours were 68.40% and 4.23 hrs, respectively. The highest average daily sunshine hours was recorded in the month of April (7.05 hrs/day) whereas the lowest was in the month of December (0.62 hrs/day). Summary of the monthly meteorological data for the year 2016 is presented in Table 3.1. Trend in monthly variation of temperature and rainfall is presented as Fig. 3.1.

At Ranchi, the annual rainfall during 2016 was 964 mm of which 83.3% (803 mm) was received during the monsoon months. All the months, except July, recorded below normal rainfall while the annual rainfall was 434 mm less than the long-term normal rainfall, leading to annual rainfall deficit of 31.1%. Comparison of monthly rainfall with the

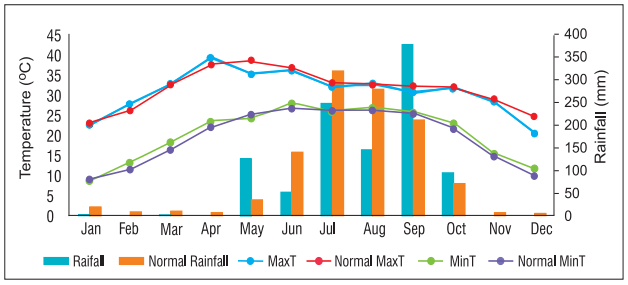


Fig. 3.1. Monthly variation of temperature and rainfall during 2016 at Patna

Table 3.1. Monthly meteorological data of 2016 at Patna

Month	Temperature (°C)				Avg. RH (%)	Avg. sunshine (hrs/day)	Total rainfall (mm)		Rainy days	Pan. evaporation (mm)
	Max.	Normal	Min.	Normal			Observed	Normal		
January	22.7	23.0	8.7	9.3	71.24	1.85	3.40	20.4	2	38.6
February	27.7	26.1	13.4	11.6	63.50	5.61	0.0	11.1	0	89.7
March	32.7	32.4	18.3	16.4	53.00	6.85	3.0	11.4	1	193.5
April	39.1	37.4	23.4	22.1	40.20	7.05	0.0	9.0	0	351
May	35.1	38.4	24.2	25.1	63.00	5.32	124.8	35.6	6	232.4
June	36.1	36.7	27.9	26.7	67.65	4.66	53.7	141.1	5	219.1
July	32.1	32.9	25.9	26.1	81.30	1.84	248.9	319.2	9	137
August	32.7	32.5	26.9	26.1	76.65	5.01	146.8	279.0	10	161.8
September	30.7	32.2	25.8	25.3	85.30	1.45	375	212.6	11	109.1
October	31.8	31.7	23.0	21.6	73.86	6.09	96.6	72.3	4	110.7
November	28.4	28.9	15.5	14.8	64.40	4.46	0.0	8.2	0	58.1
December	20.5	24.6	11.9	10.1	82.58	0.62	1.10	7.4	1	31.8
Annual	30.8	31.4	20.4	19.6	68.40	4.23	1053.3	1127.3	49	1732.8

monthly normal rainfall is presented in Fig. 3.2. The relative humidity ranged from 82.3 to 91.3%. Summary of the monthly climatic parameters is presented in Table 3.2. A total of 59 rainy days were recorded during 2016, of which 42 rainy days occurred during the monsoon season. The month of August recorded maximum (17) number of rainy days.

Air Temperature

Trends of the mean monthly maximum and minimum air temperature at Ranchi are presented in Fig. 3.3. During 2016, January was the coldest month with mean monthly minimum temperature of 8.9°C while April was the hottest month with mean maximum temperature of 39.2 °C. The highest and the lowest values of daily weather parameters observed during 2016 are presented in Table 3.3.

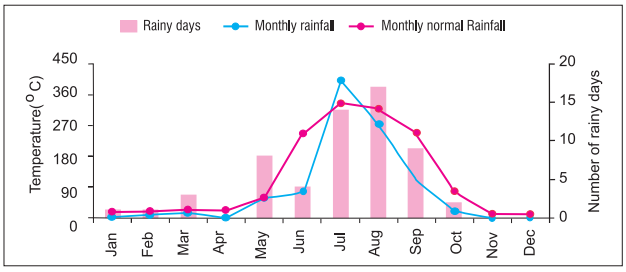


Fig. 3.2. Comparison of monthly normal rainfall with monthly rainfall for the year 2016

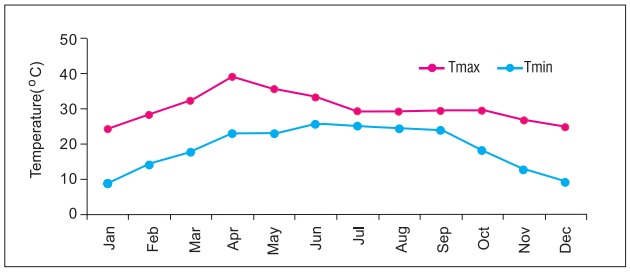


Fig. 3.3. Mean monthly minimum and maximum air temperature during 2016

Table 3.2. Mean monthly weather parameters at ICAR-RCER, Research Centre Ranchi for 2016

Month	Average temperature (°C)		Mean relative humidity (%)	Monthly rainfall (mm)
	Min.	Max.		
January	8.9	24.4	85.6	5
February	14.2	28.4	84.5	8
March	17.8	32.5	82.8	14
April	23.2	39.2	82.3	0
May	23.0	35.8	87.4	58
June	25.8	33.4	91.3	76
July	25.2	29.4	91.2	401
August	24.4	29.4	89.2	272
September	24.0	29.5	90.1	110
October	18.3	29.5	87.2	20
November	12.7	26.8	88.4	0
December	9.3	25.0	88.4	0
Annual	18.9	30.3	87.4	964*

*Total annual rainfall

Table 3.3. Important highest and lowest weather parameters observations during 2016

Weather parameter	Value	Date
Highest maximum temperature	41°C	22nd Apr 2016
Lowest minimum temperature	5.2°C	23rd January 2016
Maximum one day rainfall	98 mm	4th July 2016
Highest relative humidity	95%	3rd September 2016
Lowest relative humidly	50 %	25th February 2016

4. Climate Change

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

Four wheat genotypes (HD 2967, HD 2733, HD 3093 and DBW 17) and four rice genotypes (Rjendra Bhagwati, IR64, IR83376-B-B-24-2 and IR84896-B-127-CRA-5-1-1) were evaluated inside open top chambers (OTCs), with an objective to assess the impact of elevated CO_2 and temperature on morpho-physiological traits and yield. The treatments condition in each OTC was OTC1 (ambient CO_2; 400 ppm), OTC2 (25% higher CO_2; 500ppm), OTC3 (500 ppm + 2°C > ambient temperature) and OTC4 (2 °C > ambient temperature). Study revealed photosynthetic rate and starch content improved under elevated CO_2 concentration across the wheat and rice genotypes. Moreover, wheat genotype HD 2967 was more responsive towards elevated CO_2 as compared to other genotypes. While DBW 17 was found over all resilient towards varying climatic conditions provided inside OTCs (Fig. 4.1). Among rice genotypes, IR84896-B-127-CRA-5-1-1 (6.68 t/ha) followed by IR83376-B-B-24-2 (6.85 t/ha) were more responsive towards elevated CO_2. These genotypes also performed better under high temperature conditions (Fig. 4.2). The photosynthetic rate of these genotypes was also improved under elevated CO_2 condition (Fig. 4.3).

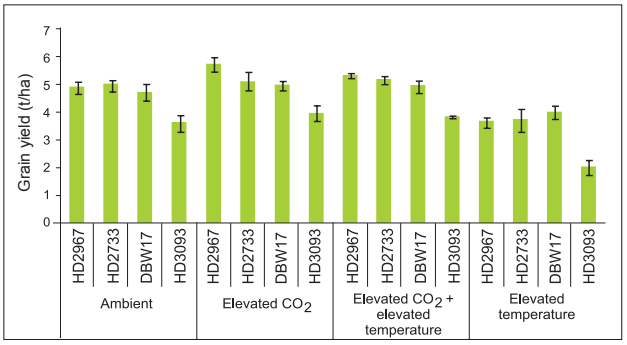


Fig. 4.1. Grain yield of wheat genotypes under different climatic conditions inside OTC

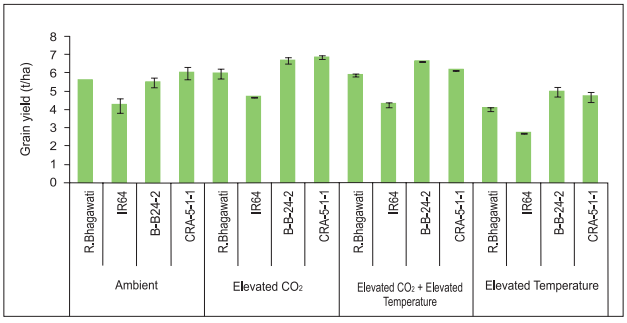


Fig. 4.2. Grain yield of rice genotypes under different climatic conditions inside OTC

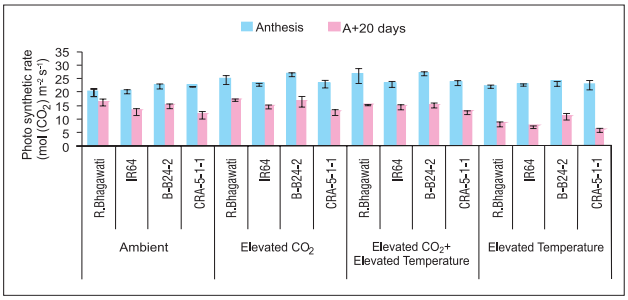


Fig. 4.3. Photosynthetic rate of rice genotypes under different climatic conditions at anthesis (A) and A+20 days.

Characterization of wheat genotypes for terminal heat stress tolerance

Fifteen wheat genotypes were evaluated for heat tolerance during *Rabi* season of 2015-16. Wheat genotypes NW 1014, NW 1012, Halna, WH 760 and HD 2987 performed better as compared to high yielding cultivars (HD 2733 and HD 2967) under late sown heat stress condition. Relative water content (RWC), membrane stability (MSI), chlorophyll content and photosynthetic rate of wheat genotypes showed declining trend from timely sown (TS) to very late sown (VLS) heat stress condition, while the activity of antioxidant enzyme catalase (CAT) increased. The promising genotypes HD 2987, NW 1014, Halna, GW 273, WH 760, and NW 1012 were able to maintain higher RWC (%), MSI (%), chlorophyll content and photosynthetic rate as compared to other genotypes under late

sown heat stress condition. The wheat genotypes NW 1012 (3.54 t/ha), Raj 4238 (3.13 t/ha), WH 760 (4.03 t/ha) and NW 1014 (3.99 t/ha) performed better. Due to impairment of starch mobilization the pollen viability was reduced which in turn resulted in poor grain set (Fig. 4.4). Moreover, salicylic acid (SA) has the positive impact on wheat genotypes under heat stress condition particularly on ascorbic acid, carotenoid, grain number per ear and 1,000 grain weight. Our findings strongly indicated that SA effect was traits specific and differential (Fig. 4.5).

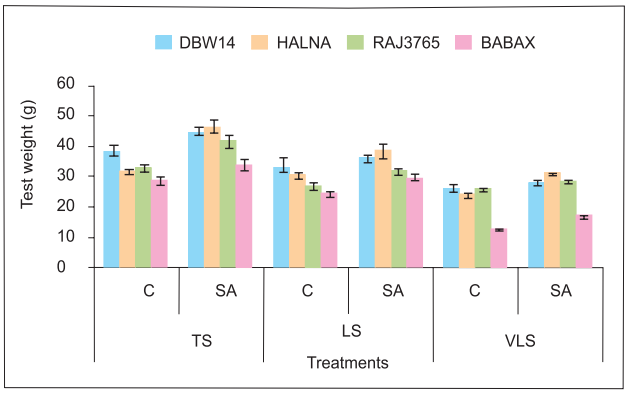
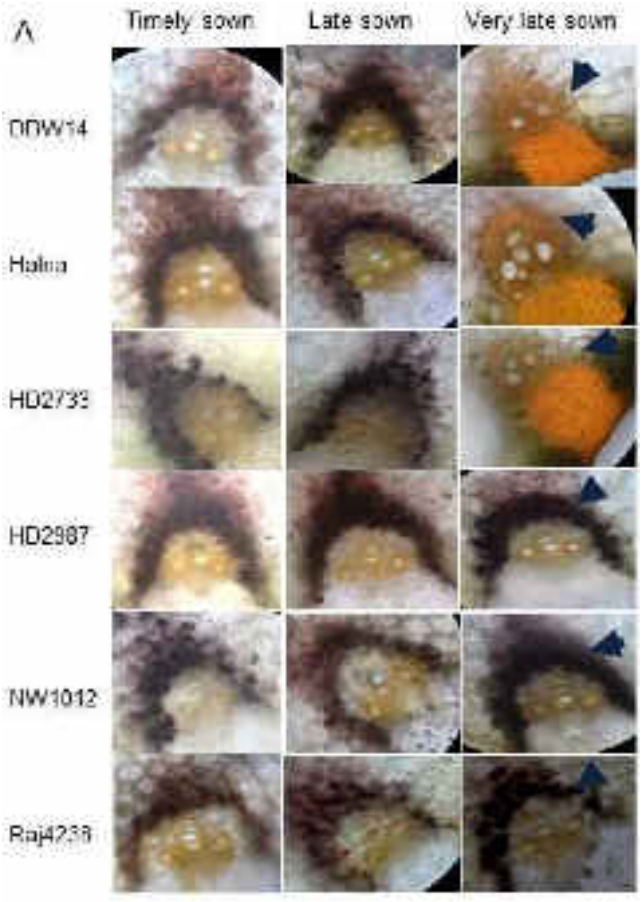


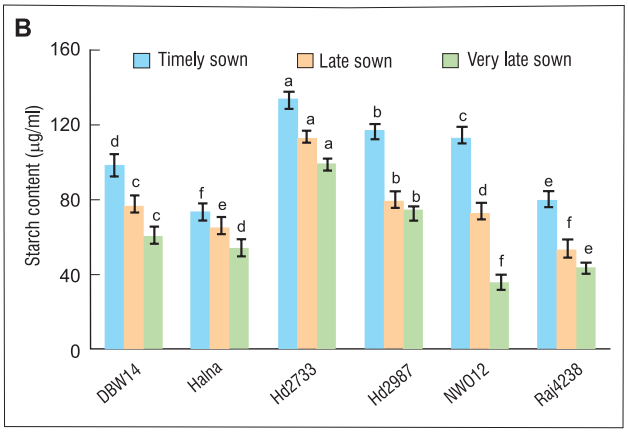
Fig. 4.5. Effect of SA (0.5 mM) on test weight of wheat genotypes under normal and heat stress conditions.

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

Insect population dynamics in relation to changing weather

Real time pest dynamics (RTPD) data was recorded for development of forewarning model of mango pests under climate change scenario through a better understanding of host pest interaction and dynamics in mango. Weekly population of fruit flies in para-pheromone traps in mango orchards was interpreted with soil moisture data and respective average temperature (Fig. 4.6). Soil moisture between 6-8% and soil temperature between 25-30°C were found to be the most favourable for fruit flies population build up. High level of fruit fly catches coincided with marble stage of mango fruits.





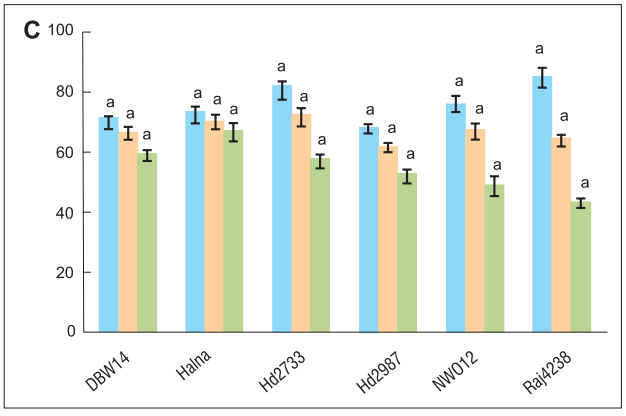


Fig. 4.4. (A) Effect of heat stress on starch flow from first node, (B) starch content of flag leaves, (C) and pollen viability (D) of wheat genotypes grown at timely sown, late sown and very late sown conditions.

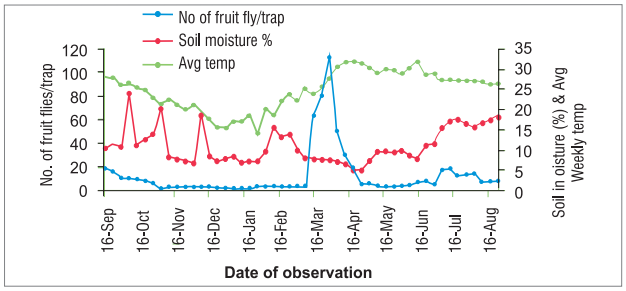


Fig. 4.6. Relationship between fruit fly population in para-pheromone traps v/s soil moisture and average weekly temperature

Insect-pest forecasting using ANN models

Artificial neural network (ANN) based models were evaluated for their applicability in forecasting of hopper, thrips and leaf webber incidence in mango. The feed-forward-back propagation ANN models with different architectures were evaluated on the basis of coefficient of determination (R^2) and mean squared error (MSE). Long term (5-13 year) weekly data pertaining to mean maximum temperature, mean minimum temperature, rainfall and mean relative humidity were used as main inputs to the ANN model. The model was structured to output the weekly average insect pest population. The developed ANN models were trained with input climate data shifted backwards by one and two weeks so that the model can forecast the pest population in one and two week advance, respectively. There was good degree of agreement between the observed and predicted weekly pest populations at all the five mango growing regions of the country (Fig. 4.7). The performance parameters, R^2 and MSE, for different model structures and under different prediction scenarios are presented in Table 4.1. At all the locations, the ANN model having 10 number of hidden neurons performed better in forecasting of hopper population. The developed models will be applicable in predicting the pest incidences in one or two weeks in advance, leading to the formulation of better management alternatives.

Impact of climate change on distribution and activity of *B. zonata*

A process-based climatic phenology model (IL-CYM) was used for predicting future distribution and abundance (damage potential) of *Bactrocera zonata* (Saunders) under changing climate scenario. This was achieved by erecting thermal reaction standards on artificial diet under laboratory conditions for cohorts of each life stage, at both constant and fluctuating temperatures within the ecologically relevant range for its development. Establishment, generation and activity generated risk indices were implemented in a geographic

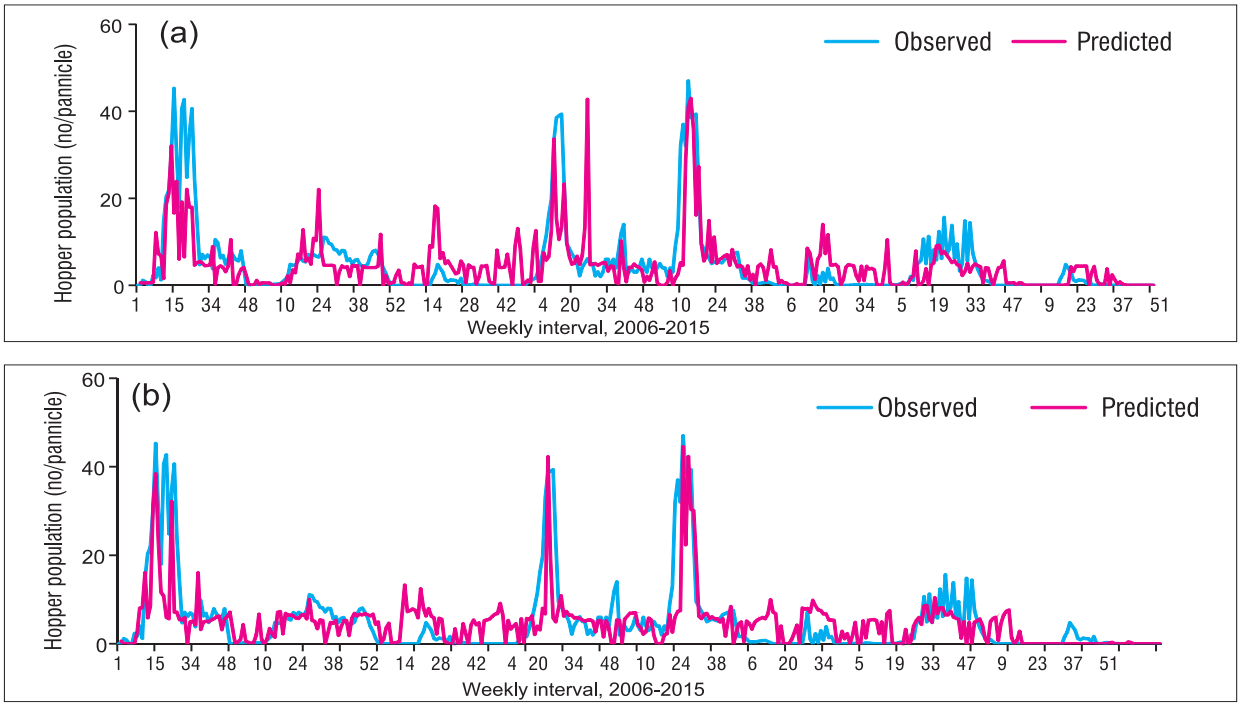


Fig. 4.7. Comparison of observed and ANN model predicted hopper population at Lucknow (a) one week advance, (b) two week in advance

Table 4.1. Performance parameters for the best ANN models in forecasting pest population dynamics across six mango growing regions of India

Location	Mango Hopper				Thrips			
	Advance prediction, week	Number of hidden neurons	MSE	R^2	Advance prediction, week	Number of hidden neurons	MSE	R^2
Bangalore	2	10	0.26	0.80	2	3	0.15	0.81
Ranchi	1	10	5.81	0.92	1	3	0.22	0.96
Paria	2	10	0.12	0.80	1	3	0.55	0.70
Sangareddy	1	10	4.28	0.95	1	3	0.03	0.91
Vengurla	0	10	0.03	0.96	1	10	0.06	0.92
Lucknow	1	10	4.68	0.28	1	10	2.46	0.74

information system (Arc-GIS) environment to map and quantify changes for climate change scenarios of the year 2050 based on downscaled climate-change data of the scenario A_1B from the WorldClim database. Results revealed that optimum temperatures for development of eggs, larvae and pupae were determined as 25.0°C, 25.8°C and 26.3°C, respectively through a linear model with corresponding lower development thresholds being 9.1, 11.2, and 13.8°C. Females could lay no eggs at the extreme low (15°C) and high (35°C) tested temperatures, demonstrating the importance of optimum temperature in determining the suitability of climate for the mating and reproduction in *B. zonata*. Study also concludes that the changing climates will be more favorable for *B. zonata* and its damage potential will progressively increase in all the mango producing regions of India where the pest already prevails (Fig. 4.8).

Impact of climate change on mango fruit fly (*Bactrocera dorsalis*)

The spatial and temporal changes in voltinism of three major mango fruit fly species *viz.*, *Bactrocera dorsalis*, *Bactrocera correcta* and *Bactrocera zonata* were estimated using growing degree days models with temperature data from MarkSim® DSSAT weather file generator in major mango regions of India. The daily temperature projections were generated from each combination of eight GCMs (BCC-CSM1-1, CSIRO-Mk3-6-0, FIO-ESM, GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-MR, MIROC-ESM-CHEM and Ensemble), four scenarios (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5) and three time periods (2020s, 2050s and 2080s). It is predicted that 1-3 more generations would occur during the three future climate periods with significant variation among scenarios, models and locations

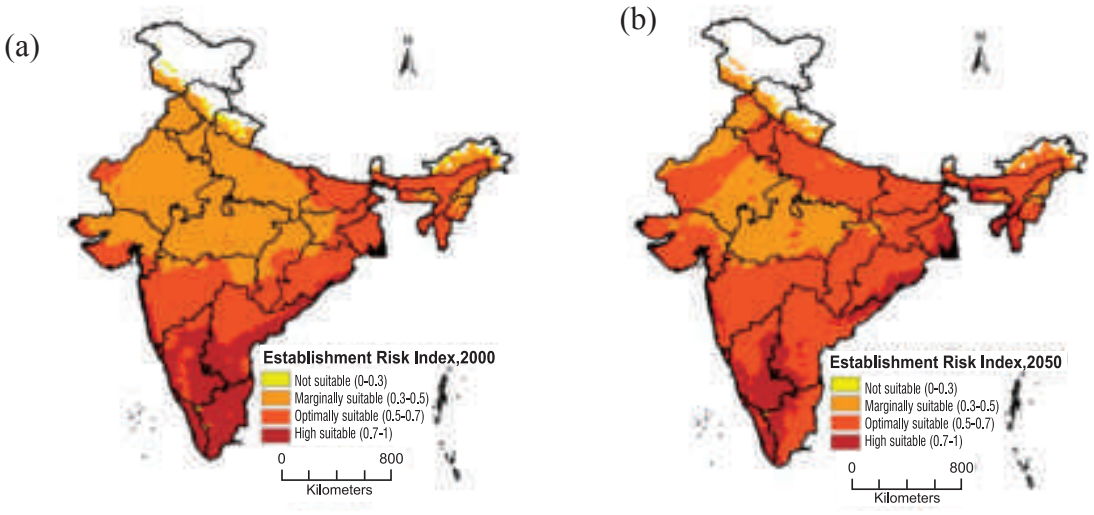


Fig. 4.8. Change in establishment and future distribution of B. zonata in India based on establishment risk index

(Fig. 4.9). Increased number of generations across ten mango growing locations of India suggests that the incidence of fruit flies may increase due to projected increase in temperatures in future climate change periods.

Fruit flies (*Tephritidae: Diptera*) diversity and their host plant determination from eastern region of India

For determination of species diversity of fruit flies in eastern part of India, survey was conducted at Faizabad (U.P.), Varanasi (U.P.), Jaspur (Chhattisgarh), Motihari (Bihar), Murshidabad (West Bengal) and Ranchi, Lohardaga and Gumla districts of Jharkhand. Fruit flies were collected through methyl eugenol and cue lure based para-pheromone traps from each place. Three fruit flies species *viz.,Bactrocera dorsalis*, *Bactrocera correcta* and *Bactrocera zonata* were trapped in methyl eugenol while *Zeugodacus cucurbitae* and *Bactrocera tau* were trapped in cue-lure para-pheromone traps from different places. Among five species, *Z. cucurbitae* was observed to be the dominant species with the highest percentage at Murshidabad (73.11%), Faizabad (87.17%) and Varanasi (48.14%). However, next dominant species was observed to be *B. dorsalis* (46.91% at Varanasi and 6.41% at Faizabad). *B. zonata* was found to be major species (>90.0%) at Jaspur (Chhattisgarh) followed by *B. dorsalis* and *B. correcta*. Data from Motihari showed that *B. zonata* and *B. dorsalis* were equally distributed in methyl eugenol traps while *Z. cucurbitae* was dominant in cue lure traps. *B. zonata* and *Z. cucurbitae* were the major and dominating species in Jharkhand state.

A field experiment was conducted at ICAR RCER, RC Ranchi to assess the losses in cucurbitaceous vegetables due to fruit fly infestation. The field was kept free from any kind of chemical or other management practices. The yield loss due to fruit fly infestation was calculated by dividing the infested fruit number by the sum of the total fruit number of the respective plot. Yield losses due to fruit fly infestation varied from 20 to 37% in different cucurbits and the damage caused by fruit fly was the most serious in musk melon (37%) (Fig. 4.10). The minimum cumulative yield loss (20%) was recorded in case of ridge gourd and sponge gourd.

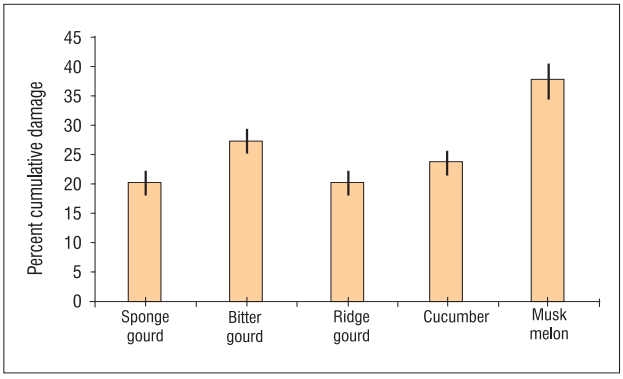


Fig. 4.10. Level of fruit fly infestation (%) in different cucurbitaceous vegetables

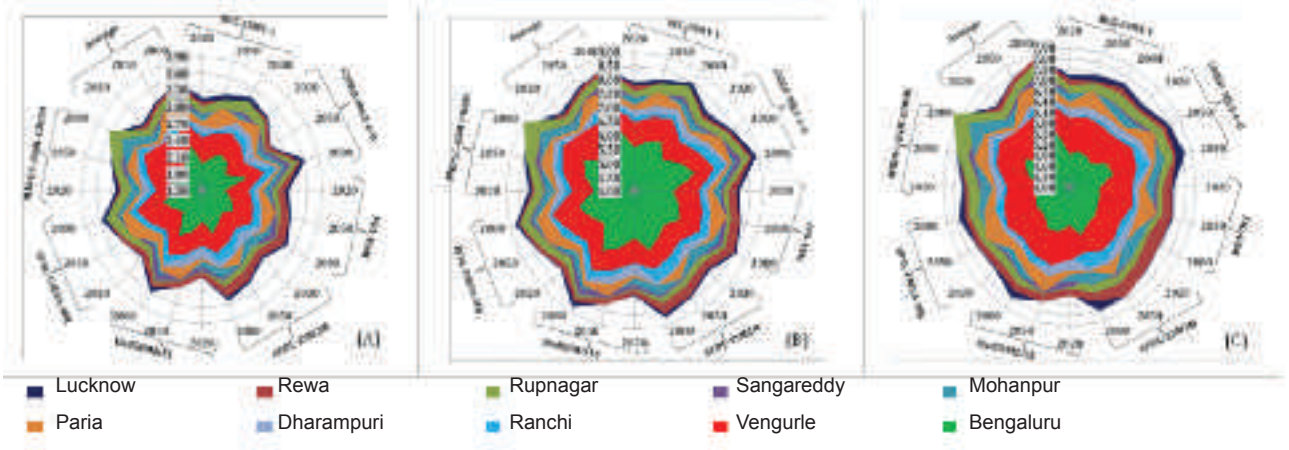


Fig. 4.9. Inter model variation in number of generations of fruit flies (A= B. correcta; B= B. dorsalis; C= B. zonata) during future climate change periods across ten locations of mango producing belts of India.

5. Cereals

RICE

Evaluation of Rice Genotypes for Tolerance to Drought at Multi-stages in DSR

Drought is the most important constraint reducing rice yield in rainfed and poorly irrigated areas. Moreover, in most rainfed regions, the probability of occurrence of terminal reproductive-stage drought is high due to the early withdrawal of monsoon rains. Twenty four rice genotypes were evaluated during *Kharif* 2016 under dry direct-seeded condition for drought tolerance at various growth stages. Under stress condition, one light irrigation was given after sowing to ensure proper germination and thereafter crop was left rainfed. Crop faced 10 days, 9 days, 7 days and 13 days water stress at seedling, vegetative, reproductive and physiological maturity stages, respectively. The non-stress plots were maintained by applying irrigation as and when required. Results revealed that nine rice genotypes were found promising under multi-stages drought stress condition as compared to checks (Table 5.1). Grain yield of different genotypes varied from 0.10 to 1.58 t/ha and 3.71 to 5.21 t/ha under stress and non-stress conditions, respectively. Irrespective of genotypes, drought stress at various growth stages caused significant reduction in grain yield (82.2%), plant height (25.1%), panicle length (6.91%), test weight (10.9%), spikelet fertility (38.4%), relative water content (22.7%), photosynthetic rate (53.4%), stomatal conductance rate (69.2%), chlorophyll content (59.5%) and transpiration rate (40.0%); however, the responses varied among genotype. Minimum yield reduction was observed in IR 84899-B-179-16-1-1-1 (67.3%) and maximum in IR 64 (97.4%) (Fig. 5.1).

Table 5.1. Performance of promising rice genotypes under drought stress and non-stress conditions.

Rice genotypes	Grain yield (t/ha)		Spikelet sterility (%)		Test weight (g)		Photosynthetic rate [μ mol (CO_2)/ m^2 /s]		Chlorophyll content (mg g^{-1} FW)	
	S	NS	S	NS	S	NS	S	NS	S	NS
IR 84899-B-179-16-1-1-1	1.58	4.82	15.7	4.8	23.1	24.3	12.9	19.4	3.57	7.38
IR83929-B-B-291-2-1-1-2	1.49	4.61	12.1	3.8	22.5	24.9	14.9	18.2	3.41	6.82
IR 88964-24-2-1-4	1.23	5.04	13.5	6.6	22.5	25.5	12.6	19.8	3.53	7.03
IR 84899-B-179-13-1-1-1	1.20	4.74	14.3	7.2	22.2	25.3	11.2	19.7	3.58	6.19
IR 88964-11-2-2-3	1.15	4.96	9.5	6.8	23.1	25.5	10.8	18.5	3.21	6.80
IR83929-B-B-291-3-1-1	1.16	4.58	12.2	8.1	21.7	22.9	9.3	17.7	2.92	5.97
IR 83387-B-B-27-4	1.08	5.12	15.8	7.7	23.8	24.3	9.8	17.3	2.62	8.32
IR84894-143-CRA-17-1	1.07	4.45	12.1	6.3	19.9	20.8	10.7	20.3	3.44	5.94
IR88963-3-7-2-4	1.05	4.24	18.6	9.7	22.2	23.4	11.7	18.6	3.71	7.66
Sahbhagi Dhan	0.78	3.79	19.1	8.6	18.9	24.7	9.6	19.7	3.03	6.65
Rajendra Sweta	0.14	3.82	54.2	8.4	10.5	12.3	3.2	17.1	1.37	5.27
Rajendra Bhagwati	0.11	4.15	55.5	5.5	20.4	25.8	4.2	19.5	1.49	8.50
IR64	0.10	3.87	59.1	5.0	17.9	25.2	4.4	18.5	2.05	5.63
MTU 1010	0.64	4.48	21.1	4.4	22.4	26.3	5.6	19.5	2.48	5.79
Mean	0.79	4.44	21.2	7.04	21.2	23.8	8.73	18.75	2.71	6.70
LSD	0.22	0.87	7.9	3.4	1.08	2.24	2.3	2.9	0.25	0.68

S = Stress, NS = Non-stress

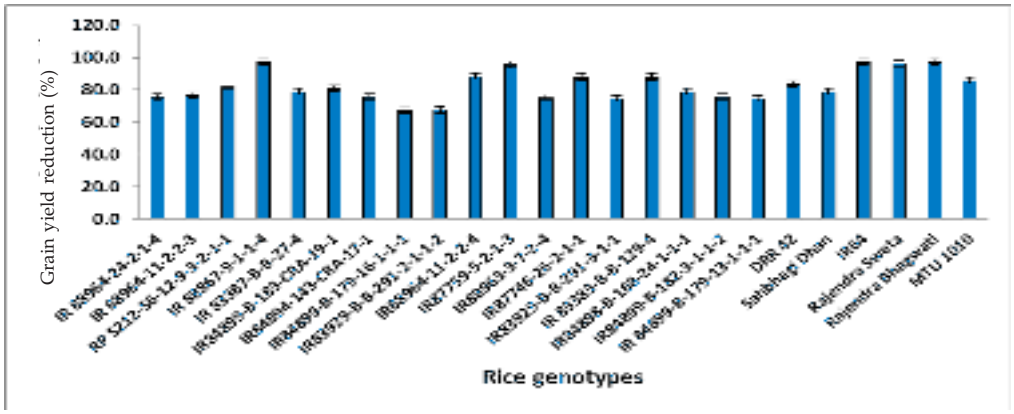


Fig 5.1. Yield reduction in rice genotypes under drought stress condition

Evaluation of rice genotypes for drought tolerance in transplanted condition

Twenty four rice genotypes were screened for vegetative stage drought tolerance during *Kharif*, 2016. Fourteen days old seedlings were transplanted into puddled fields. The stress was created by draining out the water 10 days after transplanting, and no supplemental irrigation was provided till completion of vegetative phase. Vegetative stage drought stress caused 28.5% reduction in yield as compared to non-stress condition. Among rice genotypes, IR88964-11-2-2-3 (5.35 t/ha), IR88964-24-2-1-4 (5.19 t/ha), IR 84899-B-179-16-1-1-1 (5.08 t/ha), IR84899-B-183-CRA-19-1 (4.90 t/ha), IR83929-B-B-291-3-1-1(4.78 t/ha), IR83929-B-B-291-2-1-1-2 (4.72 t/ha), IR 84899-B-179-13-1-1-1 (4.50 t/ha) and IR 83383-B-B-129-4 (4.48 t/ha) were identified as promising.

In another experiment sixty three rice genotypes received from IRRI along with some local varieties were evaluated during *Kharif* 2016 for drought tolerance at reproductive stage (Fig. 5.2). Sixty days old seedlings were subject to drought by withholding irrigation and withdrawing water from the field. Thereafter crop was left rainfed and there was no standing water up to maturity. Non-stress irrigated experimental field was kept continuously flooded after transplanting until 20 days before harvest. Grain yield varied from 6.08-9.34 t/ha and 4.02-5.75 t/ha under non-stress (irrigated) and stress (drought) conditions, respectively. Drought stress at reproductive stage caused significant reduction in grain yield (36.6%), plant height (14.5%), plant biomass (8.53 %), relative water content (13.9%), chlorophyll content (15.3%) and photosynthetic rate (21.4%) in rice genotypes; however, the responses varied among genotype.

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

Among rice genotypes, IR 93827-29-2-1-3 (5.75 t/ha), IR 102860-10:6-B-B (5.64 t/ha), IR 93810-17-1-2-3 (5.55 t/ha), IR 93827-29-1-1-3 (5.55 t/ha), IR 95793-5-2-2-3 (5.52 t/ha), IR 95785-5-2-2-2 (5.51 t/ha) and IR 93827-29-1-1-2 (5.47 t/ha) were found promising (Table 5.2).

Besides, twenty drought donor lines were also evaluated under stress condition imposed at reproductive stage. Five lines *viz.*, IR 119 (6.76 t/ha), B6149F-MR-7 (5.64 t/ha), Vellai Seeneeti (5.57 t/ha), NS 252 (5.29 t/ha) and Gopal (5.11 t/ha) showed tolerance to drought at reproductive stage as compared to Swarna (3.82 t/ha) and IR64 (3.99 t/ha). Promising drought donor lines may be utilized in drought breeding programme.

Evaluation and characterization of rice genotypes for aerobic condition

Twenty rice genotypes were evaluated during *Kharif*, 2016 under direct seeded aerobic condition. Rice genotypes Swarna Shreya (5.67 t/ha), IR84899-B-185-8-1-1-2 (5.58 t/ha), IR84899-B-183-20-1-1-1 (5.54 t/ha), IR84899-B-185-8-1-1-2 (5.42 t/ha),

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

Name of rice genotypes	Days to 50% flowering		Plant height (cm)		Grain yield (t/ha)	
	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress
IR 93827-29-2-1-3	80	89	111	117	5.75	8.09
IR 102860-10:6-B-B	84	93	110	120	5.64	8.69
IR 93810-17-1-2-3	80	89	104	109	5.55	9.21
IR 93827-29-1-1-3	78	87	110	118	5.55	8.80
IR 95793-5-2-2-3	74	83	100	102	5.52	7.87
IR 95785-5-2-2-2	75	82	105	114	5.51	7.93
IR 93827-29-1-1-2	78	87	110	112	5.47	8.90
GSR IR1-DQ112-Y1-D2	75	80	88	97	5.41	7.41
IR 93856-10-2-3-2	73	81	96	98	5.52	7.75
IR 92540-8-3-3-1	79	87	109	110	5.30	7.91
Sahbhagi Dhan	78	83	104	115	4.66	7.62
IR 64	76	82	99	104	4.19	6.56
MTU 1010	78	83	102	108	4.75	7.81
Mean	79	86	106	111	4.91	7.87
LSD (P=0.05)	0.52	5.54	6.26	8.90	0.82	1.32

IR83929-B-B-291-2-1-1-2 (5.41 t/ha) and IR84898-B-165-9-1-1 (5.39 t/ha) were found promising as compared to check 'Sahbhagi Dhan' (3.62 t/ha).

Evaluation of rice genotypes for tolerance to multiple stresses (drought and submergence)

Eighteen rice genotypes were evaluated during *Kharif* 2016 under drought and submergence conditions (Fig. 5.3). Under drought stress experiment, crop faced stress at reproductive stage. Sixty days old seedlings were subjected to drought by withholding irrigation and withdrawing water from the field. Thereafter crop was left rainfed. Under submergence experiment, plants were subjected to three times complete submergence [first time for a period of 18 days (after 10 days of transplanting); second time for 10 days (10 days after first recovery) and third time for five days (20 days after second recovery)]. The crop was kept submerged under 1.0 to 1.25 m water depth for desired period and thereafter water was drained out from the field. The control (irrigated) trial was maintained by applying irrigation as and when required. Results revealed that irrespective of the genotypes, there was significant reduction in grain yield of rice under drought (33.9%) and submergence (91.8%) stress conditions as compared to control (non-stress). Among rice genotypes,

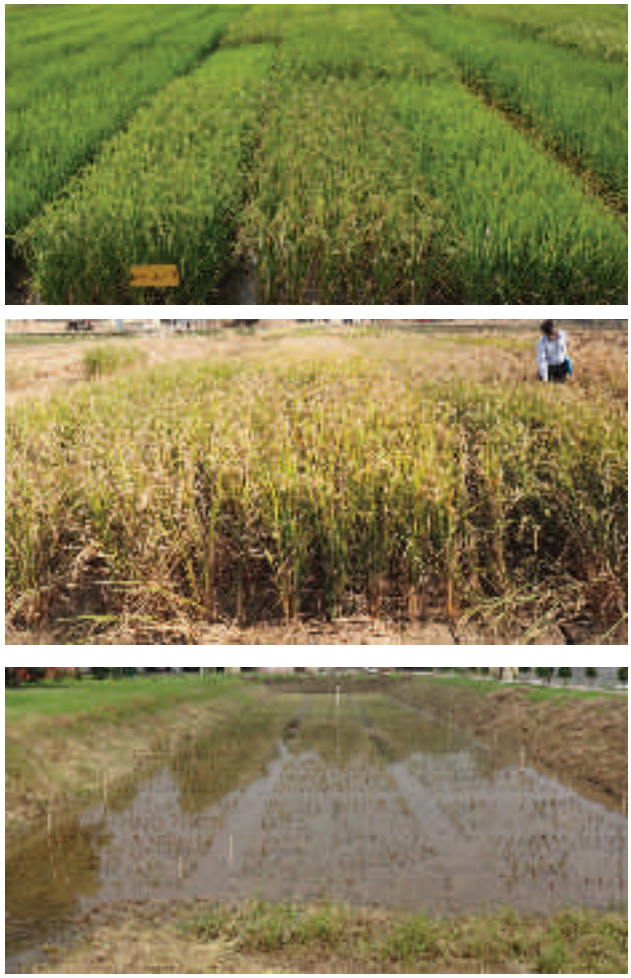


Fig. 5.3. Evaluation of rice genotypes under control, drought and submergence conditions.

IR96322-34-223-B-1-1-1, IR96321-558-563-B-2-1-1, IR96322-34-127-B-2-1-3, IR96321-1447-521-B-2-1-2, IR96321-315-323-B-3-1-1, IR96321-558-257-B-4-1-2 IR96321-558-209-B-6-1-1 were found promising for cultivation under multiple stresses situation. Grain yield of different rice genotypes varied from 2.05-7.29 t/ha, 0.04-1.01 t/ha and 5.90-8.63 t/ha under drought, submergence and control (non-stress) conditions, respectively.

Participatory varietal selection of rice for rainfed ecosystem

Twelve rice genotypes received from IRRI were evaluated in farmers participatory mode under transplanted and direct seeded conditions at on-station as well as on-farm (Fig. 5.4). Among rice genotypes IR 93827-29-1-1-2, IR 93827-29-1-1-4 and IR 95786-9-2-1-2 performed better as compared to check varieties Sahbhagi Dhan and MTU 1010 (Table 5.3). Fifty three farmers' participated in screening of rice genotypes.

Table 5.3. Performance of rice genotypes under rainfed condition

Rice genotypes	Grain yield (t/ha)			
	On-station (trans-planted)	On-farm (direct seeded)	On-farm (trans-planted)	Mean
IR 93827-29-1-1-2	8.19	5.79	5.28	6.42
IR 93827-29-1-1-4	7.60	5.55	5.39	6.18
IR 95785-15-2-1-2	7.01	4.59	4.38	5.32
IR 95786-9-2-1-2	6.11	5.42	5.25	5.59
IR 93809-101-2-2-2	7.56	4.69	4.29	5.51
IR 95836-14-3-1-2	6.17	4.56	4.19	4.97
CN 2044	6.10	4.85	4.52	5.16
PR37956-3B-44-1	6.12	5.19	4.87	5.39
PR37160-8-3-1-1-1-1	6.67	4.68	4.32	5.22
Sahbhagi Dhan	6.42	4.39	4.03	4.95
MTU1010	6.98	4.42	4.14	5.18
Local Check	7.70	4.46	4.28	5.48
Mean	6.88	4.88	4.58	5.13
LSD (P=0.05)	1.20	0.28	0.29	--

Phytosociological studies on weeds

Phytosociological studies on weeds were carried out for selected land use systems in Jharkhand during monsoon, winter and summer seasons. Surveys were conducted to assess the weed types and population in various crops. Weed-crop associations in Hill and Plateau conditions indicated that *Brachiaria deflexa* was dominant species in the crops cultivated during monsoon season while during winter and summer, *Eleusine indica* was found to be the dominant species in most of the agricultural fields. The highest Shannon's Diversity Index for weeds was found to be in the fallow land (1.00) and the lowest was recorded in case of paddy (0.81) (Table 5.4). The total dry weed biomass was higher in case of fallow land (3.82 t/ha) and the least was observed in case of pigeonpea (0.32 t/ha). In total, 99 species of weeds were identified and 13 species remained unidentified due to the absence of flower, fruit or both. When compared with three different seasons, 33 % of the weeds in monsoon season were in common with winter and summer season weeds.

Fig. 5.4. Participation of farmers in varietal selection

Integrated weed management in direct seeded rice

Weed management is the key issue under direct-seeded rice (DSR), and herbicides are the major tool for management of complex weed flora. However, herbicide alone is not sufficient to provide satisfactory weed control in DSR. Hence, an experiment on integrated weed management involving new herbicide molecules and varieties was initiated during *Kharif* 2016 (Fig. 5.5). The major weed flora observed in the field were *Echinochloa* spp., *Cynodon dactylon., Leptochloa chinensis., Physalis minima, Trianthema portulacastrum* and *Cyperus* spp. Results revealed that application of pendimethalin (pre) *fb* halosulfuron (post) resulted in better weed control and higher grain yield (5.0 t/ha), followed by pendimethaline *fb* bispyribac (4.0 t/ha) and pendimethalin *fb* tembotrion (3.8 t/ha). The lowest yield (2.4 t/ha) was observed with

Table 5.4. Species richness, density, basal area and diversity indices of weeds under different weed crop associations during winter and summer seasons.

Crops	Weed diversity parameters				Dry weed biomass (t/ha)
	Species richness	Weed density (No./ha)	Basal area (m^2/ha)	Shannon's index (H')	
Tomato	11	30x104	4.11	0.95	2.28
Brinjal	8	15x104	3.44	0.82	1.86
Turmeric	8	20x104	4.07	0.72	2.42
Pigeonpea	7	18x104	1.51	0.72	0.32
Vegetable soybean	10	17x104	1.40	0.86	1.86
Rice bean	10	27x104	3.54	0.90	2.00
Paddy	9	22x104	1.82	0.81	1.51
Finger millets	9	23x104	1.20	0.85	1.82
Pointed gourd	8	21x104	1.28	0.82	1.05
Bottle gourd	13	32x104	5.99	0.98	1.67
Pumpkin	10	48x104	14.13	0.68	4.15
Cucumber	9	22x104	5.42	0.81	1.77
Tephrosia	7	17x104	0.66	0.78	0.28
Mango (Canopy gaps)	10	25x104	1.83	0.96	3.26
Mango (Closed canopy)	5	23x104	1.75	0.56	0.74
Fallow land	13	42x104	4.25	1.00	3.82

Fig. 5.5. Weed management in direct-seeded rice

pendimethalin alone due to poor weed control. Among varieties, Arize Gold (6444) produced significantly higher grain yield (4.8 t/ha) and BPT 5204 produced the lowest yield (2.9 t/ha) due to severe weed infestation (Table 5.5).

Ferti-fortification (Iron and Zinc) in DSR

Land preparation and water management are the key factors governing the nutrient dynamics in DSR. Since direct seeding follows aerobic cultivation of rice, it usually results in different nutrient deficiencies because in DSR prepared land remains dry and aerobic throughout the season. Under aerobic condition deficiency of Fe is more significant due to oxidation of available ferrous form to unavailable ferric form in soil. Foliar-applied Fe is easily translocated acropetally and even retranslocated basipetally. In aerobic soils, Fe oxidation by root released oxygen reduces rhizosphere soil pH and limits release of Zn from highly insoluble fractions for availability to the rice plant. Keeping these facts in view, a field experiment was conducted by applying zinc and iron as basal and foliar in different concentrations at different stages (Fig. 5.6).

Fig. 5.6. Ferti fortification (Iron and Zinc) in direct seeded rice

Table 5.5. Effect of varieties and herbicides on weeds yield attributes

Treatment	Dose (g a.i./ ha)	Total weed density (no./m^2)	Effective tillers (no./m^2)	Grains/ panicle (no.)	1000- grain wt (g)	Grain yield (t/ha)	Straw yield (t/ha)
Varieties							
Arize 6444	-	93	269	46	23.5	4.8	5.8
Sahbhagi Dhan	-	145	222	39	22.5	3.5	4.6
BPT 5204	-	232	165	30	21.5	2.9	4.3
Swarna Shreya	-	173	214	36	22.4	3.4	4.5
LSD (P=0.05)	-	38	40.5	5.8	1.0	0.4	0.6
Herbicides							
Pendimethalin alone	1000	390	186	31	22.8	2.4	3.6
Pendimethalin fb bispyribac	25	109	235	41	23.1	4.0	5.0
Pendimethalin fb ethoxysulfuron	35	129	222	39	22.9	3.8	4.9
Pendimethalin fb halosulfuron	18	72	258	46	23.4	5.0	6.2
Pendimethalin fb 2, 4-D	500	156	190230	33	22.7	3.3	4.5
Pendimethalin fb tembotrion	120	86	235	38	23.0	3.8	4.8
Pendimethalin fb fenoxaprop	90	171	203	36	23.2	3.5	4.7
LSD (P=0.05)	---	1.52	18.4	6.2	0.3	0.4	0.5

* Pendimethalin at 1000 g ai/ha as pre-emergence. Other herbicides were applied as post-emergence at 20DAS

Results revealed that extraneous application of Fe and Zn sulphate, significantly increased grain yield and nutrient content in grain. Maximum grain yield (5.37 t/ha) was recorded with soil application of zinc sulphate at 25 kg/ha + iron sulphate 25 kg/ha. However, the higher Zn concentration in grain (88.83 mg/kg) was recorded with application of zinc sulphate 25 kg/ha basal + foliar application (0.5% zinc sulphate) at 30 and 45 DAS (Table 5.6). Similarly significantly higher Fe concentration (171.33 mg/kg) was observed with foliar spray of iron sulphate (3% $FeSO_4$ $7H_2O$) at 30, 60 and 75 DAS.

Table 5.6. Effect of soil and foliar application of iron and zinc on nutrient concentrations in grain

Nutrient concentration in grain					
Treatment	N (%)	P (%)	K (%)	Zn (mg/kg)	Fe (mg/kg)
T_1	1.01a	0.24a	0.72a	76.77a	115.33a
T_2	1.05a	0.18a	0.58a	81.13abc	114.80a
T_3	1.06a	0.27a	0.77ab	83.67abc	126.33ab
T_4	1.05a	0.19a	0.81ab	86.33bc	124.67ab
T_5	1.11a	0.20a	0.65a	88.83c	130.47ab
T_6	1.17a	0.24a	0.89ab	78.40ab	139.67b
T_7	1.05a	0.24a	1.17b	79.30ab	171.33c
T_8	1.10a	0.20a	0.92ab	78.73ab	157.87c
T_9	1.09a	0.21a	0.92ab	82.37abc	164.33c
T_{10}	1.07a	0.25a	0.91ab	84.17abc	166.00c

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 /ha as basal; T_4- RDF + Foliar application (0.5% zinc sulphate) at 30 and 45 DAS; T_5- RDF + Zinc sulphate 25 kg /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% FeSO4.7H2O) at 30, 60 and 75 DAS; T_8- RDF + Soil application of 25 kg /ha iron 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; T_{10}-RDF + Tank mixed foliar spray of 0.5% zinc sulphate and 3% iron sulphate at 30 and 60 DAS

Management of low temperature stress in *Boro* rice

The area under *Boro* rice is declining due to higher production costs especially on irrigation, and low profit margin. The crop is being replaced largely by winter maize due to its high productivity and comparatively less production costs. Cold injury of rice seedlings in nursery due to low temperature during December and early January is also the major cause of concern (Fig. 5.7 & 5.8) . Polythene covering of nursery beds in night times during this period has increased the soil temperature by 2-3°C as compared to normal conditions, and resulted in increased germination and early vigour of seedlings, and reduced the

Fig.5.7. Cold injury in boro rice seedlings

Fig. 5.8. Evaluation of rice genotypes for cold tolerance at farmers' fields

seedling mortality (Fig. 5.9 & 5.10). Rice genotypes *viz*., Arize 6444 Gold (7.62 t/ha), CRL 193 (7.45 t/ha), Arize 6129 (6.95 t/ha), RCPR 31 (6.91 t/ha) and Sahbhagi dhan (6.78 t/ha) were found promising. Application of vermicompost @ 2.0 kg/ m^2 in the nursery bed after seed sowing was also equally effective in reducing the cold injury in seedlings and improving the seedlings germination and early vigour. Nursery sowing during 10^{th} to 20^{th} November produced vigorous seedlings. At

Fig. 5.10. Effect of poly tunneling on germination of *Boro* rice seedlings

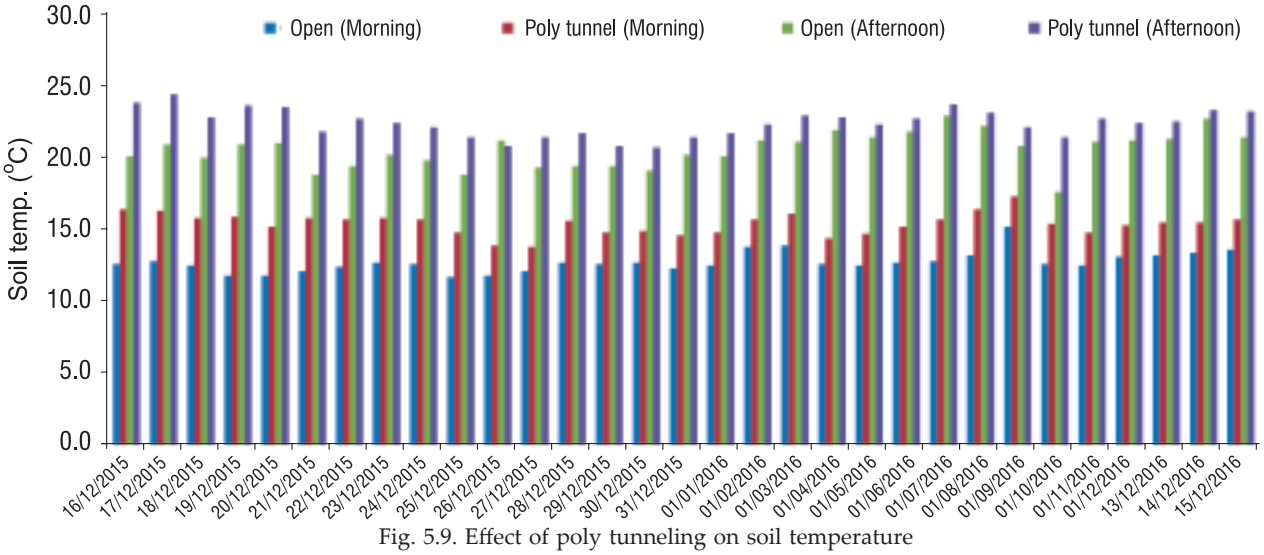


Fig. 5.9. Effect of poly tunneling on soil temperature

farmers fields in Purnea, Katihar and Kishanganj districts of North Bihar, rice genotype PNR 381 was observed to be the most cold tolerant followed by IR 64, Rajendra Bhagawati and IET 4094. The highest grain yield (6.10 t/ha) was found in IR 64 followed by Prabhat (5.24 t/ha).

Management of flood-prone rice

Rice varieties were evaluated for flood tolerance in Purnea, Katihar and Kishanganj districts of north Bihar during *Kharif* 2016. Details of duration and depth of flood in different districts are mentioned in Table 5.7. Results revealed that rice genotypes CR Dhan 909 (6.58 t/ha) and Rajendra Mahsuri (6.05 t/ha) were promising in Purnea East where there was no flood. However, in flood affected areas of Kishanganj and Katihar Swarna Sub-1 tolerated the flood and produced maximum grain yield (5.75-5.96 t/ha) followed by Rajendra Mahsuri (5.03-5.05 t/ha) (Table 5.8).

Table 5.7. Duration and depth of flood in Purnea, Katihar and Kishanganj districts and crop damage

Name of district/block		Flood duration (days)	Depth of flood (m)	Crop damage (%)
Purnea	Amour	20-35	3-3.5	90-100
	Purnea East	Nil	Nil	Nil
Katihar	Katihar	8-10	1.5-2.0	30
	Kadwa	10-20	2.5-3.0	50-75
Kishan-ganj	Kishanganj	10-15	1-1.5	10%

Table 5.8. Grain yield of rice varieties as in flood affected areas

Genotypes	Grain yield (t/ha)			
	Purnea	Kishan-ganj	Katihar	Mean
Swarna Sub - 1	5.07	5.75	5.96	5.59
Rajendra Mahsuri	6.05	5.06	5.03	5.38
CR Dhan 909	6.58	4.88	4.33	5.26
Gutraj	3.73	-	4.48	4.11
B.B. 11	4.25	-	5.20	4.73
Silky	-	4.10	-	4.10
Ranjana	-	4.65	-	4.65
Swarna (MTU 7029)	-	4.19	-	4.19
LSD (P=0.05)	0.45	0.39	0.74	

SORGHUM

Production Potential of Grain Sorghum Cultivars in Non-traditional Areas

Performance of 10 grain sorghum cultivars were evaluated under 2 sowing dates (16 February and 3 March) during summer seasons of 2016. Results revealed that crop sown on 3rd March produced significantly higher grain yield (4.30 t/ha) yields. Among hybrids, 'CSH 16' recorded significantly higher grain yield (5.51 t/ha) followed by 'CSH 13' (4.93 t/ha) and 'CSH 14' (4.45 t/ha); and among varieties, 'SPV 462' (3.89 t/ha) and 'CSV 27' (3.82 t/ha) were promising (Table 5.9).

Table 5.9. Effect of sowing dates with cultivars on grain yield of sorghum (t/ha)

Cultivars	Sowing dates		
	16 February	03 March	Mean
CSH 13	4.00	5.86	4.93
CSH 14	5.04	3.87	4.45
CSH 16	5.43	5.59	5.51
CSH 25	3.67	4.59	4.13
CSH 30	2.14	3.68	2.91
CSV 15	3.54	3.61	3.57
CSV 20	2.85	4.15	3.50
CSV 23	2.33	4.16	3.25
CSV 27	3.80	3.84	3.82
SPV 462	3.80	3.98	3.89
Mean	3.69	4.30	4.00
	Sowing date (D)	Cultivar (C)	D x C
LSD (P=0.05)	0.31	0.47	0.82

Fig. 5.11. Evaluation of sorghum cultivars

6. Pulses

Chickpea

Effect of water management on productivity and seed quality

An experiment was conducted to assess the effect of six irrigation regimes (T_1-T_6) on growth, biomass, and seed yield of chickpea (**Table 6.1**). Chickpea was cultivated on raised beds with and without black polythene mulch and drip irrigation was applied at daily, 1 day and 10 day irrigation intervals. Daily irrigation with application of polythene mulch (T_1) recorded significantly higher seed yield (2.5 t/ha) over control (T_6). The 100-seed weight was least affected by different irrigation regimes. Daily application of water resulted in higher biomass production leading to reduced harvest index under T_1 and T_2. Furrow irrigation at 7 day/ interval (T_6) recorded the lowest yield of chickpea (0.36 t/ha). Mulching of raised beds with black polythene resulted in significantly higher biomass production of 244 and 133.6 g/plant in T_1 and T_2. Among different irrigation intervals, the effect of polythene mulch on seed yield was profound when drip irrigation was applied at daily interval.

Table 6.1. Effect of different irrigation regimes on yield and yield attributes of chickpea

Treatments	Plant height (cm)	Plant spread (cm)	Single plant weight (g)	Harvest index (%)	100-seed weight (g)	Seed yield (t/ha)
T_1	70.8	56.2	244.0	41.86	24.2	2.5
T_2	66.4	58.3	133.6	48.50	23.9	1.59
T_3	70.6	59.8	121.0	47.04	24.9	1.40
T_4	30.7	24.8	3.8	57.89	23.1	0.39
T_5	66.2	59.7	89.5	52.67	22.0	1.57
T_6	34.6	23.0	3.9	51.20	22.6	0.36
LSD (p=0.05)	3.3	7.1	5.7	1.78	1.4	0.18

T_1 (Drip @ daily interval, with mulch); T_2 (drip @ 10 days interval, with mulch); T_3 (drip @ daily interval, no mulch); T_4 (drip @ 10 days interval, no mulch); T_5 (drip @ 1 day interval, no mulch); T_6 (furrow irrigation @ 7 days interval)

- Nine genotypes including 4 checks were evaluated for their performance in north east plain zone (NEPZ). The test entries 'DBGC 2' (1.54 t/ha) and 'DBGC 1' (1.22 t/ha) with 100 seed wt of 33 g and 28 g, respectively were identified as the promising.
- Parents and their F_1's and F_2's (Shubhra × BGD 9971 and JG 16 × BGD 9971) generations were grown to decipher the genetics of growth habit in chickpea. One F_1 (Shubhra × BGD 9971) showed only partial dominance of NDT (Shubhra) over the DT (BGD 9971) type. However, the second cross (JG 16 × BGD 9971) indicated complete dominance of NDT over DT types; F_2 generation showed a 15 (NDT):1 (DT) ratio.
- Field demonstration of 4 released varieties namely, 'Pusa 256', 'Pusa 372', 'Pusa 547' and 'Pusa 1103', each in an area of 43.2 m^2 was undertaken during 2015-16. 'Pusa 547' produced the highest seed yield (1.5 t/ha).

Lentil

Two station trials of lentil (first with 12 and the second with 9 genotypes) were conducted during 2015-16. In the first trial, accessions 'DBGL 105' and 'DBGL 62' yielded > 30% and >20%, respectively higher than the check variety 'Pusa Vaibhav' (1.0 t/ha) with similar maturity duration (~140 days) and 100 seed wt. of (2.5-3.0 g) (Fig. 6.1). Two *early* maturing genotypes 'DBGL 135' and 'DBGL 138' (~120 days) with slightly low yield potential (~ 1.0 t/ha) were also identified. In the second trial, 'KLS 218' produced the highest seed yield (1.69 t/ha), whereas, the lowest yield (1.19 t/ha) was recorded in 'IPL 321' (Fig. 6.2).

Field demonstration of 4 released varieties (Pusa Vaibhav, L 4594, DPL 62 and IPL 220) each in an area of 20.4 m^2 was conducted during 2015-16. 'Pusa Vaibhav' and 'DPL 62' yielded at par with each other (~1.30 t/ha).

Fig. 6.1. Lentil station trial-I

Fig. 6.2. Lentil station trial-II

Pigeonpea

One station trial comprising 4 checks and one test genotype 'DBGA 7-10' of pigeonpea was conducted during 2015-16. Two check varieties namely 'IPA 203' and 'Bahar' yielded almost similarly (2.70 t/ha). Based on the results, farmers could be recommended to grow 'IPA 203' as it is resistant to *Fusarium* wilt compared to 'Bahar'. The test genotype 'DBGA 7-10' yielded the lowest (2.0 t/ha) on account of poor plant density due to water-logging in 2 replications.

A Preliminary yield trial comprising 11 "cleisto" lines (6 NDT + 5 DT) was also conducted along with the check variety 'IPA 203' (Fig. 6.3). All the test lines bred true to the type for the "cleisto" trait (*NO* outcrossing). Out of the six, 2 NDT lines yielded at par with the check variety 'IPA 203' (~2.0 t/ha). This may have a great significance as it will obviate the need to purchase the seeds of pigeonpea varieties afresh every year by the farmers.

Fig. 6.3. An NDT "cleisto" line

Pulse Seed Hub

For augmenting the availability of quality seeds of pulses, Department of Agriculture, Cooperation and Farmers' Welfare, Government of India, has sanctioned a mega project on "Creation of seed hubs for increasing indigenous production of pulses in India" with a total outlay of Rs. 22531.08 lakhs for a period of two years from 2016-17. Under this project, two pulse seed hubs have been sanctioned to ICAR Research Complex for Eastern Region, Patna (Fig. 6.4). We have been given the target to produce 50 t and 20 t quality seeds of chickpea and lentil, respectively under pulse seed hubs at KVK, Buxar and ICAR RCER, Patna during the *Rabi* season 2016-17. Quality seed production programme in about 19 ha and 26 ha were undertaken for lentil (HUL 57 and KLS 218) and chickpea (Pusa 547), respectively during the *Rabi* 2016-17.

Fig. 6.4 Certified seed production of lentil variety 'HUL 57'

Greengram

Eight germplasm of mungbean received from AVRDC RCSA, Hyderabad were evaluated along with K-851 (check) during *kharif* season. The lines/varieties viz., BARIMUNG-4 (1.34 t/ha) and VC-3890 A (1.22 t/ha) performed better than the check variety K-851 (1.02 t/ha) in respect of dry seed yield.

Blackgram

Twenty five germplasm of blackgram received from NBPGR Regional Station, Hyderabad were evaluated along with Uttara (Check) during *kharif* season. The lines IC-466852 (2.26 t/ha) and IC-281994 (2.19 t/ha) performed better than the check variety Uttara (1.97 t/ha) in respect of dry seed yield.

Horsegram

Twenty germplasm of horsegram received from NBPGR Regional Station, Akola were evaluated and maintained. Five lines recorded seed yield >2.25 t/ha. The line IC-139382 (2.38 t/ha) performed the best.

Faba bean

Fourteen accessions of faba bean genotypes were purified and rejuvenated for their potential future use in breeding programme. Besides 5 faba bean promising genotypes *viz*., RCPFB01, RCPFB02, RCPFB03, RCPFB04 and RCPFB05 were also under varietal development programme. This year 150 kg seed of State released varieties Swarna Gaurav and Swarna Suraksha was produced for supply chain (Fig. 6.5).

Fig. 6.5. Field view of faba bean seed production plot.

7. Fruits

Mango

Collection and evaluation of mango germplasm

During 2016-17, two new promising mango germplasm were identified from Ranchi. The mango genotypes ICAR RCER MS 8/3 is regular bearing with high pulp content (67%) and TSS (18.6°B). The uniqueness of this genotype is the duration of firmness of the pulp after ripening (8 days). A total of 100 germplasm were evaluated for fruit quality parameters. The average fruit weight ranged between 71.5 g (H-51) to 549.3 g (Alfazli). Positive skewness was observed in the values of average fruit weight which indicated the need for positive selection strategy combined with introduction of new promising germplasm in the gene pool. The pulp content ranged between 52.88% (Samar Baheist Chausa) to 81.86% (Neeleswari). Negative skewness and negative value of kurtosis for pulp percentage indicates the need for negative selection and further introduction of superior germplasm in the gene pool. The TSS ranged between 11.5°B (Jahangir) to 25.5°B (Indonesia). Although the distribution of TSS was positively skewed, the value of Kutosis was negative which indicated the need for introduction of superior genotypes with high TSS in the existing gene pool. Based on the overall performance, two genotypes namely, Mahmood Bahar and Ramkela were found to be promising (average fruit wt: 200 – 400g, Pulp content > 65%, TSS>18°B and TSS/acid > 200).

Litchi

Collection and evaluation of litchi germplasm

During 2016-17, one promising genotype of litchi was identified and collected from Thakurgaon village of Ranchi district of Jharkhand. The genotype matures earlier (1st week of May) than Shahi. The fruit of the genotype had high fruit weight (22 g), pulp content (80.12%) and TSS (20.4°B). The air layers prepared from the plant have been collected from the mother plant. A total of 18 genotypes collected after 1996 and conserved in the field gene bank were evaluated for fruit quality and yield. The maximum fruit weight was recorded in CHL-4 (19.01 g). The lowest seed weight was recorded in Early Seedless (1.33 g) and the other small seeded genotypes were Late Large Green and CHL-8. The highest pulp % was recorded in CHL-8 (75.98 %) while genotype Early Seedless was at par. The maximum TSS was recorded in case of Late Large Green (21.20 °B) followed by Early Seedless whereas, the highest TSS/acidity ratio was recorded in CHL-7 (84.82). The genotypes with high yield (>30 kg/plant) were Nafarphal, CHL-3, Sarguja Sel. 2 and L-7/109. Hence, based on fruit quality and yield, the litchi genotypes 'Early Seedless' and 'Late Large Green' were found to be most promising during the year.

Standardization of grafting time in Litchi

An experiment was undertaken to standardize the optimum time of grafting in litchi under Jharkhand conditions. The branches were girdled (removing of 3 mm ring from branches of 40-50 mm girth) one month before the collection of scion sticks for grafting. Defoliation was performed 7 days before the collection of scion sticks. Wedge grafting was performed under shadenet. The graft success rate and vegetative growth were markedly improved as a result of girdling and defoliation. More than 50% success rate was observed for the grafting performed during June, July and August. The highest graft success rate (70%) was recorded during July (Fig. 7.1 and 7.2) indicating that July was the most favourable month to undertake grafting in Litchi.

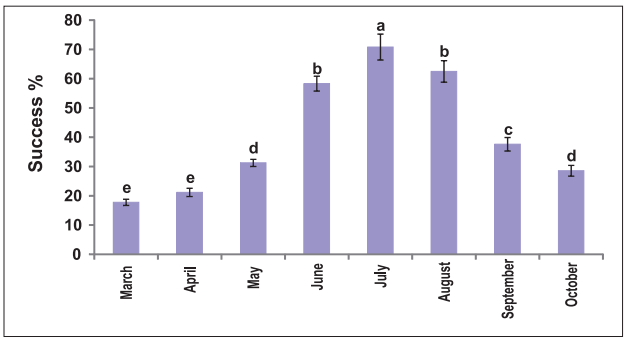


Fig. 7.1. Effect of time of grafting on success percentage in litchi.

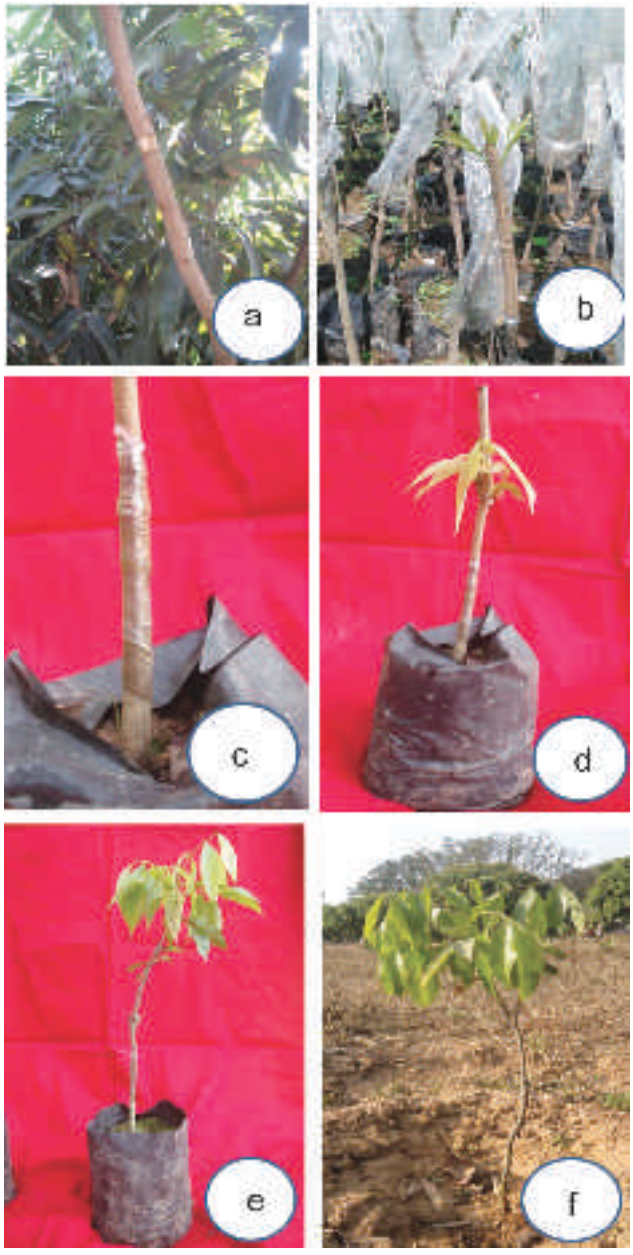


Fig. 7.2. Different stages of wedge grafting in litchi cv. Shahi. (a) Girdled branch in scion mother tree (b) Bud sprouting (c) Scion Union (d) Immature graft (e) Mature grafted plant (f) Grafted plant in the field.

Jackfruit

Evaluation of jackfruit germplasm for Table and vegetable purposes

Forty-nine genotypes conserved at the field gene bank of the institute were evaluated for table purpose under eastern plateau and hill conditions based on 23 fruit quality characters like average fruit weight, fruit length, fruit width, rind %, pulp %, seed %, TSS, total sugar etc. Average fruit weight ranged between 3.07 kg (ICARRCER JS II 3/6) to 16.73 kg (ICARRCER JS II 2/7). Pulp content ranged between 13.90% (ICARRCER JS II 4/7) to 64.9% (ICARRCER JS II 20/5). Based on the lowest values of RSQ genotype, ICAR RCER JS II 11/5 was found to be most promising for table purpose.

Biplot between PC1 and PC2 (Fig. 7.3) showed that genotypes namely ICAR-RCER JS II 15/2, ICAR-RCER JS I 3/4, ICAR-RCER JS I 8/9, ICAR-RCER JS II 2/7, ICAR-RCER JS II 11/5, ICAR-RCER JS II 5/1, ICAR-RCER JS I 10/3, ICAR-RCER JS II 14/7 and ICAR-RCER JS II 3/6 are very different from each other and are disposed in gaps and are the most promising ones for breeding purpose.

In another study, 43 genotypes were evaluated for vegetable purpose at tender stage based on per cent edible portion and firmness of edible portion after boiling. The per cent edible portion varied from 32.11 (ICARRCER JS II 6/1) to 75.47% (ICARRCER JS II 3/7). Jackfruit genotypes ICAR-RCER JS II 3/6, ICARRCER JS II 1/1, ICARRCER JS II 12/7, ICARRCER JS II 14/4, ICARRCER JS II 4/4, ICARRCER JS II 12/6, ICARRCER JS II 10/1, ICARRCER JS II 10/2 and ICARRCER JS II 3/7 had more than 65 % edible portion. The minimum firm-

Fig. 7.3. Jackfruit at farmer's field

ness was recorded with ICARRCER JS II15/7 (0.46 lbs) whereas maximum firmness was recorded in the ICARRCER JS II 9/6 (2.94 lbs) (Fig. 7.4). Hence, based on per cent edible portion and firmness ICARRCER JSII 3/7 and ICARRCER JS II10/2 were found promising for vegetable purpose.

Tamarind

Evaluation of tamarind germplasm for fruit quality

Thirteen genotypes were evaluated for fruit quality purpose based on 14 parameters. The highest fruit weight (17.96 g) was recorded with ICAR RCER TS 7/1. Genotype ICARRCER TS 8/5 had minimum seed percentage (10.08%) and seed weight (1.05 g). The pulp per cent varied from 45.71% (ICAR RCER TS 8/4) to 63.52 % (ICARRCER TS 8/5).The maximum TSS (66.00 °B) was recorded with ICARRCER TS 6/3. Hence based on pulp per cent, seed per cent, TSS and fruit weight, genotype ICARRCER TS 8/5 was found promising.

Jamun

Evaluation of jamun germplasm for fruit quality

Nine genotypes were evaluated for fruit quality based on eleven parameters. The fruit weight varied from 2.86 g (ICARRCER JS 3/3) to 8.20 g (ICARRCER JS 2/2). Out of the nine genotypes, ICARRCER JS 4/2 was found to be superior which recorded maximum pulp percentage (80.60%), minimum seed percentage (19.40%) and the highest TSS (18.40°B).

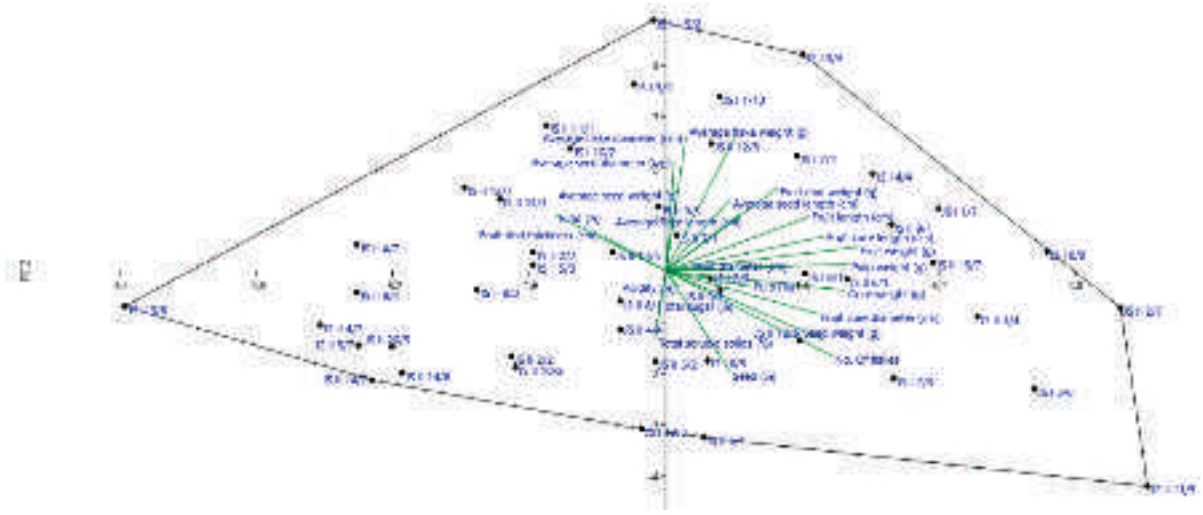


Fig. 7.3. Segregation of the 49 jackfruit germplasm according to fruit traits determined by principal component analysis (PCA).

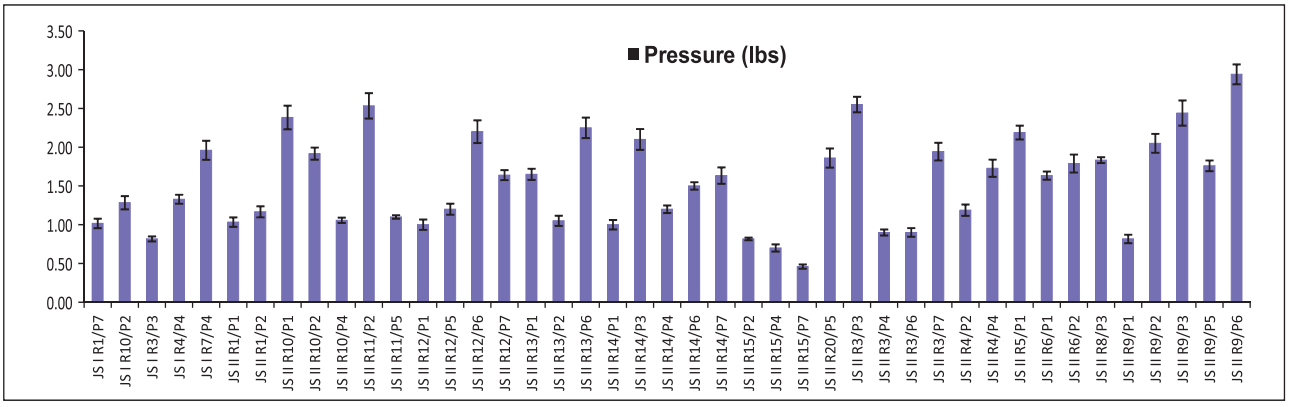


Fig. 7.4. Firmness (lbs) of different jackfruit genotypes.

8. Vegetables

Tomato

Phenotypic Evaluation of Tomato Genotypes against Root Knot Nematode

Among the parents, HAT-310 and HAT-311 showed resistance reaction to root knot nematode (RKN) as no egg masses were observed (Fig 8.1). According to the six point scale proposed by Taylor and Sasser (1978) the crosses HAT-311 x Swarna Lalima, HAT-296 x HAT-311, EC-596747 x HAT-311, Swarna Lalima x HAT-310, EC-596743 x HAT-310 and Swarna Lalima x HAT-311 were found immune to root knot nematode (Table 8.1).

Table 8.1. Screening of tomato genotype against root knot nematode

Genotypes	Reaction*	Crosses	Reaction*
EC-596747	HS	Swarna Lalima x HAT-310	I
Swarna Kanchan	HS	HAT-296 x HAT-302	HS
Swarna Lalima	HS	HAT-296 x EC-596743	HS
Swarna Anmol	HS	EC-596743 x HAT-310	I
HAT-302	HS	HAT-311 x SwarnaLalima	I
EC-596743	HS	HAT-296 x HAT-311	I
HAT-294	HS	EC-596747 x HAT-311	I
HAT-310	I	SwarnaLalima x HAT-311	I
HAT-311	I		
HAT-296	HS		

Genotypic characterisation for root knot nematode resistance

To confirm the genetic resistance of the phenotypically resistant germplasm, molecular markers namely REX-1, JB-1, PMi12 and Mi23 for RKN resistance were used. These molecular markers were also compared for identifying best suitable marker for RKN resistance.

PCR with JB-1 yielded about 900 bp DNA fragment (Fig. 8.2a). PCR products after digestion with Taq I restriction enzyme yielded nearly 420 bp in all the genotypes (Fig. 8.2b.), indicating inefficiency of JB-1 to differentiate between the nematode resistance and susceptible germplasm.

Fig. 8.1. A. Resistance reaction to RKN (no galls) in line HAT-310, B. Susceptible reaction to RKN (heavy galls) in line Swarna Lalima , C. Egg masses of root knot nematode and D. Infective Juvenile (J2) of RKN.

PCR with the REX-1 marker produced the only band of nearly 720 bp for all tomato hybrids and lines (Fig. 8.3a). Digestion of PCR products with Taq I yielded 720, 560 and 160 bp fragments (Fig. 8.3b) in homozygous resistant plants, i.e., HAT-310 and HAT-311. The susceptible plants produced a 700 bp fragment, while heterozygous genotypes yielded three bands including 720, 560, and 160 bp (EC-596743 x HAT-310, HAT-311 x Swarna Lalima, HAT-296 x HAT-311, EC-596747 x HAT-311 and Swarna Lalima x HAT-311). The cross Swarna Lalima x HAT-310 did not yield the desired band pattern. Although, genotype HAT-302 was susceptible to root knot nematode, it yielded band of 560 bp and 160 bp along with extra bands of approximately 400 bp, 320 bp and 200 bp.

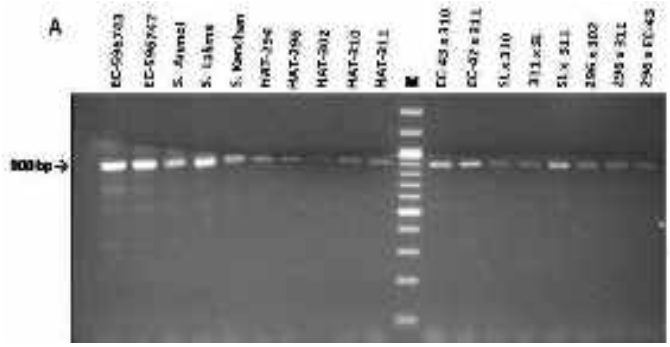


Fig. 8.2a. PCR product obtained using JB-1 marker

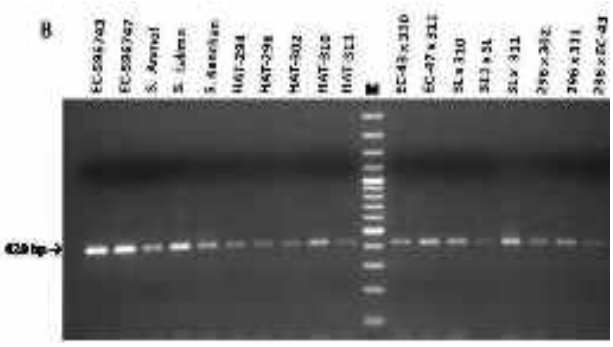


Fig. 8.2b. Digestion of JB-1 PCR products with TaqI

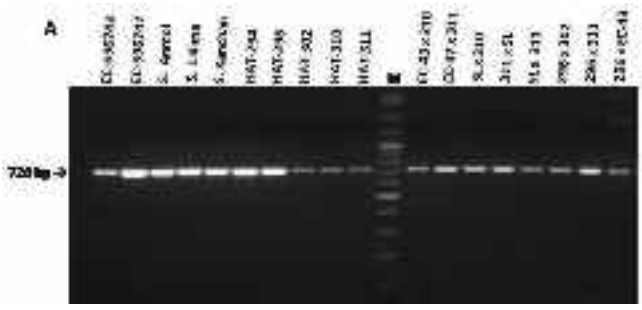


Fig. 8.3a. PCR product obtained using REX-1 marker;

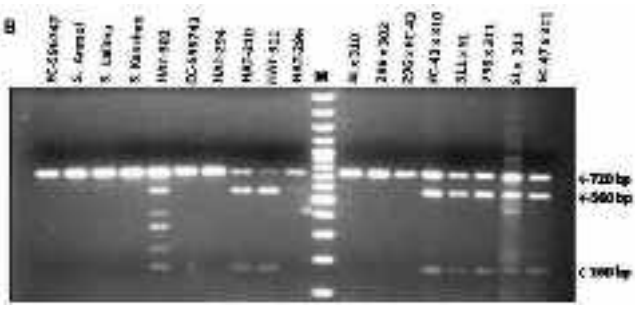


Fig. 8.3b. Digestion of REX-1 PCR products with TaqI

PCR with PMi12 yielded 620 bp and 720 bp fragments with homozygous resistant (HAT-310 and HAT-311) and susceptible genotypes, respectively. Heterozygous resistant plants (EC-596743 x HAT-310, HAT-311x Swarna Lalima, HAT-296x HAT-311, EC-596747 x HAT-311 and Swarna Lalima x HAT-311) produced 620 and 720 bp fragments along with extra bands which are about 800, 900, and 1050 bp in analysed samples. Further, this marker could not give consistent results.

Mi23 which is a co-dominant marker, produced 380 bp fragments for the homozygous genotype (Mi/Mi), i.e., HAT-310 and HAT-311. Tomato plants which lack the Mi-1 locus yielded the 430 bp fragment. Swarna Lalima x HAT-310, EC-596743 x HAT-310, HAT-311 x Swarna Lalima, HAT-296 x HAT-311, EC-596747 x HAT-311, Swarna Lalima x HAT-311 yielded two fragments 380 bp and 430 bp indicating heterozygous nature of resistance (Fig. 8.4). The result showed the feasibility of marker Mi 23 for detection of presence of *Mi-1* gene when compared with JB-1, REX-1and PMi12. Hence, Mi23 could be effectively used for rapid screening of root-knot resistance in tomato breeding programs. The six resistant crosses (HAT-311 x Swarna Lalima, HAT-296 x HAT-311, EC-596747 x HAT-311, Swarna Lalima x HAT-310, EC-596743 x HAT-310 and Swarna Lalima x HAT-311) will be further selected for fruit quality and yield so that it can be used as a high yielding RKN resistant tomato hybrids.

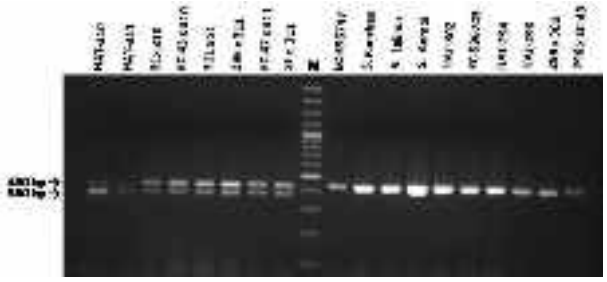


Fig. 8.4. PCR product obtained using Mi23 marker

Profitability of hybrid tomato seed production

A study on economics of hybrid seed production was conducted at progressive farmers' field in Saraitoli village of Ranchi district and Gola block of Ramgarh district. The analysis showed that hybrid seed production of tomato was highly remunerative (Table 8.2). The activities of hand emasculation, pollen extraction and pollination consumed about 59.8% and 48.9 % of the total labour employed at farmers' fields in Saraitoli and Gola, respectively. These three activities consumed the largest share

of the total expenditure. The next most expensive activity was seed extraction, drying and storing which consumed about 33.6 % and 36.8 % of the total hired human labour at Saraitoli and Gola, respectively. Altogether, hired human labour was the largest item of investment (76.5 and 64.1% at Saraitoli and Gola, respectively) in commercial venture of hybrid seed production. The hybrid seed production and the task of hybridization at institute and at farmers' field have been depicted in Fig. 8.5.

Table 8.2. Profit estimation of tomato hybrid seed production

Economic parameters	Farmers' fields in Saraitoli	Farmers' fields in Gola
Yield of hybrid seed (Kg/ha)	107.10	190.00
Cost of seed production (Rs/kg)	30,000.00	10,000.00
Gross income (Rs/ha)	32,14,286.00	19,00,000.00
Gross expenditure (Rs/ha)	19,81,323.00	8,03,630.00
Net income (Rs/ha)	12,32,963.00	10,96,370.00
Benefit cost ratio	1.62	2.36
Man days/ kg	33.70	6.50
Man days/ha	3,610.00	1,226.00

It was observed that seed recovery per kg of fruit gradually increased and average weight of individual fruits declined in successive pickings. On an average, each tomato plant yielded 3.45 kg of ripe tomato (49.67 fruits) and 13.15 g of hybrid seed. Mean seed recovery was 3.81 g/kg of tomato fruits.

Effect of Seed Priming on Field Emergence and Yield of Vegetables & Bamboo

Seed priming with KNO_3 0.5% at 25°C for 8 hrs resulted in the highest increase in field emergence in tomato (95.0%) and brinjal (82.8%) while priming in cucumber did not shown any significant effect on field emergence (Fig. 8.6). However, rate of germination was observed to be faster with KNO_3 0.5% (6 days). GA_3 (200 ppm) and GA_3 (100 ppm) showed better germination in chilli (79.75%) and bottle gourd (80.5%), respectively. Ethrel 500 ppm was found to be best priming treatment for field emergence (93.75%) in bitter gourd. In bamboo, priming of seeds with KNO_3 (1% solution) resulted in the highest germination (87.30% and 100%) with and without seed coat, respectively.

Fig. 8.6. Seedling growth of tomato after 15 days of sowing after different priming treatments

T_1- KNO_3 0.5%; T_2- KNO_3 1%; T_3- GA_3 100 ppm; T_4- GA_3 200 ppm; T_5- Ethrel 200 ppm; T_6- Ethrel 500 ppm; T_7- Hydropriming; T_8- SMP; T9- Control

Fig. 8.5. Women farmers engaged in pollination during hybrid seed production at Saraitoli, a village adopted by ICAR-RCER, RC Ranchi

Onion

Increasing seed yield of onion by increasing planting density

An experiment was conducted to standardize the planting density of onion bulbs for seed production. Onion was cultivated on polythene mulched with raised beds of 60 cm width. Planting of 3 rows of onion crop on a bed resulted in higher density of 25.2 umbels/m^2 and the highest seed yield of 1.49 t/ha as compared to onion crop planted in single row per bed (11.6 umbels/$m^2$and seed yield 0.86 t/ha). However, higher density of planting did not show any significant effect on 1000-seed weight.

Tuber Crops and Wild Edibles

A total number of 256 germplasm have been collected during the surveys conducted in Jharkhand, Chhattisgarh, Nagaland, Odisha and West Bengal. The germplasm collection mainly comprised 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). The collected germplasm were multiplied in the field for characterization and evaluation.

Sweet potato

Out of 12 lines including check evaluated, line ACC-172, a collection from Rampur Bazar under Namkum block of Ranchi district of Jharkhand, performed best and recorded tuber yield of 28.4 t/ha with a yield increase of 19% over the check variety Sree Bhadra (23.8 t/ha).

Taro/Colocasia

Forty six genotypes of taro were evaluated for yield, nutritional, anti-nutritional, and biotic stress traits using data on Overall Rank Sum Index. Out of 46 genotypes, ACC-269 (a collection from Longmisa village under Ongpangkong-North block of Mokokchung district of Nagaland), ACC-56 (a collection from Mayurnacha village under Dumka block of Dumka district of Jharkhand), ACC-225 (a collection from Jiyathar village under Dumka block of Dumka district of Jharkhand), ACC-118 (a collection from Pathari village under Kanker block of Uttar Bastar Kanker district of Chhattisgarh), ACC-60 (a collection from Sarepahari village under Jama block of Dumka district of Jharkhand), ACC-280 (a collection from Tanhai village under Wakching block of Mon district of Nagaland), ACC-38 (a collection from Meghisanthali village under Jama block of Dumka district of Jharkhand), ACC-77 (a collection from Karamdih village under Karra block of Khunti district of Jharkhand), ACC-223 (a collection from Jiyathar village under Dumka block of Dumka district of Jharkhand) and ACC-271 (a collection from Longkong village under Changtongya block of Mokokchung district of Nagaland) were identified promising for further evaluation.

Cassava

A total of 7 lines, including check, were evaluated in the field. The line ACC-152, a collection from Rupupiri village under Khijri block of Ranchi district of Jharkhand, performed best and recorded tuber yield of 40.6 t/ha with a yield increase of 115.4 % over the check variety Sree Vijaya (18.8 t/ha).

Elephant foot yam

Eleven lines of elephant foot yam were evaluated. ACC-134 (collected from Hatkacharama village under Charama block of Uttar Bastar Kanker district of Chhattisgarh), ACC-136 (collected from Chirkubera forest area under Bandgaon block of West Singhbhum district of Jharkhand) and ACC-85 (a collection from Palma village under Itki block of Ranchi district of Jharkhand) recorded the corm yield of 28.1, 26.5 and 26.3 t/ha. Theses yields were not significantly different from the non-acrid check variety Gajendra (30.85 t/ha).

Potato/Aerial yam

Out of six lines evaluated, ACC-123, a collection from Amajhola village under Kanker block of Uttar Bastar Kanker district of Chhattisgarh performed best and recorded the aerial tuber (bulbil) yield of 11.90 t/ha.

Wild Muskmelon/Kachri

Out of 7 lines including check evaluated, Kachri-4 recorded the maximum fruit yield of 9.6 t/ha but was not significantly different from the check variety AHK-119 (7.7 t/ha).

Cowpea (Bush) AVT-II

Seven lines of bush type cowpea, including the check, were tested in the field. The entries 2014/COPBVAR-5 (11.04 t/ha), 2014/COPBVAR-3 (10.57 t/ha) and 2014/COPBVAR-4 (10.01 t/ha) recorded 26, 21 and 14% increase in marketable green pod yield, respectively, over the check variety Kashi Kanchan (8.73 t/ha).

French bean (Bush) AVT-II

Out of six entries including two check varieties tested, the entries 2014/FBBVAR-3 (7.18 t/ha) and 2014/FBBVAR-1 (7.15 t/ha) performed better than the best check variety Arka Suvidha (6.69 t/ha).

Pea Early AVT-I

Out of nine entries including two check varieties tested, 2015/PEVAR-5 (17.49 t/ha) performed better than the best check variety Azad Pea-3 (15.98 t/ha) with respect to marketable green pod yield.

Nutritional Characterization of Underutilized Leafy Vegetables of Jharkhand

Surveys were conducted in eleven districts of Jharkhand (Ranchi, Khunti, Gumla, Lohardaga, West Singhbhum, Ramgarh and Hazaribagh, Saraikela Kharsanwa, East Singhbhum, Bokaro and Giridih). During these surveys, 30 underutilized leafy vegetable species were identified and considered for nutritional analysis (minerals, vitamin C, crude fibre and protein content) and anti-oxidative properties (antioxidant activity, phenols and carotenoids content). The range of nutritive & anti-oxidant properties of leafy vegetables are given in Table 8.3-8.4.

Analysis of antinutritional properties revealed that total oxalate content varied from 38.2 mg/100g in *Indigofera pulchella* Roxb to 992.8 mg/100g FW in *Vangueria spinosus* (Roxb. ex Link) Roxb. The nitrate content of the leafy vegetables ranged from 86.87 mg/100g in *Indigofera pulchella* Roxb to 829.3 mg/100g in *Ipomoea batatas* (L.) Lam. Most of the species analysed contained total oxalate and nitrate content in safe limit for human consumption. The study indicates the potentiality of these nutritious, inexpensive, easily accessible but lesser known leafy vegetables as source of unconventional foods.

Table 8.3. Anti-nutritional properties of 30 underutilized leafy vegetables species of Jharkhand

Anti-nutritional component	Range	Leafy vegetables having low content
Total oxalate (mg/100g)	38.25-992.84	*Indigofera pulchella* Roxb, *Bauhinia variegata* L., *Commelina benghalensis* L. and *Polygonum plebeium* R. Br.
Nitrate (mg/100g)	86.87-829.32	*Indigofera pulchella* Roxb, *Marsilea minuta* L., *Alternanthera sessilis* Br., *Moringa oleifera* Lam. (Flowers), *Cissus adnata* Roxb.

Table 8.4. Nutritive and anti-oxidative properties of 30 underutilized leafy vegetables species of Jharkhand

Nutrients/ Antioxidants	Range	Leafy vegetables having high content
Calcium (mg/100g FW)	125.8-737.8	*Amaranthus spinosus* L., *Cassia tora* L., *Ipomoea batatas* (L.) Lam., *Centella asiatica* (L.) Urban
Iron (mg/100g FW)	7.2-61.3	*Amaranthus gangeticus* L., *Ipomoea aquatica* L., *Chenopodium album*L., *Amaranthusviridis* L.
Magnesium (mg/100g FW)	254.3-233.7	*Amaranthus gangeticus* L., *Amaranthus spinosus* L., *Basella alba* L., *Ipomoea batatas* (L.) Lam.
Potassium (mg/100g FW)	98.5-4516.1	*Chenopodium album* L., *Centella asiatica* (L.) Urban. *Amaranthus viridis* L., *Amaranthus spinosus* L.
Phosphorus (mg/100g FW)	26.7-525.3	*Amaranthus gangeticus* L., *Amaranthusviridis* L., *Centella asiatica* (L.) Urban, *Basella alba* L.
Zinc (mg/100g FW)	1.5-9.9	*Basella alba* L., *Centella asiatica* (L.) Urban, *Chenopodium album* L., *Amaranthus spinosus* L.
Vitamin C (mg/100g FW)	2.41-156.92	*Moringa oleifera* Lam., *Cissus adnata* Roxb., *Marsilea minuta* L., *Hibiscus cannabinus* L., *Basella alba* L.
Fibre (g/100g FW)	0.72-5.93	*Bauhinia variegata* L. (Flowers), *Crotolaria juncea* L., *Indigofera pulchella* Roxb, *Centella asiatica* (L.) Urban, *Alternanthera sessilis* Br.
Antioxidant activity (mg AEAC/ 100g FW)	17.43-158.7	*Cassia tora* L., *Amaranthus spinosus* L., *Hygrophila spinosa* T. Anders, *Moringa oleifera* Lam., *Hibiscus cannabinus* L.
Total Phenols (mgGA/100g FW)	0.40-11.71	*Ipomoea batatas* (L.) Lam., *Centella asiatica* (L.) Urban, *Hygropila spinosa* T. Anders, *Hibiscus cannabinus* L., *Ficus geniculata* Kurz
Total carotenoids (mg/100g FW)	1.59-77.56	*Vangueria spinosa* (Roxb. ex Link) Roxb., *Alternanthera sessilis* Br., *Amaranthus spinosus* L., *Amaranthus viridis* L., *Cassia tora* L.
Protein (g/100g FW)	1.23 – 9.57	*Crotolaria juncea* L. (Flowers), *Indigofera pulchella* Roxb (Flowers), *Bauhinia variegata* L. (Leaves & Flower buds), *Marsilea minuta* L.

9. Mushroom

Collection, Identification and Evaluation of Wild Edible Mushroom Germplasm

During the rainy season, a wild edible mushroom was collected from the termite nest (termitarium) and identified as *Termitomyces* sp. (Fig. 9.1a) while another cultivated Oyster (*Pleurotus* sp.) mushroom (Fig. 9.1b) was collected from dried mango tree in the locality of Ranchi, Jharkhand. *Pleurotus* sp. was evaluated for their biological efficiency, size and number of sporophores/sporocarp at the centres' laboratory and at farmers' field. The biological efficiency of *Pleurotus* sp. was about 80% after 20-24 days of spawning (Fig. 9.1c, 9.1d).

Fig. 9.1a-d. New collection of mushroom strains and their evaluation in lab and farmers' fields.

AdvanceVarietal trial-1 of High Yielding Varieties/Strains of Oyster Mushroom (*Pleurotus* spp.)

Four isolates (strains) of *Pleurotus* spp. (PL-16-01, PL-16-02, PL-16-03, and PL-16-04) were evaluated for their biological efficiency, number of sporophores (fruiting bodies), weight of single sporophores and sporophore formation time, during autumn (Sept-Oct) and winter (Dec-Feb) seasons of 2016. Autumn (Temp >20°C), the strain PL-16-03 showed the highest biological efficiency of 83% followed by PL-16-01 (73%), PL-16-02 (68%) and PL-16-04 (63 %). The highest number of sporophpore was recorded in PL-16-03 and PL-16-01, but the weight of individual sporophores was the highest in PL-16-04 (6.69 g). In case of winter trials (< 20 °C), similar trend was recorded in the biological efficiency. Winter cultivation of PL-16-03 showed the highest number of sporophores (152.8) while PL-16-03 also showed the highest weight of single sporophores (6.82 g). Formation of sporophores took about 16-18 days in case of autumn trials while in case of winter cultivation, it was 20-24 days (Fig. 9.2).

Fig. 9.2. Fruiting bodies observed on different strains of oyster mushroom at Ranchi

10. Makhana

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

Different germplasms/genotypes of water chestnut collected from Jabalpur, Madhya Pradesh were evaluated and characterized. Numbers of days required for first flowering varied from 56 to 62 in JR1 (Jabalpur Red 1) to JR8, 60 to 65 in JG1 (Jabalpur Green 1) to JG5 and 60 days in DR1 (Darbhanga Red 1) and DR2, respectively. Fruit set started within 63 to 70 days after planting in JR and 69 to 73 in JG. Maturity of fruit started between 95 and 104 days after planting in JR, JG and DR. There was marked variation in root length per plant. It was maximum in JR2 (255 cm) followed by JR1 (185 cm). Among the JG germplasm, JG4 recorded the maximum root length (233 cm). The length of fruit bearing branches was maximum in JR2 (65 cm) followed by JG4 (48.55 cm).

All the local collections namely DR group had three spines on the body of the fruit. The colour of mature fruit was red in JR, green in JG and Red in DR (Fig. 10.1) . The maximum fruit size was noticed in JR2 (7.3 x 14.3 cm). Among the JG germplasm, JG4 recorded the highest fruit size (6.3x13.5 cm). But kernel size varied from 4.57x11.45 (JR4) to 7.01x13.65 (JR2) cm and 4.4x11.74 (JG1) to 5.35x12.78 (JG4) cm in JR4 and JG, respectively. The variation in weight of kernel was at par in all the collections. Weight of individual fruit as well as kernel varied in different collections. Fruit weight ranged from 25 g in JR2 to 24.1 g in JR5. Accordingly in case of JG collections it varied from 20.9 g in JG4 to 20.4 g in JG1. The maximum number of fruits per plant was found in JR2 (250) followed by DR2 (233) and JG4 (218). Thus, JR germplasm had the highest yield potential as compared to JG and DR collections.

All the collection had same shelf-life and storage life at 10 °C (Table 10.1). Both parameters were slightly lesser in case of local collections. Number of fruiting branches was found to be maximum in JR (7) followed by JG4 (6) and DR2 (5). Marked variation in yield per plant was noticed among the collections. It was only 3.89 kg in JG3 and 6.25 kg in JR2. DR1 and DR2 produced an average yield of 4.84 and 5.25 kg, respectively. Among the genotypes, JR2 was nutritionally superior with maximum protein (5.2%), carbohydrate (25%) and minimum acidity (0.242%) (Table 10.2).

Fig. 10.1. Thornless red colour and green colour fruit bearing water chestnut plants

Table 10.1. Yield and nutritional properties of water chestnut plants

Genotypes	No. of fruiting branch-es	Wt. of 10 raw fruits (g)	Shelf life (days)	Storage life at 10°C	Total soluble solid (°B)	Juice (%)	Yield per plants (kg)
JR1	5	243	4.0	8.0	9.0	51.0	5.58
JR2	7	250	4.0	8.0	9.2	53.3	6.25
JR3	4	245	4.0	8.0	8.4	52.0	5.75
JR4	3	246	4.0	8.0	8.4	52.3	5.90
JR5	5	241	4.0	8.0	8.2	52.1	5.85
JR6	5	245	4.0	8.0	8.4	52.3	6.02
JR7	4	248	4.0	8.0	9.1	52.5	5.95
JR8	5	246	4.0	8.0	8.6	52.2	6.02
JG1	5	204	4.0	8.0	7.3	56.20	4.28
JG2	5	208	4.0	8.0	7.5	56.52	4.05
JG3	6	205	3.5	8.0	7.2	56.41	3.89
JG4	6	209	4.0	8.0	7.5	57.00	4.55
JG5	6	205	4.0	8.0	7.2	55.41	4.12
DR1	5	220	3.0	6.0	6.4	52.50	4.84
DR2	5	225	3.0	6.0	6.6	52.70	5.25

Table 10.2. Nutritional quality of water chestnut

Genotypes	Acidity (%)	Total sugar (%)	Protein (%)	Fat (%)	Fiber (%)	Water (%)	Carbohy-drate (%)	Mineral (%)
JR1	0.244	4.63	4.3	0.3	0.4	71	23	1.0
JR2	0.242	4.70	5.1	0.2	0.5	69	25	1.2
JR3	0.244	4.64	4.4	0.2	0.4	70	24	1.0
JR4	0.243	4.65	4.0	0.3	0.5	71	23	1.2
JR5	0.246	4.62	4.2	0.3	0.3	72	22	1.2
JR6	0.248	4.64	3.6	0.2	0.2	72	23	1.0
JR7	0.246	4.67	4.3	0.2	0.5	71	23	1.0
JR8	0.243	4.65	4.5	0.2	0.3	70	24	1.0
JG1	0.265	3.94	4.2	0.3	0.5	72	22	1.0
JG2	0.265	3.96	4.3	0.2	0.5	70	24	1.2
JG3	0.262	3.95	4.2	0.2	0.6	73	21	1.0
JG4	0.260	3.98	5.5	0.1	0.4	70	23	1.0
JG5	0.263	3.94	4.3	0.2	0.5	70	25	1.0
DR1	0.292	3.78	3.0	0.2	0.6	72	23	1.0
DR2	0.290	3.82	3.1	0.3	0.6	72	25	1.0

Integrated Nutrient Management in Makhana

A considerable increase in organic carbon content was noticed with 100% NPK + 20 t/ha compost. The effect of INM treatment on available N, P, and K contents of the soil was significant and maximum content (316, 42 and 248 kg/ha, respectively) was observed under 100% NPK + 20 t/ha compost (Table 10.3).

The treatment comprising 100% NPK + 20 t/ha compost recorded the highest concentration of iron (49 mg/kg), manganese (27 mg/kg), copper (2.51 mg/kg) and zinc (0.92 mg/kg). Maximum yield (3.2 t/ha) was recorded with the application of 100% NPK + 20 t/ha compost (Table 10.4).

Table 10.3. Physico-chemical properties of soil under different INM treatments

Cropping systems	pH	EC (dS/ m^1)	O.C. (%)	Av. N (kg/ ha)	Av. P (kg/ ha)	Av. K (kg/ ha)
Control	7.6	0.28	0.51	233	20	215
75% NPK (@ 75:45:30)	7.3	0.24	0.56	258	31	221
100% NPK (@ 100:60:40)	7.3	0.26	0.62	266	35	227
125% NPK (@ 125:75:50)	7.1	0.26	0.62	292	37	235
100% NPK (@ 100:60:40) + Compost (20 t/ha)	6.8	0.32	0.92	316	42	248
Compost (20 t/ha) alone	6.9	0.30	0.79	246	26	229
LSD (P=0.05)	0.132	0.017	0.014	4.486	1.379	2.508

Table 10.4. Effect of INM treatments on soil micronutrients and yield of makhana

Treatments	Fe (mg/ kg)	Mn (mg/ kg)	Cu (mg/ kg)	Zn (mg/ kg)	Yield (t/ha)
Control	31	13	1.39	0.53	2.2
75% NPK (@ 75:45:30)	31	15	1.52	0.58	2.4
100% NPK (@ 100:60:40)	36	14	1.69	0.61	2.6
125% NPK (@ 125:75:50)	37	20	1.73	0.63	2.6
100% NPK (@ 100:60:40) + Compost (20 t/ha)	49	27	2.51	0.92	3.2
Compost (20 t/ha) alone	45	21	2.14	0.88	2.8
LSD (P=0.05)	1.826	1.452	0.014	0.025	0.150

11. Integrated Farming System

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

Studies on nutrient dynamics, water quality under fish- duck integration, employment generation and energy budgeting were carried out in one acre IFS model (Crop + Goat + Poultry + Mushroom) and two acre IFS model (Crop + Dairy + Fish). Results revealed that 13.8 t of cow dung from two cows, 11.3 t of vegetables waste and 1.21 t of duck dropping were produced in two acre IFS model, and upon recycling, these wastes within the system 56.5 kg N, 39.6 kg P and 42.7 kg K valued Rs. 4,826/year added to the soil. Likewise, under one acre IFS model, 2.5 t of goat manure, 6.62 t of vegetable wastes, 1.78 t of poultry droppings and 4.64 t of rice/maize/lentil straws were recycled within the system that added 44.0 kg N, 29.5 kg P and 31.2 kg K worth Rs. 3,175/year to the soil. Further, an increasing trend in respect of NPK status and organic carbon content in the soil was observed for those plots where wastes were recycled along with calculated doses of chemical fertilizers (INM). Organic carbon content declined in cereal cropping system with RDF (Table 11.1).

A study on carbon sequestration was also performed under the developed IFS models. More C- stock was observed with orchards soil under both IFS models over field crops. Total C- stock was reported as 2.60 and 7.0 Mg C/ha in one and two acre models, respectively. Negative C- stock was observed with fodder soils advocating that fodder crops exhausted more carbon and other nutrients in comparision to other crops while orchards added more carbon due to heavy litter decomposition. Under two acre IFS model more C- stock was recorded with fodder soil. The reason may be that fodder plots got submerged during rainy season and fodders were decomposed in the plots itself which added more organic matter to the soil and more C-stock was sequestrated under 2-acre fodder block. (Fig. 11.1 & 11.2).

Studies on employment generation with different combinations revealed that IFS models with different combinations created more farm employment ranging 90-335 man-days/year. Cattle integration with cereals or horticulture created maximum no. of employment (335 man-days). One acre and two acre IFS models consumed 401 and 572 man-days/year over 237 man-days under rice—wheat cropping system indicating more employment generation in IFS (Fig. 11.3).

Economic analysis revealed that one acre and two acre IFS models provided an annual net income of Rs. 79, 251/- (B:C ratio 1.9) and Rs. 1,37, 209/- (B:C ratio 1.8), respectively which was about three to four times higher than rice—wheat cropping system.

Table 11.1. Nutrient status of soil under different IFS models (2011 and 2016)

Farming System	2011	2016				Increase (%)			
	Initial kg/ha	N kg/ha	P kg/ha	K kg/ha	O.C. (%)	N	P	K	O.C.
Cereal only + RDF	N216.5 P 27.2 K226.5 O.C. 0.59 (%)	234.5	28.3	241.0	0.57	9.70	4.04	6.40	-3.39
Crop + Veg. + INM		251.6	29.8	245.8	0.63	8.36	9.56	12.58	6.78
Crop + Fish + Poultry + INM		240.2	30.5	246.4	0.64	10.95	12.13	8.79	9.3
Crop + Fish + Duck + INM		245.6	30.5	246.7	0.61	13.44	12.13	8.92	3.39
Crop + Fish + Goat + INM		250.2	35.4	255.1	0.62	17.04	30.15	12.63	5.08
Crop + Fish + Dairy + INM		256.6	34.5	251.4	0.65	16.54	27.57	10.99	10.17
Crop+Fish+ Poultry+ Dairy + INM		257.6	34.8	254.7	0.66	18.98	27.21	12.45	11.86
Crop+Mushroom+Goat+ INM		253.4	32.5	248.6	0.64	17.60	19.49	9.76	8.47

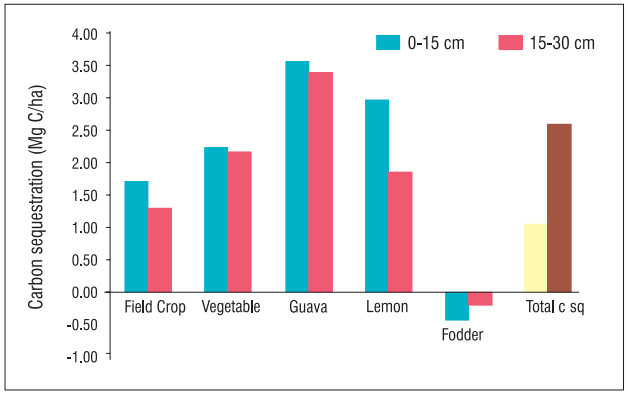


Fig. 11.1. Carbon sequestration in one acre IFS model

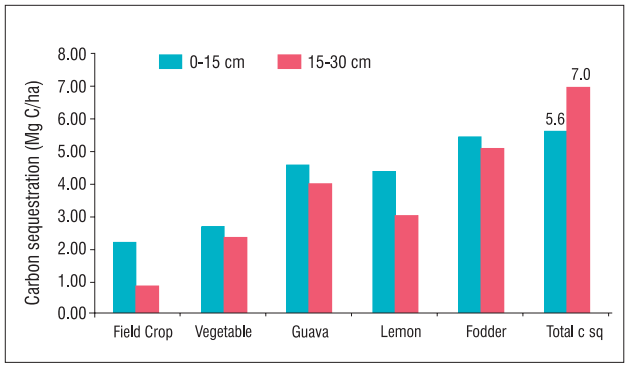


Fig. 11.2. Carbon sequestration in two acre IFS model

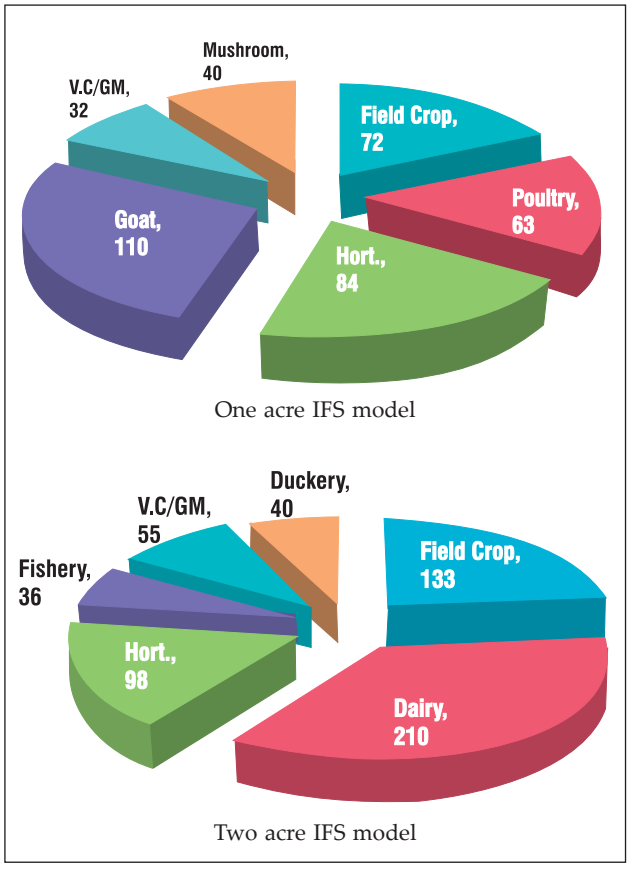


Fig. 11.3. Employment generation (man days) in different IFS models

Integrated Farming System for Improvement of Nutrition and Livelihood of Farm Women

A project was undertaken at Naubatpur block, Patna district with an objective to implement the integrated farming system models for nutritional and livelihood security of farm women. It was found that the women in the rural areas of Bihar do not engage in the outside field activities/work. So, we need to look deep into the perspective of women before implementing any interventions keeping both nutrition and livelihood in mind. Hence, our intervention was based on women perspective as well as women friendly and it was found to be quite effective. Some of the interventions were mushroom cultivation, varietal replacement, good quality planting material, vermicomposting, mineral mixture in the feed, green fodder, creating awareness on scientific management of livestock, vaccinations etc. (Fig. 11.4). These interventions improved the nutrition requirement of the family

Fig. 11.4 Vermicompost and mushroom production by farm women

members, increased crop yield, reduced the use of chemical pesticides, increased use of organic fertilizer, helped in recycling of farm waste, improvement in milk production, animal health, awareness in scientific livestock management, knowledge on balanced ration.

Integrated Farming System Model for Rainfed Ecosystem

The project was initiated under two different irrigation scenarios, 1. completely rainfed conditions, 2. need based supplemental irrigation during winter and spring-summer. Under rainfed conditions with no supplemental irrigation, a 0.75 acre Integrated Farming System (IFS) model was developed with twin objectives of supporting the needs of the farming family and to supplement (recycle) the nutrition for the cropped area of the IFS. In this IFS model, livestock (2 cows+ 1 calf), and fruits (guava and papaya) were integrated with rice, ragi, ragi+blackgram, blackgram and horsegram cropping systems (Fig. 11.5). All around the field bunds, tephrosia, pigeonpea and blackgram as well as trees like drumstick and bakain (*Melia azedarach*) were planted to enrich the field bunds, to reduce the erosion and to supplement the additional source of income to the farmer's family. Nutrient recycling within the system was studied through production of vermicompost, FYM and crop biomass.

The total yield of high density guava was 0.61 t/0.75 acre whereas the yields of fodder and ragi were 0.53 t/0.75 acre and 0.25 t/0.75 acre, respectively. Intercropping of blackgram with rice and ragi produced the lower rice equivalent yields than that of blackgram sole (Table 11.2). Fodder biomass was estimated as 1.77 t/ha. Besides, the total FYM production (3.44 t/yr), vermicompost production (0.75 t/year) and cow urine production (3142 litres/year) from two cows and one calf were obtained. Cow dung production from an adult cow was estimated as 13.5 kg/day. Milk production during July, 2016 to January, 2017 was 921.5 litres.

Fig. 11.5. A view of IFS rainfed model

Table 11.2. Total yield and rice equivalent yield of different cropping systems under rainfed condition

Cropping system		Total yield t/0.75 acre	Rice equivalent yield t/0.75 acre
Rice (DSR)		0.17 (0.56)	0.17 (0.56)
Rice + blackgram	Rice	0.13 (0.43)	0.25 (0.84)
	Blackgram	0.02 (0.07)	
Ragi		0.25 (0.83)	0.48 (1.59)
Ragi+ blackgram	Ragi	0.13 (0.42)	0.42 (1.43)
	Blackgram	0.03 (0.10)	
Blackgram		0.17 (0.58)	1.07 (3.57)
Horsegram		0.04 (0.14)	0.16 (0.54)
Fodder		0.53 (1.77)	0.20 (0.68)
High density guava		0.61 (2.03)	0.94 (3.12)

* Values in parenthesis are yield t/ha

As a result of nutrient recycling within the system, i.e., 0.75 tonnes of vermicompost and 3.44 tonnes of FYM added nutrients equivalent to 23.9 kg N, 9.4 kg P and 24.2 kg K. The nutrient recycling from 1.2 tonnes of biomass to the system was equivalent to 6.2 kg N, 2.5 kg P and 5.1 kg K.

Under the scenario of need-based supplemental irrigation for winter and spring-summer crops, the grain yield of paddy and rice bean crops was severely affected due to the devastating hail storm at maturity of the crops. The cropping sequence 'vegetable soybean – lentil – cucumber' resulted in significantly higher gross returns of Rs. 88,318 /ha leading to the highest B:C ratio of 3.02 (Table 11.3). High density orchard of guava recorded the yield of 482 kg (16.07 t/ha) and gross returns of Rs. 8740/yr/acre. The livestock enterprises comprise of 4 adult cows and 4 young calves with total milk production of 1406.2 litre/year.

An income of Rs 7151/- was obtained from the sale of bull. The annual gross returns from milk production was Rs. 46,170/acre. The weed and crop waste biomass were collected and stored in a polythene bed of size 3.4 x 1.1 x 0.45 m. Cow dung slurry was applied on the stored biomass

Table 11.3. Gross and net returns obtained under different cropping sequences

Cropping Systems	Gross returns (Rs/ha/yr)	Net returns (Rs/ha/yr)	B:C ratio
Paddy + ricebean –field pea- urd	57,862	31,447	2.19
Paddy + ricebean –faba bean- urd	38,616	21,384	2.24
Paddy + ricebean – chickpea – mung	55,778	32,889	2.44
paddy + ricebean – linseed – mung	47,574	26,471	2.25
Paddy – lathyrus – watermelon	57,341	39,773	3.26
Vegetable soybean – lentil – cucumber	88,318	59,091	3.02
Vegetable soybean – mustard – bitter gourd	45,909	30,682	3.01

and the earth worm were introduced at a population density of 1000 no/m^3. A total of 549 kg of biomass, 185 kg of cow dung and 625 lit of water yielded about 253 kg of vermicompost, with recovery of 18 % in 3 months. The nutrient content of vermicompost was: N-1.12 %; P-0.33 %, K- 0.7 %, Ca- 0.46%, Mg- 0.28%, Fe- 4413 ppm, Mn- 1400 ppm, Cu- 32ppm, Zn 124 ppm and moisture- 42%. The total FYM production throughout the year recorded 500 cft and total urine collection of 2.05 cubic litres. The combined gross returns from FYM & vermicompost was Rs 15,000 /year. The soil moisture variation at different depth throughout the season in rice + rice bean-faba bean-urd; rice + rice bean – chick pea – mung and vegetable soyabean – lentil – cucumber cropping system throughout the season are depicted in Fig. 11.6.

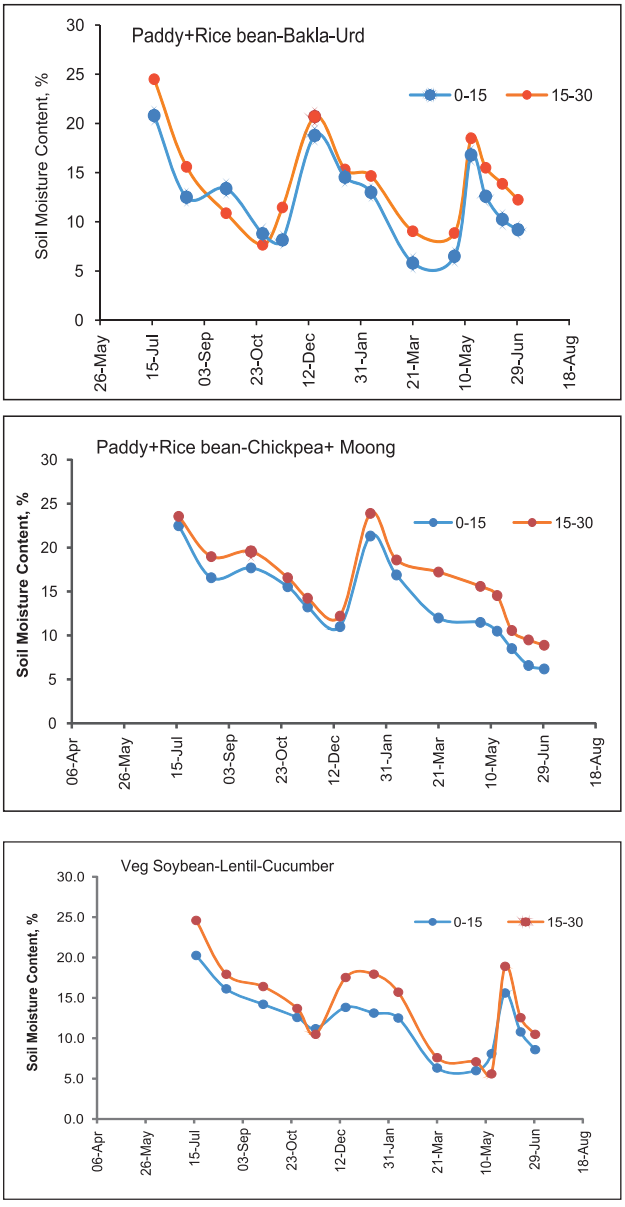


Fig. 11.6. Soil moisture variation at different depths under different cropping systems.

Development of Makhana-based Integrated Farming Systems for Lowlands and Waterlogged areas of North Bihar

Economic analysis of pond-based IFS model

The pond based IFS model fetched Rs 13,378/- and Rs 19,382/- as net returns and gross returns, respectively (Fig. 11.7). The makhana + fish integration recorded the net returns of Rs. 10,258/- The fruit crops grown on pond bunds fetched net returns of Rs. 3,120/- (Table 11.4).

Fig. 11.7. Horticulture + fish under pond based IFS model

Table 11.4. Economic analysis of pond-based IFS model

Name of components	Area (m^2)	Production details		Market rate of produce (Rs/kg)	Gross returns (Rs)	Net returns (Rs)
		Items	Weight (kg)			
Makhana + fish	1600	Makhana	58	120/-	6954	4868
		Fish	55	140/-	7700	5390
Horticulture:	1400	Mango	100	20/-	2000	1320
Mango – 30 plants Guava – 35 plants		Banana	70	10/-	700	462
Banana – 40 plants		Guava	169	12/-	2028	1338
Total					19,382	13,378

Economic analysis of field-based system

The major output could be recorded with cattle components. Under horticultural components, banana yielded 50 kg (Fig. 11.8). The total yield of milk obtained from two cows was 3085.75 litres/year which fetched a net income of Rs. 31,100/- (Table 11.5). During the fifth year (2016-17) of this project, the net returns and gross returns from all components were Rs. 32,111/- and Rs. 1,02,704/-, respectively.

Fig. 11.8. Banana and lime plants growing under field based IFS model

Comparison of fertility status of soils under pond and field based IFS models

Soils of both pond and field are slightly acidic to alkaline in reaction. The organic carbon content of pond soil (0.58%) was 30% higher than the field soil (0.42%). Pond soil registered 29% higher available phosphorus (23 kg/ha) than the field soil (17 kg/ha). The pond soil also recorded 25%, 23%, 19% and 26% higher concentrations of Fe (39 mg/kg), Mn (16 mg/kg), Cu (2.10 mg/kg) and Zn (0.38 mg/kg), respectively than the field soil [Fe (29.25 mg/kg), Mn (12.32 mg/kg), Cu (1.70 mg/kg) and Zn (0.28 mg/kg)].

Table 11.5. Economic analysis of field-based IFS model

Name of components	Area (m^2)	Production details		Market rate of produce (Rs./kg)	Gross returns (Rs.)	Net returns (Rs.)
		Item	Weight (kg)			
Fruit plants	400	Banana	50	Rs. 10/-	500	340
		Mango	17	Rs. 20/-	340	220
Makhana-water chestnut	1000	Water chestnut	69.50	Rs. 10/-	695	451
Cattle (two cows	100	Milk	3085.75 litres	Rs. 30/-	1,01,169	31,100
					1,02,704	32,111

12. Cropping System

Optimization of Water Productivity of Aerobic Rice-based Cropping System

In rice based cropping system rice grain equivalent yield (RGEY) and water productivity (WP) of rice-maize-mungbean cropping system was found to be the highest, i.e., 13.20 t/ha and 1.11 kg/m^3, respectively, while significantly the lowest RGEY was recorded with rice-wheat-mungbean cropping system. Yield of aerobic rice was not affected significantly due to heavy rain (140 mm) at grand growth period. However, mungbean yield differed significantly due to difference in irrigation schedules. Requirement of irrigation water was similar in case of rice-wheat-mungbean and rice-maize-mungbean cropping systems. The rice-maize-mungbean cropping system recorded 41 and 37 percent higher RGEY over rice-wheat-mungbean and rice-mustard-mungbean cropping systems, respectively. Rice-maize-mungbean system also recorded the highest water productivity which was 46.1 percent higher than rice-wheat-mungbean system (Table 12.1).

Development of Multitier Cropping System for Rainfed Uplands of Eastern Plateau and Hills

A project was undertaken to develop multitier system for rainfed uplands of eastern plateau and hills. The intercrop yield was monitored under two-year-old multitier cropping system. The grain yield of rice (0.96 t/ha) and finger millet (1.50 t/ha) were the highest in control as against different multitier systems (Table 12.2). Both the intercrops added maximum nutrients under the control. The grain and biomass yields of rice and finger millet were found similar under lemon + mango + mahogany, aonla + mango + mahogany and peach + mango + mahogany based multitier systems. Under different multitier systems, the highest mortality of perennials was observed in lemon (83.33%)

Table 12.1. Yield and water productivity of various aerobic rice-based cropping systems at different irrigation levels

Treatments	Mungbean grain yield (t/ha)	Rice grain yield (t/ha)	Yield of *rabi* crops (t/ha)	Rice grain equivalent yield (t/ha)	Total rainfall (mm)	Total irigation water (mm)	Total water (mm)	WP for RGEY (kg/m^3)
Cropping systems								
C_1-Rice-wheat-mungbean	0.45	3.83	3.96	9.36	1012.9	306.7	1332.9	0.76
C_2-Rice-maize-mungbean	0.73	3.75	13.72	13.20	1012.9	306.7	1332.9	1.11
C_3-Rice-mustard-mungbean	0.52	3.92	1.71	9.64	1012.9	293.3	1306.2	0.82
LSD (P = 0.05)	0.08	0.62						
Irrigation scheduling (40 mm each irrigation)								
I_1-IW: CPE = 0.70 (0.25 in case of mungbean)	0.46	3.24	3.22 10.01 1.23	8.51	1012.9	253.3	1279.6	0.66
I_2-IW: CPE = 0.85 (0.40 in case of mungbean)	0.59	3.86	4.03 14.44 1.82	10.91	1012.9	280.0	1292.9	0.84
I_3-IW: CPE = 1.00 (0.55 in case of mungbean)	0.65	4.41	4.64 16.71 2.1	12.66	1012.9	373.3	1399.6	0.90
LSD (P = 0.05)	0.09	0.55						

Table 12.2. Performance of intercrop under different multitier cropping system for rainfed uplands

Multitier system	Intercrop yield									
	Rice					Finger millet				
	Grain yield (t/ha)	Total biomass added in the soil (t/ha)	Nutrients added by biomass (kg/ha)			Grain yield (t/ha)	Total biomass added in the soil (t/ha)	Nutrient added by biomass (kg/ha)		
			N	P	K			N	P	K
Lemon + mango + mahogany	0.802	3.35	19.10	4.02	37.86	1.303	6.04	39.29	7.25	102.16
Aonla + mango + mahogany	0.800	3.29	18.73	3.94	37.14	1.297	6.13	39.84	7.36	103.60
Peach + mango + mahogany	0.805	3.32	18.92	3.98	37.52	1.301	6.17	40.09	7.40	104.22
Mango + mahogany	0.857	3.45	19.70	4.15	39.05	1.383	6.48	42.11	7.77	109.48
Control (only intercrop)	0.960	4.04	23.00	4.84	45.61	1.502	6.96	45.25	8.35	117.66

followed by mango (50.00%). The mortality was high in these two components as a result of the hailstorm. No mortality was recorded in mahogany tree. Peach and aonla also performed better as filler crops due to higher survival rate under the rainfed conditions (Table 12.3). Among the filler crops, peach and aonla showed the highest plant growth. The girth of peach and aonla increased up to 25.15% and 48.05%, respectively. The annual increment in girth and height of mahogany was 47.32% and 38.96%, respectively.

Table 12.3. Mortality of different perennial component under multitier system

Components	No. of plants planted	No. of plants died	% mortality
Mahogany	81	0	0.00
Mango	90	45	50.00
Lemon	60	50	83.33
Peach	60	6	10.00
Aonla	60	1	1.67
Total	351	102	29.06

Testing of Legumes in Rainfed Cropping System

In rice-legume cropping system under rainfed upland situation in *kharif* season, the upland rice (Anjali) and legumes like soybean (Swarna Vasundhara), groundnut (Birsa Bold), blackgram (Uttara), greengram (CN 9-5) and cowpea (EC 452) were grown both as sole crops (each of 12 rows) and in combination (6 row rice + 6 row of each legume). The sale prices of rice, groundnut (fresh with shell), blackgram and greengram were 12, 30, 60 and 80 Rs/kg, respectively. The sale prices of cowpea and soybean was Rs. 40.0/kg whereas that of rice bean and horse gram was Rs 50.0/kg. The sole crop of soybean recorded the maximum rice equivalent yield of 8.26 t/ha which was at par with that of groundnut (8.10 t/ha) (Table 12.4). The rice equivalent yield of the treatment of 6 row rice + 6 row soybean (5.89 t/ha) was at par with that of 6 row rice + 6 row groundnut (5.81 t/ha), sole crop of rice bean (5.57 t/ha) and sole crop of black gram (5.22 t/ha). The result indicated that growing of sole crop of soybean or groundnut in rainfed upland situation during *kharif* season would be more profitable in respect of rice equivalent yield.

Table 12.4. Rice equivalent yield in rice-legume cropping system

Treatments	Rice equivalent yield (t/ha)
Rice sole	3.17
Groundnut sole	8.10
Rice bean sole	5.57
Soybean sole	8.26
Horsegram sole	3.61
Greengram sole	2.94
Blackgram sole	5.22
Cowpea sole)	3.84
Rice + groundnut (6 row + 6 row)	5.81
Rice + rice bean (6 row + 6 row)	3.30
Rice + soybean (6 row + 6 row)	5.89
Rice + horsegram (6 row + 6 row)	3.14
Rice + greengram (6 row + 6 row)	2.73
Rice + blackgram (6 row + 6 row)	3.72
Rice + cowpea (6 row + 6 row)	2.67
LSD (P=0.05)	1.60

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

Millets can be grown successfully in summer season in hot and dry environments. With the threat of climate change looming large on crop productivity, millets being a drought hardy crop will play an important role in food, feed and fodder security of the eastern region. Keeping these facts in view, a long-term experiment involving 10 diversified cropping systems has been initiated during *kharif* 2016 to evaluate the system productivity, sustainability and energy efficiency of different systems in Eastern India (Fig 12.1). The highest system rice equivalent yield (SREY) was recorded with maize (cob)-toria- mungbean (15.93 t/ha) followed by sorghum fodder-mustard-urdbean (15.88 t/ha) and DSR-mustard-urdbean (11.1 t/ha) (Table 12.5).

Fig. 12.1. Performance of different crops under diversified cropping system

Table 12.5. Rice equivalent yield (REY) and system REY as influenced by cropping system

Treatment	Rice equivalent yield (t/ha)		System rice equivalent yield (t/ha)
	Kharif	*Rabi*	
Rice-wheat-mungbean (FP)	4.56	5.84	10.40
DSR-wheat-mungbean (RCT)	5.25	4.59	9.84
DSR-lentil-fallow	4.92	5.06	9.98
DSR-mustard-urdbean	5.09	6.01	11.10
Foxtail millet-wheat-mungbean	1.78	4.77	6.55
Pearl millet-chickpea-Fallow	3.96	6.22	10.18
*Finger millet-toria-urdbean	0.00	3.35	3.35
Sorghum(grain)-chickpea-fallow	4.37	6.10	10.47
Maize (cob)-toria-mungbean	12.61	3.27	15.88
Sorghum (F)-mustard-urdbean	9.84	6.10	15.93
LSD (P=0.05)	0.40	0.24	0.42

*Crop failed due to water logging

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

Under rainfed upland conditions of Eastern Plateau and Hill region, the experiment on diversification of direct sown upland rice was conducted during *kharif* 2016. The treatments were, sole crop of rice, finger millet, blackgram, horsegram, pigeonpea, vegetable cowpea, rice + blackgram in area ratio of 1:1, rice + horsegram in area ratio of 1:1, finger millet + blackgram in area ratio of 1:1 and finger millet + horsegram in area ratio of 1:1 (Fig. 12.2). The sale prices of rice and blackgram were Rs 12.0 and Rs 60.0 per kg, respectively. The sale prices of pigeonpea and horsegram was Rs 50.0/kg whereas that of finger millet and vegetable cowpea was Rs 20.0/kg. The sole crop of vegetable cowpea recorded the maximum rice equivalent yield of 16.4 t/ha followed by that of pigeonpea (15.0 t/ha), horsegram (9.9 t/ha), blackgram (9.7 t/ha) and finger millet (6.2 t/ha) (Table 12.6). The sole crop of rice recorded yield of 1.29 t/ha only. The study highlighted that the diversification of rainfed upland rice system with vegetable, pulses and millets would be more profitable in Eastern Plateau and Hill Region.

Fig. 12.2. Crop diversification in rainfed upland rice system

Improving Rice-Lentil-Mungbean System Productivity through Water Management

In order to improve the water productivity, an experiment was initiated in rice-lentil-mungbean cropping system during 2016 (Fig. 12.3). Treatments comprised of two level of land management, i.e., zero tillage (ZT) and conventional tillage (CT),

Table 12.6. Rice equivalent yields under diversified cropping system

Treatments	Rice equivalent yield (t/ha)
Rice sole	1.29
Finger millet sole	6.21
Blackgram sole	9.67
Horsegram sole	9.89
Vegetable cowpea sole	16.39
Pigeonpea sole	14.99
Rice + blackgram	5.46
Rice + horsegram	6.59
Finger millet + blackgram	6.5
Finger millet + horsegram	6.66
LSD (P=0.05)	0.83

Fig. 12.3. Field view of lentil under rice-lentil-mungbean cropping system

along with IW: CPE based four water management levels *viz.*, (1) Rainfed (W_1); (2) IW: CPE = 0.2 (W_2), (3) IW: CPE = 0.3 (W_3) and (4) IW: CPE = 0.4 (W_4) were tested in 3 replications. One pre-sowing irrigation (40 mm) was uniformly provided to all plots. Data (Table 12.7) showed that zero tilled plot produced significantly higher lentil grain yield (1.13 t/ha) as compared to conventional tilled plot. Among water management treatments, the highest grain yield (1.31 t/ha) was recorded with one pre sowing irrigation (W_1) whereas significantly the lowest yield (0.95 t/ha) was recorded with two irrigations applied at IW: CPE = 0.4. Water productivity was not affected by land management treatments, though it was high (1.66 kg/m^3) in zero tilled plot. The highest water productivity of 3.18 kg/m^3 was obtained in the treatment W_1. Water productivity was recorded 9.4% higher in zero tillage (1.66 kg/m^3) than conventional tillage whereas more than 2.3 times water productivity was recorded in W_1 (3.18 kg/m^3) than W_2, W_3 and W_4. The interaction of land and water management was non-significant.

Table 12.7. Yield attributes and yield of lentil influenced by land and water management schedules

Treatments	Pods/ plant	Grain yield (t/ha)	HI (%)	Water productivity (kg/m^3)
Land Management				
ZT	31.3	1.13	27.37	1.66
CT	30.5	1.06	24.83	1.51
SEm±	0.37	0.02	0.65	0.06
CD (P=0.05)	NS	0.06	1.83	NS
Irrigation Schedules				
W_1 (Rainfed)	34.3	1.31	30.56	3.18
W_2 (IW:CPE = 0.2)	33.0	1.05	26.32	1.35
W_3 (IW:CPE = 0.3)	32.8	1.06	24.95	1.35
W_4 (IW:CPE = 0.4)	28.5	0.95	22.57	1.24
SEm±	1.19	0.07	1.73	0.13
CD (P=0.05)	3.12	0.21	5.18	0.41

13. Carbon Sequestration and Nutrient Dynamics

Carbon Stock Estimation in Litchi

Mean carbon content of different tree components on percent dry weight varied between 45.8 and 48.8%. The maximum carbon was recorded in leaf (48.8%) followed by root (46.7%), bole (45.8%) and branches (45.8%). The overall mean carbon content of litchi plant samples was computed as 46.8% of their dry weights. The stored biomass carbon stock in litchi plantation (branches, bole, and roots) varied from 0.10 t/ha in 2 years to 1.85 t/ha in 10 years plantation (**Table 13.1**). The emitted biomass carbon stock varied from 0.052 to 0.587 t/ha in litchi plantation in 2–10 year old plantations. The carbon mitigation varied from 0.052 to 1.26 t/ha during 2–10 years age, which sequestered 0.19–4.63 ton CO_2/ha from the atmosphere. The carbon mitigation potential of litchi plantations was found to be dependent on the tree density, age, and structure and carbon concentration in different components.

Rate of Decomposition and Nutrient Mineralization of Leaf Litter from Different Orchards

Litter decomposition expressed as the loss of dry matter (DM) at the end of each month showed that 40 % of the total DM was lost during the first 5 months in mango leaf litter, while 15 % in guava and 5 % in litchi. The annual decomposition rate constant for the dry matter was high in mango (1.97), followed by guava (1.07) and litchi (0.50). The time required for decomposition of 50% (T_{50}), 95% (T_{95}) and 99% (T_{99}) of litchi litter was found to be the highest with 1.39, 6.03 and 10.05 years, respectively as compared to others.

The lignin content in mango, guava, and litchi leaf litter at the time of decomposition was 17.2, 21.2 and 33 %, respectively. The rate of lignin decomposition was the highest in mango leaf litter and had the lowest T_{99} period of 2.15 years, while the litchi leaf litter had the highest T_{99} period of 7.46 years.

The cellulose content in mango, guava, and litchi leaf litter at the time of decomposition was 45, 40 and 36 %, respectively. The rate of cellulose decomposition was faster in mango having the highest annual decomposition rate constant of 2.61 and has the lowest T_{99} period of 1.91 years, while the litchi leaf litter had the lowest annual decomposition rate constant of 0.88 with the highest T_{99} period of 5.65 years.

The lignocellulose content in the leaf litter of mango, guava, and litchi were 69, 69 and 85 %, respectively at the time of decomposition. The highest annual decomposition rate constant was 2.17 in mango leaf litter and least in litchi leaf litter (0.72). The T_{99} period of different leaf litters followed the order as, litchi (6.94 yrs) > guava (4.17 yrs) > mango (2.3 yrs).

The polyphenol content of the leaf litter of different orchard was 18.2, 16.2 and 27.2 mg/g in

Table 13.1. Component wise carbon stock estimates (t/ha) in Litchi

Age (Yrs)	Average collar diameter (cm)	Stored C (Mg/ha)				Emitted C (Mg/ha)	Mitigated C (Mg/ha)	CO_2 stored (Mg/ha)
		Branch	Bole	Root	Total	Leaf		
2	1.33±0.206	0.036 ± 0.003*	0.043 ± 0.004	0.025 ± 0.002	0.104 ± 0.009	0.052 ± 0.005	0.052	0.191
4	3.31±0.255	0.251 ± 0.034	0.196 ± 0.027	0.082 ± 0.008	0.529 ± 0.070	0.172 ± 0.018	0.357	1.310
6	5.75±0.289	0.544 ± 0.028	0.458 ± 0.028	0.167 ± 0.009	1.169 ± 0.065	0.352 ± 0.019	0.817	2.998
8	9.50±0.465	0.768 ± 0.015	0.675 ± 0.013	0.248 ± 0.006	1.691 ± 0.035	0.523 ± 0.013	1.168	4.287
10	13.33±0.494	0.838 ± 0.004	0.733 ± 0.003	0.279 ± 0.002	1.850 ± 0.009	0.587 ±0.004	1.263	4.635

*± SE

mango, guava, and litchi, respectively at the time of decomposition. The highest decomposition rate constant was 6.75 in guava with least T_{99} period of 0.74 year, while mango and litchi leaf litter had the lowest decomposition rate constant of 6.1 with T_{99} period of 0.81 year.

Nutrient release patterns in decomposed leaf litter of orchards

The N-content in the leaf litter of mango, guava, and litchi gradually decreased with the progress of decomposition. The N-mineralization rate (% release month^{-1}) was higher after 1st, 7th and 9th months of decomposition in mango leaf litter **(Fig. 13.1)**. The highest N-mineralization rate in guava leaf litter was 59% after 1st months of decomposition. The highest N-mineralization rate in litchi leaf litter was 43.4% after the 1st month of decomposition. The immobilization of N was observed after 4th and 6th month of decomposition at the rate of 17.7 and 22.5%, respectively.

The P-mineralization rate in mango leaf litter was the highest of 57 and 68 % after 7th and 9th months of decomposition, respectively **(Fig. 13.2)**. The highest P-mineralization rate in guava leaf litter was 44.1% after 10 months of decomposition. The highest P-mineralization rate of 22.5, 27.0 and 32.2% was observed after 1st, 11th and 18th months of decomposition in litchi leaf litter, respectively. The P-decomposition rate constant was highest in mango (2.58) followed by guava (1.66) and litchi (1.06).

The highest K-mineralization rate of 50.3 and 69.1% was observed after 7th and 9th months of decomposition, respectively in mango leaf litter **(Fig. 13.3)**. The average K-mineralization rate in guava leaf litter throughout the period of investigation was 21.6 % with the highest K-mineralization rate

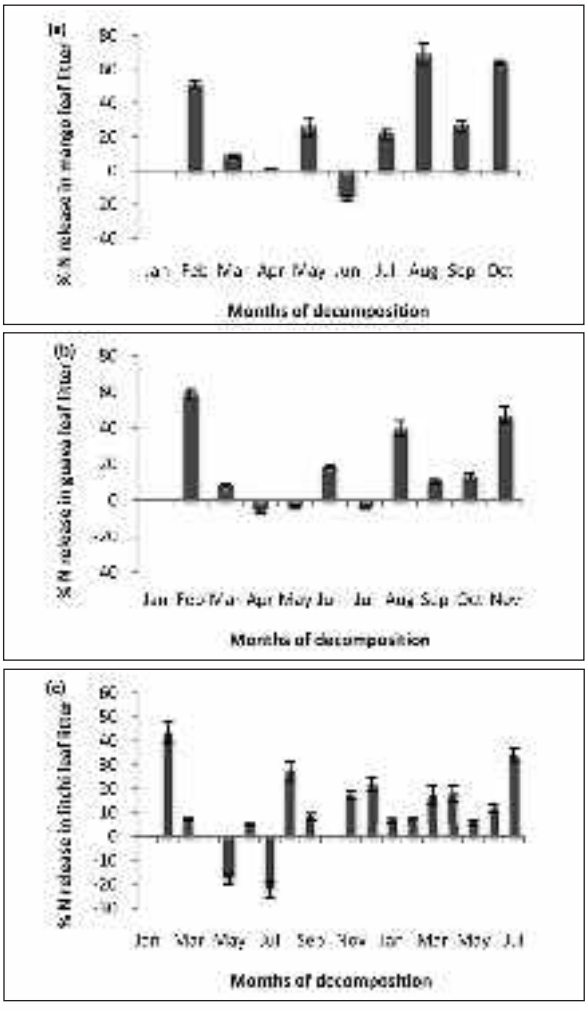


Fig. 13.1. Net N mineralization rate (% release per month) in the decomposing leaf litter of different orchards (a), Mango, (b), Guava, (c), Litchi.

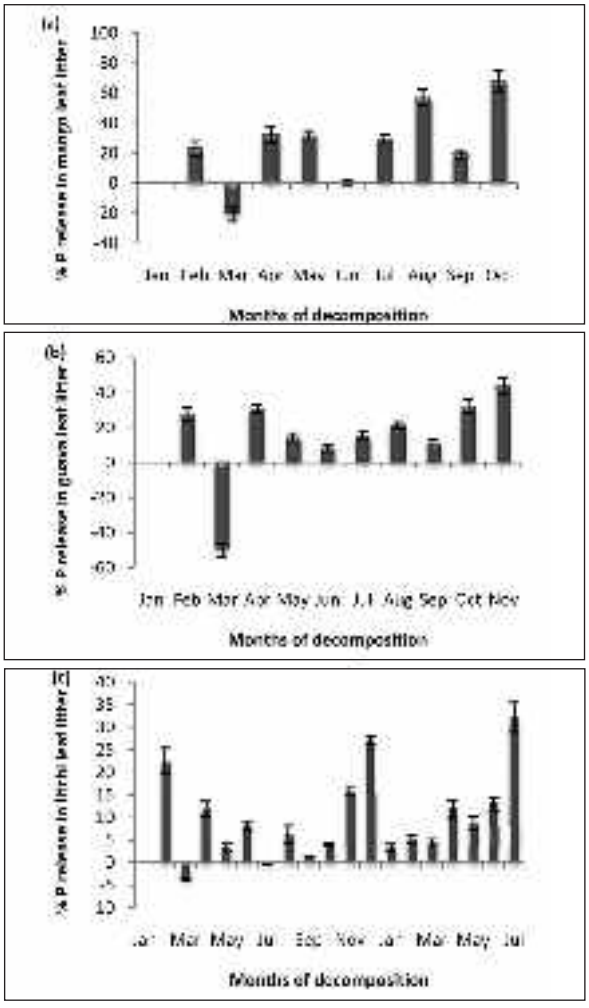


Fig. 13.2. Net P mineralization rate (% release per month) in the decomposing leaf litter of different orchards (a), Mango, (b), Guava, (c), Litchi

of 48.9 % after 10th months of decomposition. The K-mineralization rate from litchi leaf litter was not uniform throughout the period of decomposition and the highest K-mineralization rate was 37.9 % after 11 months of decomposition.

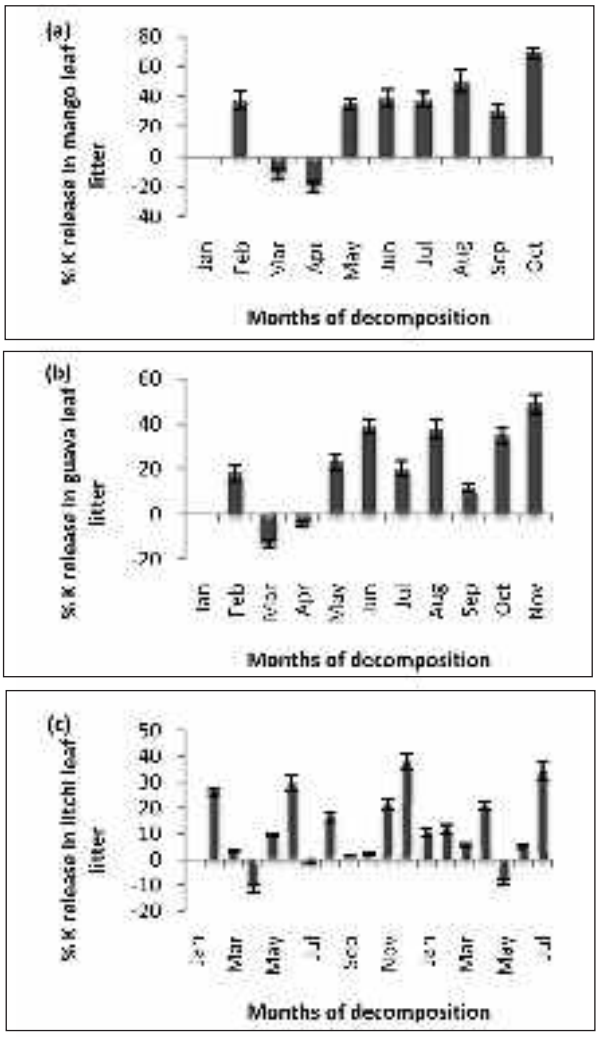


Fig. 13.3. Net K mineralization rate (% release month-1) in the decomposing leaf litter of different orchards (a), Mango, (b), Guava, (c), Litchi

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

The straw and root decomposition pattern of rice, wheat and maize were studied through litter bag technique in which Nylon net bags of 40x 30cm with 1mm mesh size were used. Decomposition rate was estimated as loss of dry mass at the end of each month. The complete decomposition of wheat, maize and paddy straw was observed after 7, 9 and 10 months of its placement in the field, while the complete decomposition of wheat, maize and paddy roots was observed after 5, 6 and 7 months, respectively.

Quantum of nutrient supplied by the straw and roots of the substrates of maize, paddy, and wheat is shown in **Table 13.2**. Supply of nitrogen (30.2 kg/ha) and phosphorus (9.9 kg/ha) was highest in maize straw compared to wheat and paddy straw while per hectare supply of potassium was highest in wheat straw (58.8 kg/ha). Supply of nitrogen (3.4 kg/ha) and phosphorus (0.6 kg/ha) from the roots of the maize was the highest, whereas the maximum amount of potassium was supplied by paddy roots (6 kg/ha).

Table 13.2. Nutrient supply per hectare by different substrates

Substrates	Biomass yield (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Paddy Straw	4.83	27.5	5.8	54.5
Paddy roots	0.78	3.2	0.4	6.0
Wheat Straw	5.55	26.6	5.6	58.8
Wheat roots	0.80	2.0	0.2	4.4
Maize Straw	4.50	30.2	9.9	55.8
Maize roots	0.75	3.4	0.6	3.0

Nutrient dynamics during decomposition of substrates

Nutrient dynamics in decomposition of paddy, maize and wheat substrates showed three sequential phases: (i) the initial release phase in which leaching predominates; (ii) the net immobilization phase in which nutrients are imported into the residual material through the activity of microorganism; and (iii) the net release phase in which an absolute decrease in the nutrient mass. The analysis of elemental composition of decomposing substrates of paddy, maize, and wheat straw revealed an initial rapid loss of N, P, and K during the initial months, followed by an increase in the concentration in subsequent months and thereafter N, P and K-concentrations gradually decreased with the passage of time (**Fig. 13.4**).

Evaluation of Different Production Systems for Carbon Sequestration Potential

A long-term field experiment with three cropping systems, i.e., C_1: rice-wheat (RW), C_2: rice-maize (RM), C_3: rice-lentil (RL) and three tillage

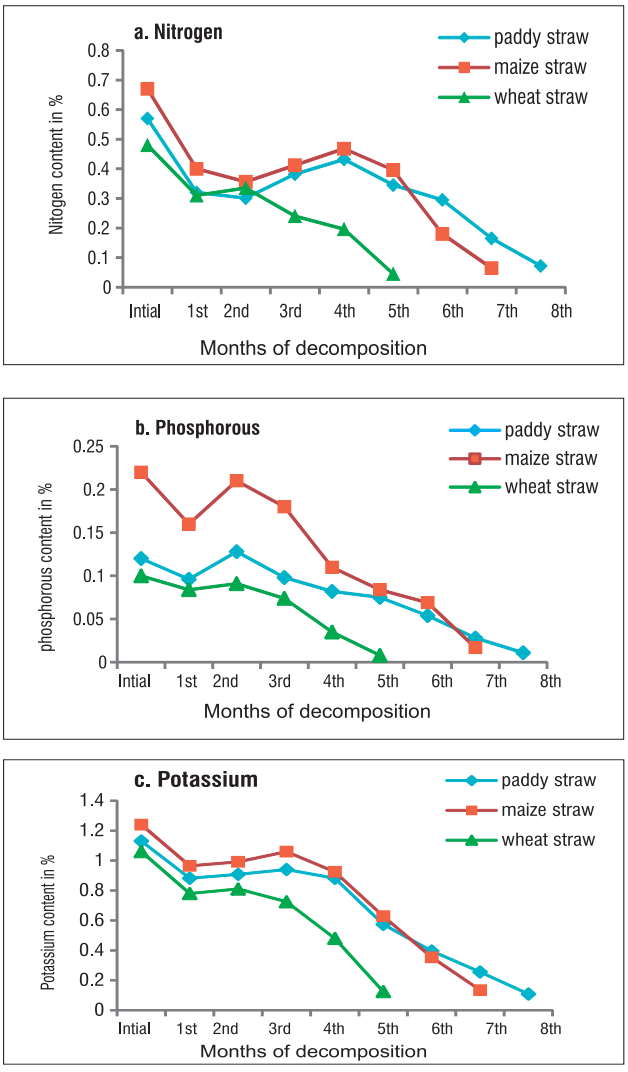


Fig. 13.4. Nitrogen, phosphorous and potassium release patterns in decomposing Paddy, Maize and Wheat straw

practices [T_1: conventional tillage without residue (CT) T_2: reduced tillage without residue RT), T_3: reduced tillage with 30% residue (RTR30)] in factorial R.B.D. is undergoing at Patna since 2012. All these cropping systems were assessed for their carbon sequestration potential.

There was no significant difference between the rice grain yield of all the three cropping systems. Grain yield of all *rabi* crops i.e wheat, maize and lentil were converted into rice equivalent yield. Rice equivalent yield of wheat (3.6 t/ha) was higher than that of maize and lentil. System productivity of rice-wheat cropping system was also found significantly higher among cropping systems. However, tillage practices had no effect on the grain yield of *rabi* and *kharif* crops.

The distribution of different carbon fractions under tillage practices and cropping systems were in the order: C pool I > C pool IV > C pool III > C pool II (Table 13.3). The cropping systems followed under different tillage practices significantly influence the different carbon pools. The carbon pool I was found significantly highest (4.6 g/kg) in RL-RTR30 than other treatment combinations. The different cropping systems of RTR 30 exhibited significantly higher carbon pool II than RT and CT but when compared among themselves, it was non-significant. The carbon pool III and carbon pool IV was highest in RL-RTR30 (3.38 g/kg) and RW-RTR30 (3.48 g/kg), respectively.

Carbon stock and sequestration rate

Carbon stock in the soil was significantly highest (23.29 Mg/ha) in RL-RTR30 treatment. The highest organic carbon stock in legume rotation after rice was attributed to the higher stabilization of carbon in the soil. When carbon sequestration rate was compared between the treatments, negative carbon sequestration rate was observed under CT and positive under RT and RTR30 treatments which emphasized that tillage reduced the soil carbon.

Table 13.3. Effect of tillage practices and cropping system on TOC (g/kg soil), its different oxidisable fractions (g/kg soil) and lability index

Treatment	TOC	C pool I (very labile)	C pool II (labile)	C pool III (less labile)	C pool IV (non-labile)
Tillage					
CT	7.97^{C}	3.01^{B}	1.52^{C}	1.92^{C}	1.52^{C}
RT	10.81^{B}	3.32^{B}	1.79^{B}	2.72^{B}	2.99^{B}
RTR30	12.99^{A}	3.99^{A}	2.44^{A}	3.12^{A}	3.44^{A}
Cropping system					
RW	10.51^{A}	3.43^{A}	1.94^{A}	2.55^{A}	2.59^{A}
RL	10.56^{A}	3.59^{A}	1.91^{A}	2.49^{A}	2.57^{A}
RM	10.71^{A}	3.3^{A}	1.90^{A}	2.72^{A}	2.78^{A}
Interaction					
RW-CT	8.21^{d}	3.15^{c}	1.53^{b}	2.03^{de}	1.50^{c}
RL-CT	7.40^{d}	2.85^{c}	1.53^{b}	1.73^{e}	1.29^{c}
RM-CT	8.29^{d}	3.02^{c}	1.50^{b}	2.00^{de}	1.78^{c}
RW-RT	10.75^{c}	3.22^{c}	1.92^{b}	2.82^{bc}	2.79^{b}
RL-RT	10.48^{c}	3.31^{bc}	1.78^{b}	2.36^{cd}	3.03^{ab}
RM-RT	11.22^{c}	3.42^{bc}	1.68^{b}	2.98^{ab}	3.14^{ab}
RW-RTR30	12.56^{b}	3.91^{b}	2.37^{a}	2.80^{bc}	3.48^{a}
RL-RTR30	13.80^{a}	4.60^{a}	2.42^{a}	3.38^{a}	3.40^{ab}
RM-RTR30	12.62^{b}	3.47^{bc}	2.53^{a}	3.19^{ab}	3.44^{ab}

14. Water Quality and Productivity

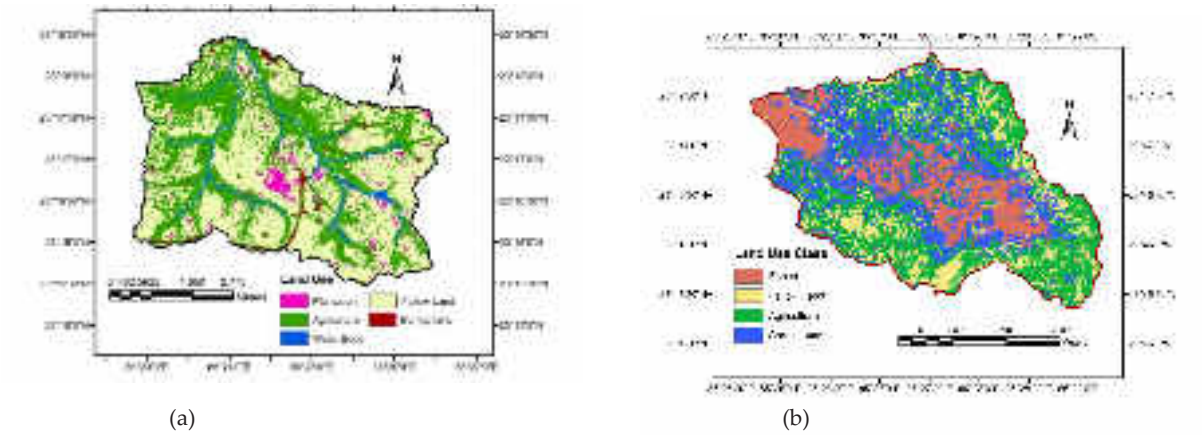
Hydrological Response of Micro-watersheds in Eastern Plateau and Hill Region

Two watersheds, Plandu and Keribanda, in the Eastern plateau and hill region were selected for quantitative assessment of hydrological response under varying Land Use Land Cover (LULC) and agro-climatic conditions. The watershed boundaries and drainage network were delineated using the Digital Elevation Model (DEM) obtained from SRTM data with 90 m spatial resolution. The LULC maps of the watersheds were developed using LISS III, 4 band remote sensing digital data having a spatial resolution of 25 m. Area of Plandu and Keribanda watersheds was 1541 and 1865 ha with an average slope of 1.15 and 2.24 %, respectively. These two watersheds represented a distinct LULC pattern (Fig. 14.1). Percent agricultural and forest cover was 64 and 4 % in Plandu watershed while that in Keribanda watershed was 36 and 47%, respectively.

The peak discharge of 5.35 and 9.39 m^3/s was observed from Plandu and Keribanda watersheds, respectively. Peak sediment concentration from Keribanda, a forest dominated watershed was far low (181 g/m^3) as compared to agriculture dominated Plandu watershed (223 g/m^3). Annual water yield of 4.75 and 5.02 MCM and total sediment loss of 437 and 384 t/yr was observed from the Plandu and Keribanda watersheds, respectively. Total nutrient (N, P and K) loss of 14 kg/ha and 21 kg/ha was recorded from the Plandu and Keribanda watersheds respectively. The abundance of mica ores in the top soils of the Keribanda watersheds resulted in higher K loss in runoff water.

Flood and Drought Mapping in Eastern Region

Some digitized maps/ spatial data were collected for the assessment of water bodies. The spatial analysis of digitized maps of the three states *viz*. of Bihar, Jharkhand, and West Bengal was done to extract district-wise data for the area of water bodies in tabular form. Data contains district-wise information for standing water bodies of various categories in respect of area in hectare (0.5-10, 10-50, 50-100, 100-500, 500-1000 and more than 1000) of Bihar, (0.5-2, 2-5, 5-10, 10-50 and more than 50 ha) of Jharkhand, and (0.5-10, 10-50, 50-500, 500-1000 and above 1000 ha) for West Bengal. It also contains district-wise information about the number of water bodies and the total area of water bodies in hectare. The analysis revealed that the total area of standing water bodies in the form of ponds, lakes, etc. in Bihar, Jharkahnd and West Bengal is approximately 1,30,199.47 ha, 55,473.31



(a) (b)

Fig. 14.1. Land use land cover map of (a) Plandu and (b) Keribanda watersheds

ha, and 2,13,981.18 ha, respectively. Out of three states, the highest area of standing water bodies was found in West Bengal followed by Bihar and the lowest in Jharkhand (Fig. 14.2). These data will be useful for utilization of water resources in agriculture for increasing crop production in these states. This information has been sent to the different stakeholders for their benefits.

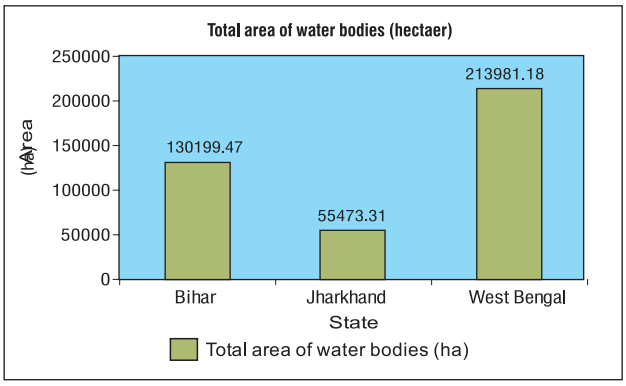


Fig. 14.2. State wise total area of standing water bodies

Yield and Water Productivity of Vegetables Under Drip Irrigation with Mulch

A field study was conducted to investigate the efficacy of drip irrigation (DI), drip irrigation with bicolor polythene mulch (DIM) and furrow irrigation (FI) on different cropping sequences (Cabbage–mungbean–tomato, cauliflower – cowpea – vegetable soybean, broccoli – french bean-capsicum) were considered for the study. During the *rabi* season, DIM recorded highest curd yields of 31.9, 26.6 and 10.3 t/ha for cabbage, cauliflower, and broccoli, respectively, as compared to others (Fig. 14.3). Cultivation with drip and polythene mulch resulted in the highest water productivity (WP) of 14.3, 11.9 and 4.6 kg/m^3 in case of cabbage, cauliflower, and broccoli leading to respective economic water productivity (EWP) of 143, 119 and 92 Rs/m^3, respectively. The yields of summer crops like mung bean (0.68 t/ha), cowpea (15.29 t/ha), french bean (2.46 t/ha) obtained under DIM were significantly higher over DI and FI methods. The DIM also resulted in higher WP and EWP in case of summer crops.

During the summer season, DIM recorded the highest yields of 8.39, 7.31, 3.57 t/ha in tomato, vegetable soybean and capsicum respectively. During the winter season (January to March), use of

Fig. 14.3. Vegetable cultivation under drip + polythene mulch

polythene mulch maintained significantly higher temperatures in the subsurface root zones (10-15 cm) of the crops. In all three cropping sequences, DIM showed the highest yield, nutrient uptake, available soil NPK, WP and EWP over drip and furrow irrigation and was found to be effective for commercial cultivation of vegetables in eastern plateau hill region (Fig. 14.4).

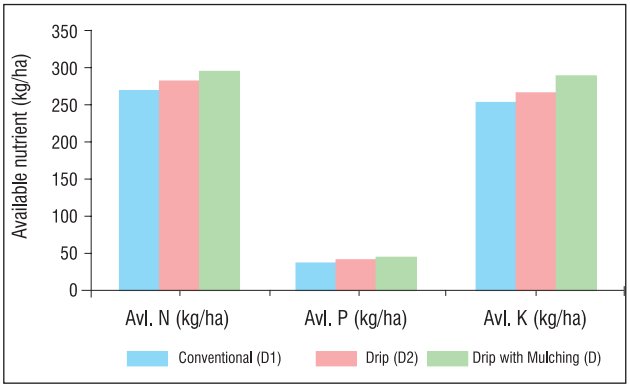


Fig. 14.4. Nutrient availability in soil under different irrigation systems

Evaluation of Vegetable Varieties under Different Irrigation Methods

Different varieties of tomato, brinjal, cucumber and ridge gourd were evaluated and compared with local variety under surface and drip irrigation method with and without plastic mulch. Drip irrigated tomato and brinjal crop produced 18.6% and 41% higher yield over surface irrigation. However, no significant effect of drip irrigation was found on the yield of cucumber and ridge gourd. Mulching in tomato, brinjal, cucumber and ridge gourd produced 43.7%, 54%, 38.6%, and 47% higher yield, respectively over non-mulched crop. There was significant interaction effect of mulch and irrigation on tomato and brinjal yield (Table 14.1 & 14.2). The

Table 14.1. Interaction effect of irrigation and mulching on yield of tomato

Treatments	Mulch	No mulch	Mean
Surface irrigation	40.73	32.10	36.42
Drip irrigation	53.21	33.28	43.24
Mean	46.97	32.69	--

LSD (P=0.05) : Irrigation x Mulch: 3.97; Irrigation: 5.3; Mulch: 2.8

Table 14.2. Interaction effect of irrigation and mulching on yield of brinjal

Treatments	Mulch	No mulch	Mean
Surface irrigation	30.91	20.82	25.87
Drip irrigation	44.82	33.28	36.57
Mean	37.87	24.57	--

LSD (P=0.05): Irrigation x Mulch: 2.85; Irrigation: 8.5; Mulch: 2.01

mulched treatments showed significantly less weed biomass production in comparison to non mulched treatments. The maximum weed biomass was found in surface irrigated non-mulched treatment and the least was in drip irrigated mulched treatments. The loss in yield due to weed infestation was very low, i.e., 3-5% in mulched plot receiving drip irrigation while in unmulched surface irrigated plots, weed reduced the yield up to 22%. Tomato variety Swarna Sampada produced significantly higher fruit yield (42.8 t/ha) than Swarna Naveen (39 t/ha) and local variety (37.7 t/ha), irrespective of mulch and irrigation. White coloured brinjal variety Swarna Shobha (V2) produced maximum yield (33.7 t/ha) than Swarna Pratibha (V1) and local variety (V3). In case of cucumber and ridge gourd performance of all varieties was at par with respect to yield attributes and yield. However, bitterness in taste was found in cucumber variety Swarna Ageti and Swarna Sheetal.

Drip irrigated crop with mulch showed the highest water productivity in all crops whereas surface irrigated crop without mulch showed the least water productivity (Fig. 14.5). Irrigation through drip saved 33% irrigation water in tomato, 32% in brinjal, 37% in cucumber and 31 % in ridge gourd as compared to surface irrigation.

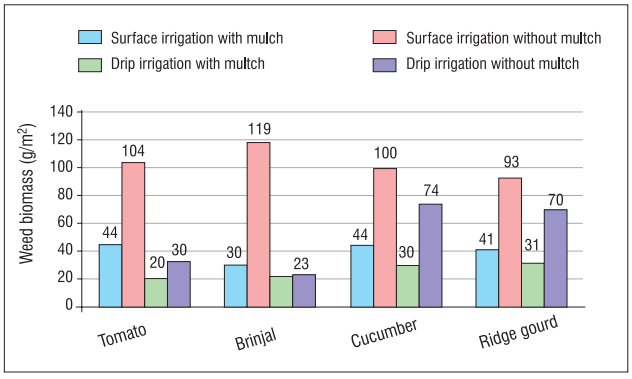


Fig. 14.5. Effect of irrigation and mulching on weed biomass (g/m^2)

15. Conservation Agriculture

Evaluation of Pulses and Oilseeds Under Different Crop Establishment Methods in Rice-fallows of Eastern India

Performance of three winter pulses *viz.* lathyrus (Ratna), chickpea (JG-14) and lentil (HUL-57), and two oilseeds *viz.*, linseed (T-397) and Indian mustard (Pusa Mustard) was evaluated under three crop establishment methods, i.e., *utera* (sowing crops in standing rice 10 days before rice harvest), zero tillage (ZT) and ZT with straw mulch @ 5 t/ha) (Fig. 15.1). Results revealed that *utera* system in rice–fallows recorded significantly higher rice equivalent yield (2.03 t/ha), system rice equivalent yield (6.41 t/ha) and production efficiency (17.56 kg/ha/day) compared to ZT with straw mulch @ 5 t/ha and ZT (Table 15.1).

Linseed

Lentil

Fig. 15.1. Pulses and oilseeds grown under ***Utera***

Table 15.1. Rice equivalent yield and system productivity of crops as influenced by different crop establishment methods

Treatment	Rice equivalent yield (t/ha)	System rice equivalent yield (t/ha)	Production efficiency (kg/ha/day)
Crop establishment methods			
Utera	2.03	6.41	17.56
Zero tillage	1.19	5.58	15.29
Zero tillage with mulch	1.42	5.83	15.98
LSD (P=0.05)	0.19	0.59	1.61
Crops			
Lathyrus	2.73	7.12	19.52
Lentil	1.70	6.08	16.66
Mustard	0.59	4.99	13.66
Linseed	1.96	6.37	17.46
Chickpea	0.75	5.14	14.09
LSD (P=0.05)	0.16	0.22	0.61

Evaluation of establishment methods for improving productivity of rice fallows

Three rice establishment methods *viz.*, zero-till direct-seeded rice (ZT-DSR), ZT transplanting (ZT-TP) and conventional (puddle) transplanting (CT-TP) were evaluated during *kharif* 2016. The ZT DSR recorded the maximum rice yield (5.14 t/ha) (Fig. 15.2) followed by CT (5.05 t/ha) and ZT (3.89 t/ha), respectively. In similar set during *rabi*, two pulses (chickpea and lentil) and three oilseeds (mustard, linseed, and safflower) were superimposed on *kharif* treatments with crop resides management, i.e., retaining 30% residue and without residues (Fig. 15.3). Among establishment methods, maximum yield was recorded with ZTDSR compared to ZTTP and CTTP.

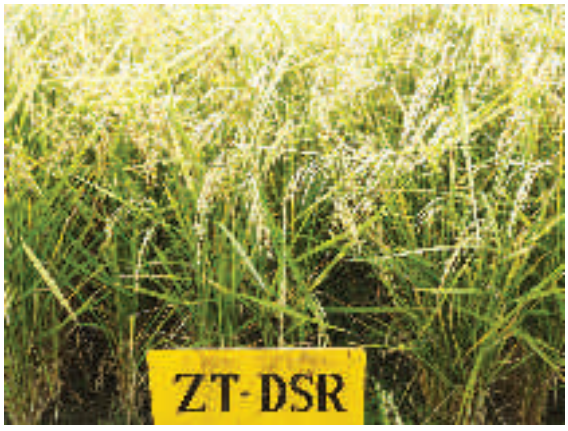


Fig. 15.2. Rice grown under different establishment methods

Fig. 15.3. Pulses and oilseeds grown under different establishment practices

Results revealed that amongst crop establishment methods, ZT-DSR recorded significantly higher seed yield (1348.8 kg/ha), rice equivalent yield (3656.3 kg/ha) and system rice equivalent yield (6226.3 kg/ha). In residues management, significantly higher seed yield (1049.1 kg/ha) was recorded with residues retention of 30%. With respects to the crops, the highest rice equivalent yield (3271.2 kg/ha) and system rice equivalent yield (5799.3 kg/ha) were recorded with chickpea as compared to rest of the crops (Table 15.2).

Table 15.2. Yield attributes under different establishment methods and residues management

Treatments	Seed yield (kg/ha)	REY (kg/ ha)	SREY (kg/ ha)	Production efficiency (kg/ha/ day)
Crop Establishment Method				
ZT-DSR	1348.8	3656.3	6226.3	17.0
ZT-Transplanted	922.6	2535.3	4480.3	12.2
CT-Puddled	755.2	2078.1	4603.1	12.6
SEm±	30.86	85.1	85.1	0.2
LSD (P=0.05)	97.21	267.9	267.9	0.7
Residue management				
Residue retention 30 %	1049.1	2860.3	5206.9	14.26
Control/No residue	968.6	2652.8	4999.5	13.69
SEm±	25.2	69.5	69.5	0.2
LSD (P=0.05)	79.4	NS	NS	NS
Crops				
Lentil	1139.4	3061.5	5408.1	14.8
Chickpea	1202.1	3271.2	5799.3	15.3
Safflower	1088.2	2739.1	5325.3	13.9
Linseed	731.2	2487.7	4817.8	12.2
Mustard	883.3	2223.2	4639.5	12.5
SEm±	40.0	109.19	109.19	0.3
LSD (P=0.05)	113.8	310.6	310.6	0.9

Evaluation of lentil and linseed varieties in rice fallows under ZT

Eleven linseed varieties were evaluated during the *Rabi*, 2016 after rice harvest (Fig. 15.4). Results revealed that significantly higher yield was recorded with cv. Pusa Masoor 5 (2.16 t/ha) followed by Vaibhav (1.99 t/ha) and Arun (1.94 t/ha). Similarly, 11 linseed varieties were also evaluated after to find out best cultivars for rice fallows. Higher seed yield (1.21 t/ha) was recorded with Uma followed by RLC 143 (1.21 t/ha) (Table 15.3).

Fig. 15.4. Evaluation of lentil and linseed varieties under rice-fallow system

Table 15.3. Performance of lentil and linseed varieties under rainfed condition

Lentil	Seed yield (t/ha)	Linseed	Seed yield (t/ha)
HUL 57	1.87	RLC 133	1.15
DPL 62	1.46	RLC 138	1.17
Arun	1.92	RLC 143	1.21
DPL 15	1.85	Uma	1.28
Vaibhav	1.99	Indu	1.07
IPL 01	1.94	BAU 06-03	1.18
Ranjan	1.39	BAU 2012-1	0.98
IPL 406	1.80	BAUP 101	1.16
K-75	1.79	SLS 79	1.10
IPL 316	1.39	JLS 95	1.09
Pusa Masoor 5	2.16	Shekhar	1.02
LSD (P=0.05)	0.35	LSD (P=0.05)	0.09

Effect of Crop Establishment Methods in Rice-Wheat-Greengram Cropping System

A field experiment was initiated during *kharif* 2015 to study the effect of crop establishment methods on system productivity, input-use efficiency, and weed dynamics (Fig. 15.5**)**. Results revealed that machine transplanted rice (MTR) being on a par with puddle line transplanting (PLTPR) produced the maximum grain yield (Table 15.4). ZTDSR produced the lowest yield. Conventional drilled wheat after PLTR produced the highest yield (4.45 t/ha) followed by ZTMTR-ZT wheat (4.24 t/ha). Green gram yield did not vary significantly due to variation in establishment techniques of the preceding crops. Maximum rice equivalent yield (17.95 t/ha) was recorded with ZTMTR-ZT wheat and ZT green gram (complete CA practice). Studies on weed dynamics revealed that DSR-ZT wheat system drastically reduced the problem of Phalaris minor in wheat. Maximum weed density was recorded with SRI-SWI system (Table 15.5).

Fig. 15.5. Field view of crop establishment methods on the productivity of rice–wheat–greengram system

Table 15.4. Effect of crop establishment methods on system productivity

Crop establishment method			Grain yield (t/ha)			
Rice	Wheat	Green gram	Rice 2015	Wheat 2015-16	Green gram 2016	REY
PRTPR	CT (BC)	ZT	8.15	3.89	1.30	16.81
PLTPR	CT (Line)	ZT	8.34	4.45	1.20	17.20
CTMTR	ZT	ZT	8.51	3.94	1.31	17.27
ZTMTR	ZT	ZT	8.68	4.24	1.37	17.95
SRI	CT (SWI)	ZT	8.40	4.22	1.36	17.62
CTDSR	ZT	ZT	7.94	4.16	1.35	17.06
ZTDSR	ZT	ZT	7.84	4.23	1.26	16.89
LSD (P=0.05)			0.46	0.36	NS	

Table 15.5. Effect of crop establishment methods on weed density in wheat

Establishment method		Weed density (no./m^2)						Total
Rice	Wheat	Pm	Rd	Md	Vs	Sn	Ca	
PRTPR	CT (BC)	42.0	4.7	12.0	4.0	1.30	2.30	68.0
PLTPR	CT (Line)	32.3	1.3	3.3	4.3	2.0	2.0	46.7
CTMTR	ZT	23.0	0.0	4.3	5.7	0.70	1.7	37.0
ZTMTR	ZT	16.0	1.7	10.7	6.7	0.70	0.7	39.7
SRI	CT (SWI)	71.7	8.3	41.7	0.30	5.30	7.7	139.3
CTDSR	ZT	16.3	3.3	7.7	1.7	0.30	1.7	31.7
ZTDSR	ZT	15.7	1.3	10.3	7.0	0.30	1.0	36.3

Pm– *Phalaris minor*, Rd– *Rumex dentatus*, Md– *Medicago denticulata*, Vs–*Vicia sativa*, Sn–*Solanum nigrum*, Ca– *Chenopodium album*

Long-term Effect of CA Practices on Soil Organic Carbon

Seven years study on conservation agricultural practices revealed that following complete CA practices (ZT rice – ZT wheat – ZT greengram – S_3) registered the highest total organic carbon (TOC) stock of 47.71 Mg C/ha and resulted in significant increase of 14.57% over S_1 (Farmer's practice) in 0-30 cm soil depth. The S_4 scenario having intensified cropping system recorded the lowest TOC of 39.33 Mg C/ha and resulted in significant depletion of 17.56% C stock with respect to S_3 in 0-30 cm soil depth. The TOC enrichment was higher in S_2, S_3 and S_4 scenario in the surface soil (0-10 cm) compared to S_1. At lower depth (20-30 cm), the TOC enrichment was significantly higher in S_2 (12.82 Mg C/ha) and S3 (13.10 Mg C/ha soil) over S1 scenario. The S_2 and S_3 scenario recorded the highest increased allocation of TOC (3.55 and 6.13 Mg C/ha) to passive pool over S_1. The S2 (15.72 t/ha), S_3 (16.08 t/ha) and S_4 (16.39 t/ha) scenarios recorded significantly higher system rice equivalent yield over S_1 (10.30 t/ha). Among the scenarios, S_3 had greater amount of total soil organic carbon, passive pool of carbon and higher system rice equivalent yield, thus, is considered the best cropping management practice to maintain soil health and food security in the middle IGP.

Rehabilitation of Coal Mine–Affected Areas through Agroforestry Interventions

A model of Agri-horti-silvi-pastural system was developed in the year 2015 at coal mine affected area of Phusri village in Mandu block of the Ramgarh district. Plantation of selected Agroforestry species *viz.*, *Aegle marmelos, Artocarpus heterophyllus, Citrus limon, Dalbergia latifolia, Mangifera indica, Melia azedarach, Pongamia pinnata, Psidium guajava, Punica granatum, Swietenia mahogany, Tectona grandis and Dendrocalamus asper* had been done in a predefined model layout. Data on soil moisture content in the root zone of the planted crops was recorded at monthly interval. The highest percentage of moisture content was recorded in the month of August 2016 and was declining gradually over the months. The water sources like pond, river, and dobha were able to supply lifesaving irrigation up to the month of February, after which, watering of the saplings was not possible. This situation led to complete mortality (100%) in all the fruit plants except pomegranate (*P. granatum*) which recorded the mortality of 52.78%. There was 100% survival recorded in *D. latifolia, M. azedarach* and *S. mahogany*. The percent increase in plant height and diameter was found maximum (46.0% and 67.0%, respectively) in *M. azedarach* and the lowest was observed in *P. granatum* (1.8% and 4.1%, respectively) (Table 15.6).

Table 15.6. Plant growth parameters of selected coal mine-affected area

Species	No. of plants	Mortality (%)	Initial plant growth		Plant growth after 1 year		% increase	
			Height (m)	Dia* (cm)	Height (m)	Dia (cm)	Height	Diameter
Aegle marmelos	13	100	0.29± 0.11	0.63± 0.23	—	—	—	—
Artocarpus heterophyllus	13	100	0.52± 0.10	0.75± 0.14	—	—	—	—
Citrus limon	36	100	0.61± 0.15	0.66± 0.23	—	—	—	—
Dalbergia latifolia	14	0.0	0.22± 0.04	0.3± 0.09	0.32± 0.06	0.40± 0.02	45.0	33.0
Mangifera indica	22	100	0.43± 0.08	0.62± 0.15	—	—	—	—
Melia azedarach	26	0.0	1.03± 0.17	0.91± 0.25	1.50± 0.26	1.50± 0.30	46.0	67.0
Pongamia pinnata	14	14	2.15± 1.15	1.45± 0.32	2.83± 1.10	1.55± 0.21	32.0	7.9
Psidium guajava	36	100	0.40± 0.07	0.68± 0.20	—	—	—	—
Punica granatum	36	53	0.55± 0.18	0.74± 0.19	0.56± 0.09	0.77± 0.23	1.8	4.1
Swietenia mahogany	10	0.0	0.64± 0.09	0.87± 0.14	0.73± 0.10	1.00± 0.17	14.1	14.9
Tectona grandis	13	23	0.46± 0.10	0.42± 0.04	0.50± 0.08	0.70± 0.10	8.7	66.7
Dendrocalamus asper	25	24	1.62± 0.58	1.00± 0.20	2.07± 0.10	1.33± 0.32	27.8	33.0

*Trunk diameter measured at 25 cm from ground level

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

During the third year of experimentation, there was marked increase in the biomass yield of all the crops over that of the previous year which could be attributed to the higher rainfall during 2016-17. As recorded during the previous years, the maximum biomass yield was in Tephrosia (dry weight 51.31±7.75 t/ha).

The concentration of nutrients in the biomass of different crops differed significantly. The concentration of nitrogen was highest in tephrosia and subabul (2.94%), whereas the concentration of phosphorus and potassium was the highest in weed (0.25% and 1.65%, respectively). Vegetable soybean had the highest concentration of zinc (68.87 ppm), manganese (233.80 ppm) and iron (392.63 ppm).

Significant effects of the treatments were recorded on soil organic carbon, available nitrogen and phosphorus. At 15-30 cm soil depth, soil incorporation of tephrosia or weed biomass resulted in significant increase in the organic carbon (Fig. 15.6). All the treatments except soil incorporation of tephrosia or subabul resulted in significant increase in the content of available nitrogen over that of control in 0-15 cm soil depth whereas in 15-30 cm soil depth, soil incorporation with subabul or rice bean resulted in significant increase over that of control.

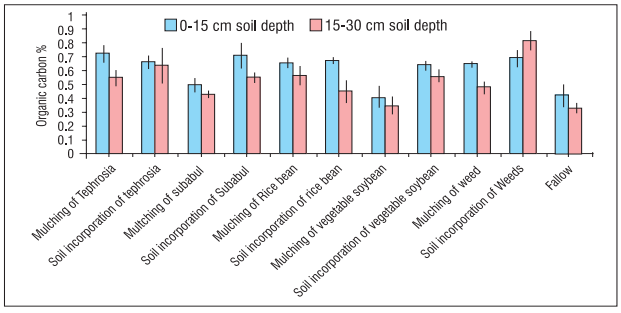


Fig. 15.6. Effect of basin enrichment on organic carbon in the basin soil of bael plants

During the period of the 2nd fortnight of December 2016 to the 1st fortnight of February, 2017, markedly higher soil moisture content (0-15 cm) was recorded in case of mulching with tephrosia followed by that of subabul. The highest value was recorded in case of mulching of Tephrosia (64.0 ± 2.93 mm)

Sustainable & Resilient Farming System Intensification in the Eastern Gangetic plains (SRFSI)

The gender issue is being considered at each stage of planning, capacity building, focus group discussion and implementation of field trials of the SRFSI project. Twenty seven per cent *kharif* field trials and thirty four per cent rabi trials are being managed by women farmers.

Farmers' participatory trials were conducted in 33 farmers' fields during *kharif* 2016. Average rice yield in ZT DSR (Zero tillage direct seeded rice), UPTR (Unpuddled transplanted rice) and transplanted rice was 4.23, 4.15 and 3.99 t/ha respectively. Node-wise analysis revealed that average grain yield was the highest in Korahia village followed by Sukhet (Table 15.7). During *rabi* 2015-16, wheat trials were conducted in 45 farmers' fields in Madhubani. DSR followed by ZT Wheat (ZTW) produce the highest average wheat yield (2.77 t/ha) while conventional transplanted rice (CTR) followed by CT Wheat (CTW) produced minimum average wheat yield of 2.57 t/ha. There was no significant yield difference in rice and wheat yields under different methods of establishment.

Table 15.7. Node-wise rice yield under different method of establishment during 2016-17 in Madhubani

Rice yield under different establishment methods (t/ha)												
Node	TR-CTW			TR-ZTW			ZTDSR-ZTW			UPTR-ZTW		
	Grain yield	Bio-mass	HI	Grain yield	Bio-mass	HI	Grain yield	Biomass	HI	Grain yield	Bio-mass	HI
Sukhet	4.27	8.94	0.47	4.31	8.97	0.48	4.5	9.31	0.48	4.40	9.23	0.48
Khairi	4.08	8.61	0.47	4.18	8.73	0.48	4.28	8.78	0.48	4.20	8.92	0.47
Mahuahi	4.14	8.69	0.47	4.16	8.71	0.48	4.41	9.24	0.47	4.35	9.17	0.47
Nanore	2.97	6.26	0.47	2.97	6.27	0.47	3.26	7.89	0.41	3.09	6.50	0.48
Korahiya	4.73	9.83	0.48	4.75	9.98	0.48	4.91	10.26	0.48	4.85	10.05	0.48

16. Solar Energy Application

A Solar System Model for Small Farm

The schematic of a solar system, developed for a small farm is shown in Fig. 16.1. The components used for developing the system and their utility are reported in Table 16.1. A dc centrifugal surface pump of 2 horsepower (hp) of rating 1.5 kW with performance curve (Fig. 16.2) was used for groundwater pumping. This pump operated by 1.8 kWp solar array keeping in view the solar insolation intensity in Eastern region of India. At rated power, the total dynamic head of the pump is 18 m with maximum suction of 7- 8 m. However, water can be extracted even from more than 8 m by placing the pump beneath the ground level. The depth to water level map of India shows that, in pre-monsoon, in many parts of the country groundwater level ranges between 2—5 m bgl and 5—10 m bgl. In post monsoon the ground water level is bound to rise, making the pumping more convenient. Therefore, a solar centrifugal surface pump of this size can be a good option for groundwater pumping in these areas. In the

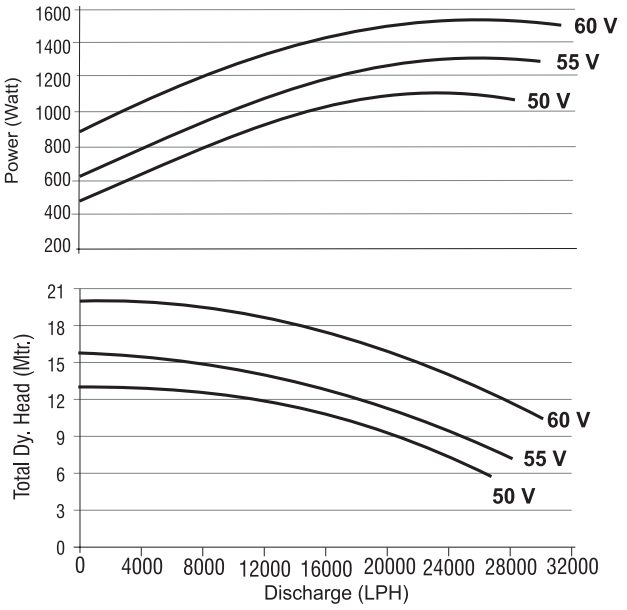


Fig. 16.2. Performance curve of 2 horsepower, DC centrifugal surface pump

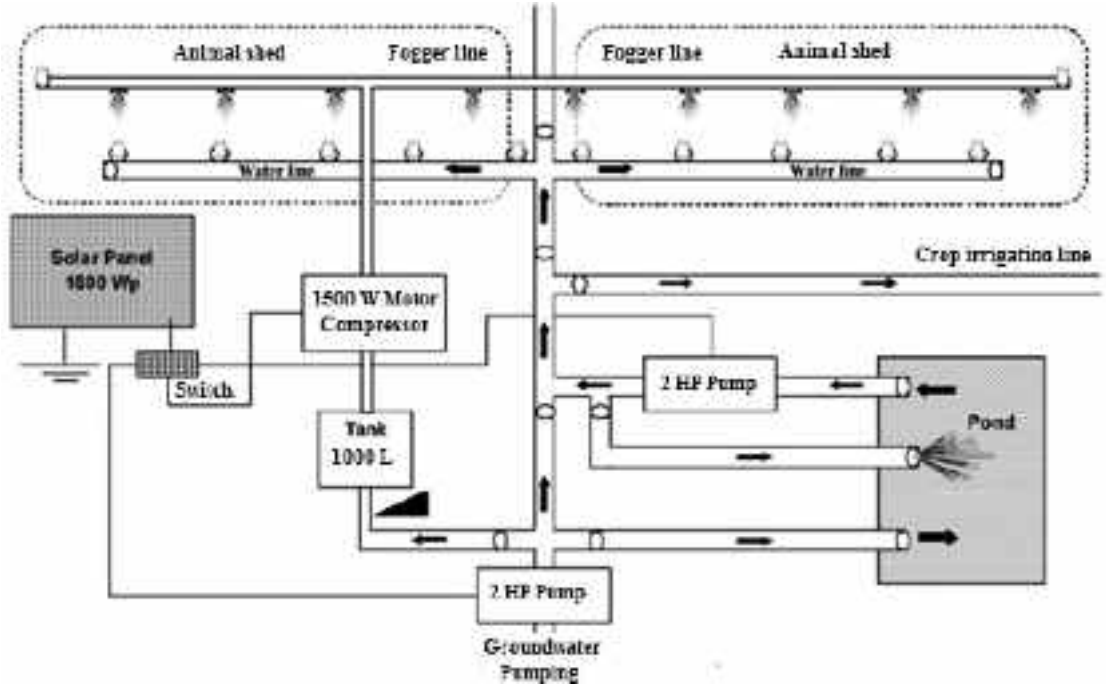


Fig. 16.1. Schematic of the solar system, components and layout

Table. 16.1. Specification of system components and their functions

Sl. No.	Item	Nos	Specification	Function
1.	Motor pump	02	• Capacity : 2 hp, centrifugal surface pump • Motor: Permanent magnet **DC** motors, 1500 W • RPM, at rating: 2900 • Operating PV array: 1800 Wp, 60 V • Maximum discharge 30 m^3/h at 10 m head • Suction head: 7 m	Used for groundwater extraction and lifting water out of pond for washing cattle shed, cooling rooftop and irrigating crops by pressured method or by surface method of irrigation.
2.	Compressor	01	• Required motor of rating : 750 W • Operating RPM :1440 • Number of guns : 01 • Working pressure: 10.0 kg/cm^2	Used to create high pressure.
3.	Motor	01	• Motor: Permanent Magnet **DC** Motors, 1500 W • RPM at rating: 2900 • Operating PV array: 1800 Wp, 60 V.	To operate compressor for humidification.

summer season, in Eastern region of India, the landscape temperatures averages to 32 - 40 °C and maxima of temperature hovers around 48-50 °C. This much increase in ambient temperature and subsequent reduction in humidity causes stresses to the dairy cattle. Keeping this in view, a humidifier was developed with 1.5 kW rating dc motor and a compressor (Fig. 16.3).

Fig. 16.3. Solar humidifier system, installed in buffalo shed

Solar System Groundwater Pumping for Dry season Agriculture

Two solar groundwater pumping systems, each one is of capacity 3 hp, were installed at Bhagwatipur village, in Madhubani districts of Bihar for improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains. This pump is to be used under co-operative approaches for land, water and energy management leading to improved food security and reduced poverty. Each pump is energised by 3.0 kWp solar array keeping in view the solar radiation intensity in this region. These pumps are being analysed for the water output/day for different months along with the radiation data and groundwater regime fortnightly to assess the feasibility of solar pumps for this region.

Solar Systems for Improving Dry Season Irrigation in Eastern Gangetic plains

Solar pumping systems are less reliant on expensive or unreliable electricity and diesel, and are appropriate to the needs of the marginal (owning < 0.5 ha) and tenant farmers in Eastern Gangetic Plains. Water pumped by solar pumping systems was used for agriculture and for augmentation of the adjoining ponds to be used for fish production. Drip and sprinkler systems of appropriate capacity were used in the fields for ensuring efficient use of pumped water (Fig 16.4 a-c)

Two 3 hp solar pump sets were installed at the farmers' fields in the Bhagwatipur village in the Madhubani district of Bihar. Assessments were carried out on the discharge of the 3 hp solar pump sets in relations with the daily variation in the solar radiation and solar panel angles. The performance of the solar pumping system was assessed at 110°, 180° and variable angle of solar panels. When the panel angle was 180°, the instantaneous discharge reached the maximum value of 1.96 lps at 11.00 AM. Variable angle (tracking) of the solar panels

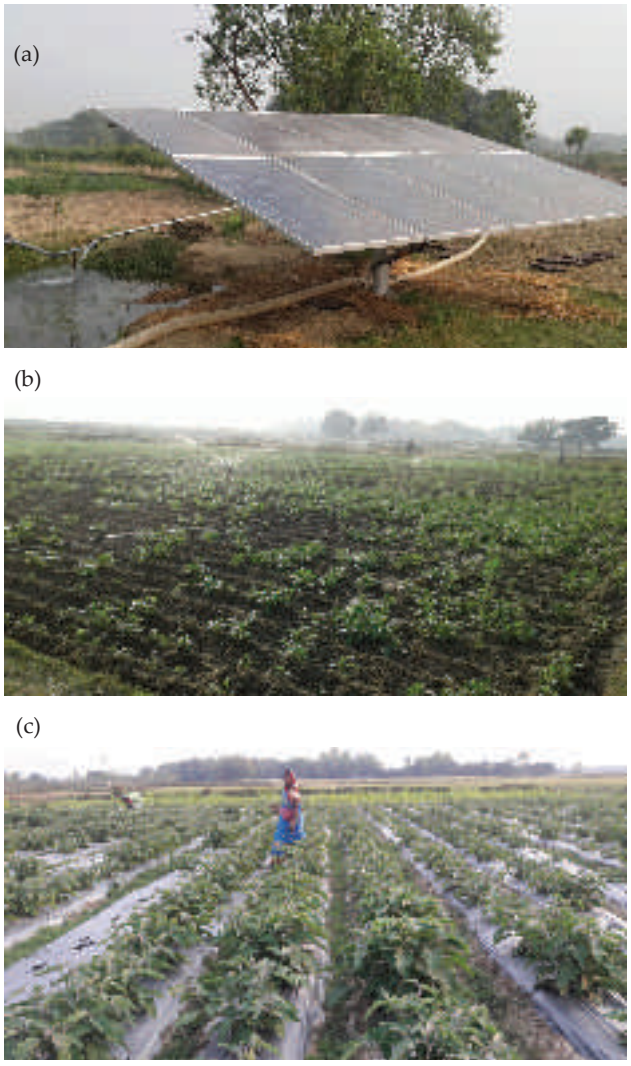


Fig. 16.4 (a-c). Solar pumping system and solar pump operated sprinkler and drip irrigation systems

resulted in the higher volume of water pumped in a day (55.73 m^3/day) as compared to 110° (29.56 m^3) and 180° (54.1 m^3) angles of solar panels (Fig. 16.5). The quantity of water pumped in a day by the solar pump sets was sufficient to provide one irrigation to 0.1 hectare of the vegetable cultivation area.

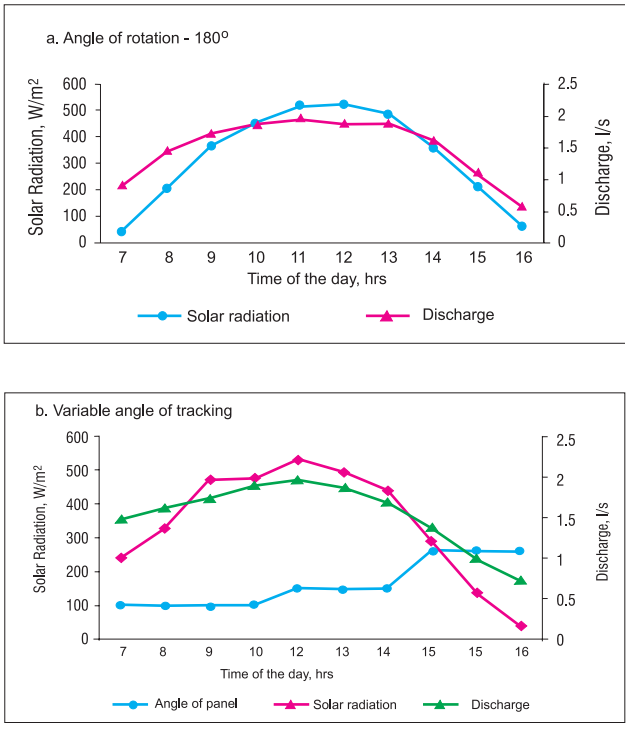


Fig. 16.5. Variation in the discharge of solar pump at 1800 angle.

17. Farm Machinery

Ergonomic Study of Farmers Friendly Farm Implements

Ergonomic study of farm women in paddy harvesting

To evaluate paddy harvesting for ergonomic point of view, 10 female workers in the age group of 35 to 44 years with average age of 39.70 years, body height of 154.20 cm and weight 45 kg, respectively were selected. The anthropometric rod and weighing balance were used to measure the physical characteristics. Stop watch was used for recording the time. Polar Heart Rate Monitor (Model-RS 400) was used for recording heart rate of subjects during the course of study.

Results indicated that the working efficiency was increased by 3.16% using serrated sickle developed by CIAE, Bhopal. The output by local serrated sickle was 83.87 m^2/hr as compared to CIAE serrated sickle (80 m^2/hr). During harvesting with local sickle the average Δ HR, energy expenditure and cardiac cost were 15 beats/min, 7.24 kJ/s, 10.73 beats/m^2. However, in case of CIAE serrated sickle, these parameters were 16.20 beats/min, 7.49 kJ/s and 12.15 beats/m^2, respectively. The results revealed that CIAE serrated sickle saved 11.68% cardiac cost compared to local sickle (Table 17.1).

Table 17.1. Performance data of different parameters of women farmers during harvesting of paddy (N=10).

Particulars	Local sickle	Improved sickle (CIAE Bhopal)
Time (hrs.)	7	7
Number of hills/ cut	01	01
Average working heart rate (beats/min)	100.40 ± 8.17	102.00 ± 11.25
Average heart rate during rest (beats/min)	85.40 ± 8.35	85.80 ± 16.32
Δ HR (beats/min)	15.00	16.20
Output (m^2/hr)	83.87	80.00
Energy expenditure (kJ/s)	7.24	7.49
Cardiac cost (beats/m^2 area covered)	10.73	12.15
Reduction in drudgery (%)	-	11.68
Increase in efficiency (%)		3.16

Design and ergonomic evaluation of gender neutral marker and weeder for system of rice intensification

A survey was conducted for 20 anthropometric dimensions in 55 male (Table 17.2) and 45 female (Table 17.3) farm workers in the state of Bihar. For the efficient designing of farm tools and implements for higher productivity, the anthropometric data of the operators are very essential which were recorded with the hand anthropometric kit.

Design and development of rolling markers for paddy transplanting

In System of Rice Intensification (SRI), proper spacing in the transplanting of seedlings is one of the essential principles underlying the technology. A spacing of 25×25 cm in a uniform square pattern is normally adopted. To overcome this constraint, the Institute developed a rolling marker which was rolled on wet paddy field making an uniform square impression (Fig. 17.1). The uniform spacing stamped by the rolling marker facilitated

Overall dimensions	Field performance
• Main base length : 1750 mm • Diameter : 250 mm • Row to row distance : 250 mm • No. of fingers in the marker : 7 • Weight: 19 kg	• Field capacity (ha/hr) : 0.122 • Cost of operation/ha: Rs. 256/-

Fig. 17.1. Details of Rolling Marker

Table 17.2. Anthropometric parameters of male worker

Parameters of study	Mean± SD	5th percentile	95th percentile
Age (yrs)	32.00±13.51	19.00	58.00
Weight (kg)	58.00±7.63	44.50	70.00
Stature (cm)	162.70±6.43	151.30	175.30
Eye height (cm)	152.00±5.80	142.40	162.00
Shoulder height (cm)	133.60±5.57	123.10	142.50
Elbow height (cm)	103.80±4.20	95.30	110.90
Knuckle height (cm)	90.70±4.82	81.20	98.70
Knee height (cm)	47.00±3.37	39.20	50.60
Middle finger to elbow (cm)	45.30±2.02	42.20	48.60
Upper arm length (cm)	34.00±1.99	30.80	38.10
Forward arm reach (cm)	75.40±4.99	67.30	85.50
Elbow breath(cm)	42.00±3.45	38.00	48.60
Elbow height from base (cm)	109.10±4.53	101.50	117.00
Elbow to elbow at forward hands (cm)	38.60±11.25	33.10	46.60
Circumference at elbow (cm)	25.00±2.33	22.00	29.50
Circumference at biceps (cm)	26.50±2.54	23.00	31.00
Hand breadth (mm)	94.86±9.41	80.79	117.60
Hand length (mm)	182.00±24.46	161.00	194.00
Grip diameter (mm)	24.11±1.98	21.14	28.38
Foot length (cm)	24.30±1.48	22.30	27.20

Table 17.3. Anthropometric parameters of female worker

Parameters of study	Mean±SD	5th percentile	95th percentile
Age (yrs)	41.00±8.75	25.00	55.00
Weight (kg)	46.50±7.38	35.00	57.00
Stature (cm)	146.60±7.28	134.30	156.20
Eye height (cm)	137.20±6.20	126.20	146.60
Shoulder height (cm)	121.20±5.30	112.50	131.90
Elbow height (cm)	96.00±8.21	85.70	113.30
Knuckle height (cm)	85.30±4.87	80.20	92.30
Knee height (cm)	44.60±3.33	41.00	51.80
Middle finger to elbow (cm)	40.70±2.30	38.10	45.20
Upper arm length (cm)	30.50±2.83	28.30	38.20
Forward arm reach (cm)	68.50±5.00	62.20	77.30
Elbow breath(cm)	38.60±3.58	32.60	43.50
Elbow height from base (cm)	99.00±9.58	90.00	120.50
Elbow to elbow at forward hands (cm)	33.60±3.62	28.00	39.30
Circumference at elbow (cm)	22.00±1.72	20.50	25.50
Circumference at biceps (cm)	24.50±2.42	21.00	28.50
Hand breadth (mm)	78.81±6.45	70.41	90.36
Hand length (mm)	165.00±8.58	150.00	178.00
Grip diameter (mm)	22.62±1.92	20.21	26.35
Foot length (cm)	22.00±1.47	20.10	24.65

easy transplanting of seedlings and operation of cono / rotary weeders. The rolling marker consists of a cylindrical contraption (or marker) rotating along an axial rod and a metallic handle (manually pulled) to facilitate rolling of the marker. The cylindrical contraption has rods welded together so as to form square impressions when rolled on the wet paddy field.

Testing of Cono Weeder and Mandava Weeder

An experiment was conducted to evaluate the relative performance of cono weeder and mandava weeder during *kharif* season under irrigated ecosystem. The field capacity, weeding efficiency and cost of operations were evaluated during weeding in SRI field.

The results indicated that field capacity and weed control efficiency of mandava weeder was higher (0.0178 ha/hr and 83-91%) as compared to cono weeder (Fig. 17.2 & 17.3) (0.0147 ha/hr and 74-85%). Whereas the cost of operation/ha was estimated as Rs. 1860/- for cono weeder and Rs.1756/- for mandava weeder. Among the two weeders, mandava weeder helps the worker by providing easy push and pull action to the implement as compared to the cono weeder, and also useful in completing the weeding in lesser time.

Performance evaluation of different weeding tools in faba bean

A field study was undertaken using different weeding tools like *khurpi*, wheel hoe and power weeder in faba bean. The soil of the experimental plot was clay loam (sand: 23.69%, silt: 39.64% and clay: 37.0%). The moisture content in the soil at

Specifications	
• Total Length : 2040 mm • Length of handle: 1250 mm • Height: 1120 mm • Nominal width: 195 mm • Working width : 125 mm • Handle width: 500 mm • Working depth : 40 mm • Number of rotors : 02 • Type of handle: T-Type • Weight: 6.1 kg.	• Cost of unit: Rs.1200/- (Approx.) **Field performance** • Field capacity (ha/hr) : 0.0147 • Weeding efficiency (%): 74-85 • Plant damage (%): 6.75-9.38 • Cost of operation/ha: Rs. 1860/-

Fig. 17.2. Details of Cono-weeder

Specifications	
• Total Length : 1530 mm • Length of handle : 1020 mm • Height : 980 mm • Nominal width : 152 mm • Working width : 123 mm • Handle width: 460 mm • Working depth : 65 mm • Number of rotors : 01 • Type of handle : T-Type • Weight : 5.5 kg	• Cost of unit : Rs.1000/- (Approx.) **Field performance** • Field capacity (ha/hr) : 0.0178 • Weeding efficiency (%): 83-91 • Plant damage(%) : 4.23-5.62 • Cost of operation/ha: Rs. 1756/-

Fig. 17.3. Details of Mandava weeder

weeding time before using the tools was 7.4% at 0-15 cm and 7.7% at 15-30 cm depth. The crop was sown in rows at 40x20 cm apart. The average height of plants at weeding was 19.82 cm. The field performance of different weeding tools are given in Fig. 17.4 to 17.6.

Specifications	Field performance
• Handle length : 106.45 mm • Handle dia : 32.63 mm • Cutting width: 60.29 mm • Blade thickness : 2.88 mm • Weight : 318.10 g • Cost : Rs.60/-	• Field capacity(ha/hr) : 0.0050 • Field efficiency: 91.50% • Weeding efficiency : 98.90% • Plant damage : 1.40% • Cost of operation/ha : 6250/-

Fig. 17.4. Details of *Khurpi*

Specifications	Field performance
• Length : 1340 mm • Height from base: 1010 mm • No.of tynes : 3 • Working width : 150mm • Working depth : 25 mm • Weight : 4.8 kg • Cost: 800/-	• Field capacity(ha/hr) : 0.0136 • Field efficiency: 70.0% • Weeding efficiency : 80.0% • Plant damage : 1.0% • Cost of operation/ha: 2297.80/-

Fig. 17.5. Details of wheel hoe

Specifications	Field performance
• Power : 2.0 hp • RPM : 250 • Engine type: 2-stroke • Cutting depth: 2.54-5.1 cm • Cutting width : 25.4 cm • Weight of machine: 11 kg • No.of blades : 4 • Cost : 25,000/-	• Field capacity(ha/hr) : 0.0760 • Weeding efficiency: 83.0% • Field efficiency : 71.95% • Plant damage : 1.0% • Fuel cons. : 8.3 lit/ha • Cost of operation: 1014.90/- ha

Fig. 4. Details of power weeder

18. Livestock and Fisheries

LIVESTOCK

Network Project on Buffalo Improvement

Network Project on Buffalo Improvement is being implemented with the objective of selecting genetically superior Murrah bulls for improving the performance of non-descript buffalo in terms of production and reproduction traits. The total herd strength of Murrah buffaloes is presently 72 which includes 37 adults, 15 heifers and 20 calves. The average lactation yield, lactation length, service period and inter-calving period of the herd during the year 2016-17 were found to be 1645.53 ± 5.24 kg, 312.76 ± 4.17 days, 168.35 ± 7.17 days and 412.16 ± 3.07 days, respectively.

The buffaloes were assessed for their production and reproduction performances. Their wet average, herd average and average peak yield were found to be 6.07 kg, 4.93 kg and 9.01 kg, respectively. Individual peak yield was recorded to be 20.6 kg per day. In order to improve reproductive efficiency of buffaloes, hormonal intervention was resorted apart from nutritional supplementation. The conception rate of buffaloes was 43.5% on total insemination basis. Allowing the buffaloes for wallowing has brought significant effects in terms of production and reproduction parameters (Fig. 18.1). The conception rate of buffalo was improved to 59.2%. Calf mortality rate in the herd reduced to a minimum of 3.45%. Calves were dewormed every month up to 6 months and large animals were dewormed twice in a year. Vaccination against FMD, HS and BQ was carried out for all buffaloes above 4 months of age. In order to reduce the heat stress on buffaloes, mist cooling system has been installed aiming at improving the production and reproduction performances.

Characterization of Lesser Known Farm Animals

The Gangatiri breed of cattle is one of the lesser known breeds of cattle which is habituated in Ghazipur and Balia districts of Uttar Pradesh, and Buxar, Kaimur and Bhojpur districts of Bihar.

A study was conducted in Itarhi block of Buxar district to undertake phenotypic characterization of Gangatiri cattle (Fig. 18.2). The study revealed that Gangatiri cattle is a medium-sized cattle with white coat colour. The mean herd size of Gangatiri cattle with the farmers ranged from 4 to 16. Coat color of the cattle was light grey; however, the study witnessed 15.5% of cattle with dark grey coat in the breeding tract. Face was long and slender whereas the shoulder was compact. Horns were generally crescent in shape. Eyelashes, hoof and tail switch were generally black in colour. Udder and milk vein were moderate in size.

Fig. 18.1. Murrah buffaloes in wallowing tank

Fig 18.2. Gangatiri cattle in their breeding tract of Buxar district, Bihar

Milk production in these animals ranged from 2 to 6 liters per day under farmers' management. However, the peak yield was recorded at 8 liters per day. The age at first mating in the bulls was found to be 3 to 3½ years whereas the age at first calving in Gangatiri cows was reported to be 3½ to 4 years. Considering its significant performance in the breeding tract, it is highly essential to undertake field level breeding and development program.

Performance of Sahiwal cattle

Ten Sahiwal cattle were brought from Fatehpur district of Haryana to study their performance in the present agro-climatic condition and they were compared with the performance of crossbred cattle. After getting acclimatized for a period of one month to the new environment, these Sahiwal cattle began to show their real productive potential. Most of the animals were brought in late pregnancy passing their peak milk yield. The peak yield was recorded to be 9.3 liters per day. Four Sahiwal cattle gave birth to 4 male calves. Interesting finding was that the average birth weight of the calves was 20.23±0.05 kg. But, within a span of four month, these three calves attained a body weight of 47.46±0.15 kg, registering the growth of 226.92 g/day, and the gain in four month period was more than their initial body weight. The result also indicated that the rate of growth of Sahiwal calves was higher than the rate of growth of crossbred calves (203 g/day) of similar age group.

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

Evaluation of maize as fodder-cum-grain during winter season

Performance of hybrid maize 'Bisco Bumper' was evaluated for dual purpose (fodder & grain) during winter season 2016-17. Crop was sown at 50x20 cm spacing with 40 kg/ha seed rate. Treatment includes T_1– Only fodder, T_2– Fodder + grain and T_3– Only grain. In case of T_1, total fodder was harvested at 100 DAS. In T_2, alternate rows were harvested at 100 DAS and remaining were left for grain production, however, in T_3, total crop was harvested at maturity for grain purpose (Fig. 18.3). Results revealed that harvesting of 50% plant as fodder significantly reduced the grain yield by 42.73% but overall total biomass yield was not affected (Table 18.1). Hence, it is recommended that 20 cm row to row sowing of maize and its

Fig. 18.3. Harvesting of maize fodder from alternate rows at 100 DAS

Table 18.1. Performance of maize crop grown for dual purpose

Particular	Only fodder	Fodder cum grain	Only grain
Fodder DM yield (t/ha)	7.20±0.35	3.95±0.13	—
Stover DM yield (t/ha)	—	3.01±0.03	4.84±0.05
Grain DM yield (t/ha)	—	2.68±0.02	4.68±0.03
Total biomass yield on DM basis (t/ha)*	7.20^{a}±0.35	9.63^{b}±0.13	9.52^{b}±0.08

*Values having different superscripts in a row differ significantly P < 0.01

harvesting of 50% fodder may be a technique of getting both green fodder, dry fodder and grain.

Assessing productivity and quality of fodder with carrying capacity under different land use system

Relative performance of annual fodder crops *viz*. multicut sorghum, local sorghum, pearl millet, maize and cowpea was evaluated during *kharif* 2016 (Fig. 18.4). Annual fodder crops were sown in main field during May—June, 2016, while Napier grass root slips were transplanted on bunds during June, 2015. Fodder yield of different crops was recorded and its nutrients were analyzed (Table 18.2). Cumulative annual fodder yield from Napier var. CO_3 from bunds was recorded as 300 t/ha. Hence, from bund area (400 m^2) of one acre land, 12 t green fodder was harvested which was sufficient to meet the requirement of two adult cattle round the year (25 kg/d/animal).

Fodder productivity and nutrient contents of different annual cereal fodder were almost similar. However, performance of multi-cut sorghum was better due to more numbers of cuttings. Fodder productivity of legume fodder (cowpea) was recorded as 28.67 t/ha with almost 50% higher protein content in comparison to annual cereal fodder. Hence, it is recommended to grow multicut sorghum and cowpea in combination (3:1 ratio of area) during *kharif* season which can provide good quality fodder of 49 t/ha. It can meet up the fodder requirement of 16 adult cattle for balanced feeding @ 20 kg green fodder per day per animal for 150 days.

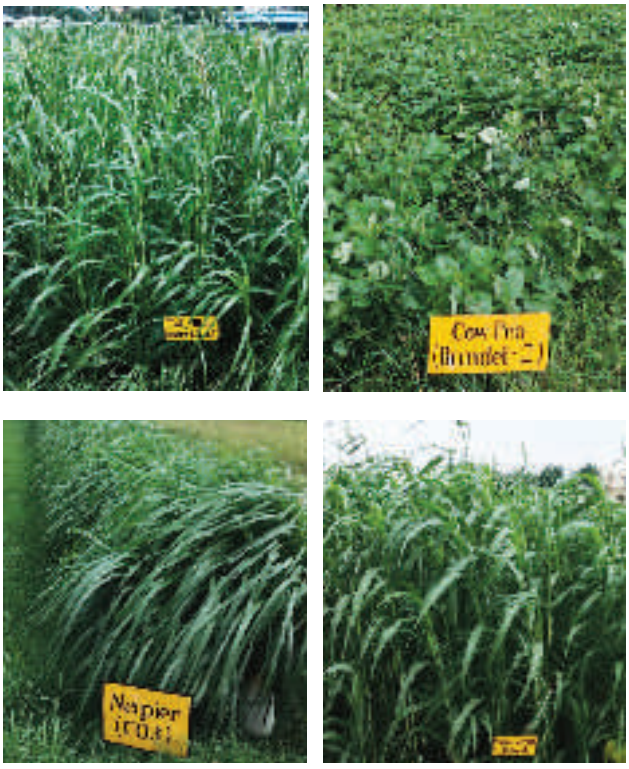


Fig. 18.4. Performance of fodder under different land use system

Evaluation of nutrients balance in soil under different fodder crop rotation

Experiment was conducted to assess the nutrients balance in soil under different fodder crops rotation. Nutrient status in soil after one year revealed the deficiency of N under annual fodder crop rotation group T_1 and T_4; however, group T_2

Table 18.2. Fodder productivity with nutrients content during *kharif* season

Crop	Harvesting days after sowing	Cummulative fodder yield (t/ha)	Av. DM (%)	Nutrients (g/100g DM)			
				CP	EE	CF	TA
Hybrid Napier var. CO3	50, 90, 140, 200, 320	300.33 ±8.37	16.45	10.18	1.28	32.01	14.67
Multicut sorghum var. Hybrid Gagan	70,110	55.60 ±1.06	22.96	8.64	1.38	36.93	7.52
Maize var. African Tall	70	35.63 ±1.17	14.18	9.30	1.19	33.66	9.18
Pearl millet var. Bajra local	70	32.63 ±1.43	22.07	8.10	1.12	38.73	9.21
Sorghum var. Jowar local	70, 110	36.10 ±0.13	22.08	7.85	1.19	34.18	9.44
Cowpea var. Bundel-2	70	28.67 ±0.37	14.53	13.12	2.24	24.53	9.91

and T_3 showed N—built-up for future use (Table 18.3). The P and K balance study showed negative balance in all treatments in main plot as well as on bunds and it may require more addition.

Management of Heat Stress in Buffalo

Blood profile and hormone level (Cortisol, T_3 and T_4) were measured in pre-winter and winter season to study the effect of heat stress in Murrah buffalo.

Measurement of hematological profile

Blood samples were collected from 15 buffalo in vials with and without anticoagulant during pre-winter and winter season at 15 days interval. Total erythrocyte count (TEC), Total leukocyte count (TLC), Hemoglobin concentration (Hb) and Packed cell volume (PCV) were estimated (Table 18.4).

This reduction in TEC and hemoglobin level in winter season could be attributed partly to the reduced feed intake during extreme winter leading to reduced erythropoiesis.

Table 18.4. Hematological profile of Murrah buffalo

Parameter	Pre-winter	Winter
Hb (g/dl)	13.79±1.28	12.98±1.17
TEC (10^6 /µL)	7.43±0.94	6.9±1.08
TLC (103 /µL)	9.6±0.64	9.02±0.69
PCV (%)	46.32±11.36	41.56±10.05

Measurement of hormonal assay

Heat stress activates the hypothalamo—pituitary—adrenal cortical axis (HPA) and sympatho—

Table 18.3. Nutrients balance in soil under different fodder crop rotation

Crop *Kharif/Rabi*	Main plot: Annual fodder crop rotation				Bund: Perennial
	T_1 Cowpea–wheat	T_2 Baby corn–annual eye	T_3 MP chari–berseem	T_4 Soybean–oat	Napier
Total DM yield as fodder, straw, grain (t/ha)	14.37	12.89	17.99	13.04	49.56
Addition in one year					
FYM on DM basis (t/ha)	2.5	2.5	2.5	2.5	2.5
DAP (kg/ha)	90	90	90	90	60
Urea (kg/ha)	180	325	360	180	60
N— Balance					
Initial N status in soil	248	248	248	248	222
N— status after one year	166	179	142	163	188
N—Mining by crop	213.04	210.17	238.01	191.97	792.96
N— Balance	+164.21	+233.78	+222.04	+185.28	-502.31
N— Net balance	-1.79	+54.78	+80.04	+22.28	-314.31
P— Balance					
Initial P status in soil	22.00	22.00	22.00	22.00	25.70
P –status after one year	17.10	15.00	21.10	17.40	16.10
P—Mining by crop	99.68	100.95	159.30	95.02	436.13
P— Balance	-45.59	-46.86	-105.21	-40.93	-384.37
P— Net balance	-28.49	-31.86	-84.11	-23.53	-368.27
K— Balance					
Initial K status in soil	290	290	290	290	332
K—status after one year	177	172	162	179	226
K—Mining by crop	163.65	231.15	171.66	154.28	490.64
K— Balance	+154.60	+87.10	+146.59	+163.97	-130.39
K- Net Balance	-22.40	-84.90	-15.41	-15.03	-356.39

adrenal medullary axis. This leads to increase in plasma concentration of cortisol and decrease concentrations of triiodothyronine (T_3) and thyroxine (T_4) in plasma and milk of heat stressed animals. Hence, Cortisol, T_3 and T_4 level were measured and values were presented in Table 18.5.

Table 18.5. Hormonal profile of Murrah buffalo

Parameter	Pre-winter	Winter
Cortisol (ng/ml)	4.43±1.68	4.03±1.8
T_3 (ng/ml)	2.15±0.58	2.72±0.84
T_4 (ng/ml)	32.86±1.07	35.39±1.07

Amplification of HSP 70 gene fragment

A 539 bp fragment of hsp 70 gene was amplified by polymerase chain reaction to study its association with heat stress in Murrah buffalo. Primer was designed on the basis of sequence available publicly at NCBI. PCR program followed for amplification of gene fragment was initial denaturation of 94°C for 2 min than 35 cycles of denaturation at 94°C for 30 sec, annealing at 55°C for 1 min, extension at 72°C for 1 min and then final extension of 72°C at 10 min (Fig. 18.5).

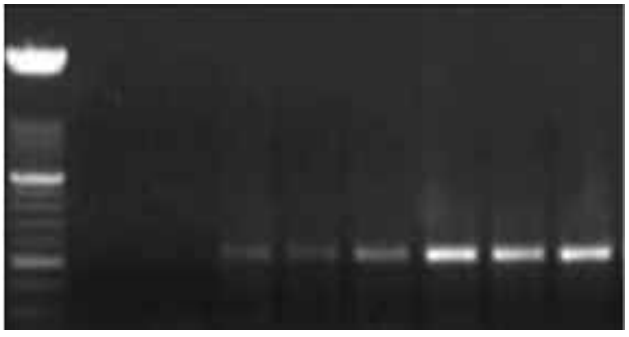


Fig. 18.5 PCR amplification of HSP70 gene fragment

Evaluation of Area-specific Mineral Mixture "Swarna Min"

Area-specific mineral mixture for Bihar "Swarna Min" was evaluated in farmers' field and institute farm. Serum mineral profiles of buffalo was estimated after feeding Swarna Min and mineral mixture available commercially (Table 18.6). It has been observed that concentration of Fe, Cu, Mn, Zn, Ca and P was higher in Swarna Min fed group as compared to serum of buffalo fed with mineral mixture available commercially in the market. On—farm trial on effect of feeding mineral mixture was conducted and presented in Table 18.7. It has been observed that supplementation of Swarna Min improved the milk yield of crosbred cattle and buffalo at 4.50 and 7.93%, respectively depending on the status of supplementation of commercial mineral mixture before trial.

Table 18.6. Serum mineral profile of buffalo

Parameters	Critical level	Swarna Min	Commercial mineral mixture
Fe (ppm)	< 1.00	3.25 — 3.55	3.12 — 3.86
Mn (ppm)	< 0.20	0.31 — 0.39	0.14 — 0.21
Zn (ppm)	< 1.00	0.82 — 0.92	0.50 — 0.62
Cu (ppm)	< 0.65	0.81 — 1.26	0.89 — 1.09
Ca (g/dl)	8.00	9.20 – 9.33	8.07 – 8.19
P (g/dl)	4.00	4.96 — 4.98	3.75 – 3.99

Table 18.7. On-farm evaluation of Swarna Min

Place	Type of animal	Initial milk yield (kg)	Final milk yield (kg)	Percent increase
Badipur, Patna	Crossbred cattle	12.5	13.1	4.8
Khajuri, Patna	Crossbred cattle	28.8	29.1	1.04
Nawada	Crossbred cattle	16.4	16.9	3.05
Sonpur, Vaishali	Crossbred cattle	8.8	9.6	9.1
Jandah, Vaishali	Crossbred cattle	11.2	11.9	6.25
Dal Singh Sarai, Samastipur	Crossbred cattle	17.9	18.4	2.8
Dal Singh Sarai, Samastipur	Buffalo	8.4	8.9	5.9
Dal Singh Sarai, Samastipur	Buffalo	6.2	6.9	11.3
Bikramganj, Sasaram	Buffalo	9.1	9.7	6.6

Characterization and Evaluation of Duck Germplasm in Eastern Region

A survey was conducted in Katihar, Purnea and Araria districts of Bihar to study the different duck rearing practices being followed in villages. It was observed that ducks were raised under semi—intensive management system and mostly dependent on scavenging for their nutritional needs. The ducks were being raised both for meat and egg production. The annual average egg production per duck was very poor (89.96 ± 4.07) and the flock

size was usually small, 7.27 ± 0.49. In both drake and duck, body carriage was slightly upright and bill shape was horizontal. Prominent head colour in drake was black (43.33%) whereas in duck it was brown (43.75%). In both drake and duck, the dominant neck colour was white (55 & 53.75%, respectively). About 55% drake had white breast colour whereas 42.50% ducks had brown and black spotted colour. In both drake and duck, wing colour was brown/black & white while prominent bill colour was yellow, bean colour was black and prominent eye colour was brown. Dominant shank colour in drake was orange (51.67%) whereas in duck it was yellow (56.25%). Values for all the morphometrical measurement, i.e., body weight, body length, bill length, bill width, shank length, wing length, head length, neck length and head width varied from 1.37 to 1.40, 34.71 to 37.49, 5.86 to 6.26, 3.20 to 3.22, 6.27 to 6.36, 31.36 to 32.07, 10.79 to 11.66 and 2.96 to 3 cm, respectively.

About 88.57% of the farmers provided some kind of separate shed for their birds, constructed mainly by locally available materials like bamboo—straw (50%), mud (35.71%) and brick with plastic shed (2.86%) (Fig. 18.6). About 11.43 % farmers did not possess any shed and kept the ducks in their house.

Comparative performance of Khaki Campbell, White Pekin and Desi duck germplasm collected from Odisha, Jharkhand, Bihar and West Bengal were evaluated (Fig. 18.7). Hen day egg production (%) up to 30th week of age was recorded higher in Khaki Campbell (45 %) followed by desi duck germplasm of Odisha (35%), Jharkhand (28%) and Bihar (27%). Egg weight was observed highest in Khaki Campbell. Hatchability percentage was highest in Khaki Campbell (70%) followed by White Pekin (65%), Odisha Desi (60%), Jharkhand Desi (60%) and Bihar desi (55%).

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

Comparative performance of indigenous (Kadaknath) and improved varieties (Vanraja and Grampriya) of chickens was studied under backyard system of rearing (Fig. 18.8). Age at first laying of Kadaknath variety was recorded higher (22 weeks) in comparison to improved varieties

Fig. 18.6 Different kinds of duck shed

Khaki Campbell

White Pekin

Bihar Desi

Odisha desi

Fig. 18.7 Indigenous ducklings collected from different eastern states

Fig. 18.8. A. Chicks and adults of Kadaknath B. Chicks of Gramapriya (left) and Vanaraja (right)

of Vanraja (18 weeks) and Grampriya (20 weeks). Similarly, hatchability of Kadaknath was recorded at 82% with hatch weight of 30–35 g. However, in Vanraja and Grampriya variety, hatchability and hatch weight were recorded at 85.45 & 84.74% and 39.0–40.5 & 35.0–38.2 g, respectively. Hen day egg production up to 28 weeks of age for Kadaknath was 35%, which was lower in comparison to Vanraja (55%) and Grampriya (62%). Average daily gain up to 2 months of age was found lower (6.55 g/d) in Kadaknath, which was the lowest as compared to Vanraja (16.55 g/d) and Grampriya (10.0 g/d). Body weights from 0 to 8th weeks of age of male and female Vanaraja, Gramapriya and Kadaknath chicks maintained in deep litter system has been depicted in Fig. 18.9, which shows that the body weight of Vanaraja chicks at different ages was higher in both the sexes followed by Gramapriya and Kadaknath.

Study on High Prolific Goat Germplasm

Bengal goats are known for their fecundity rate as most of the goats give mostly twins and triplets whereas quadruplets are reported sporadically. Increasing the herd horizontally by increasing the herd size could be one of the ways of improving total biomass productivity of the farm. In order to collect the baseline information, an initial survey was undertaken to study the production and reproduction performances of Black Bengal goats in Katihar and Purnea districts of Bihar. The result showed that the body weights of Black Bengal

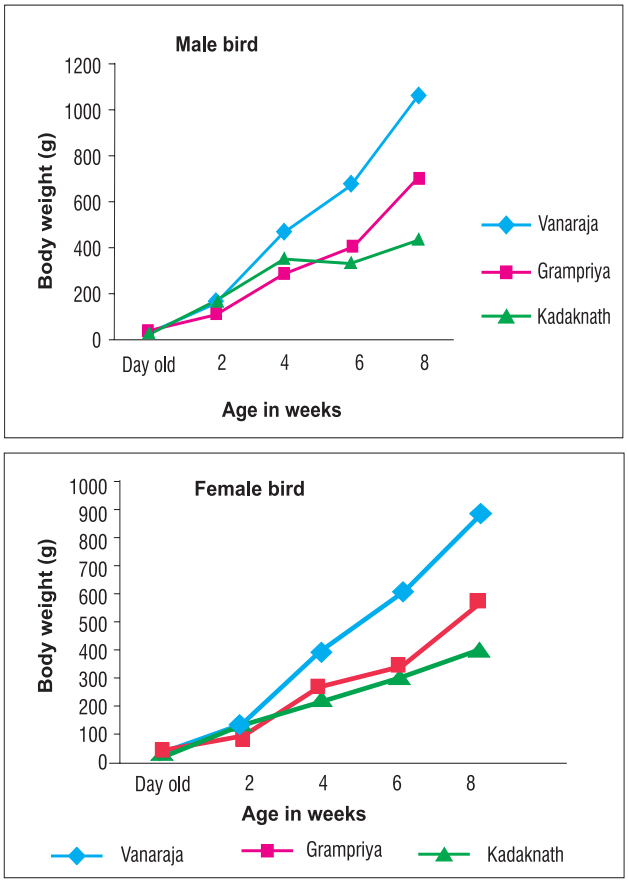


Fig. 18.9. Sex and age wise growth performance of Vanaraja, Gramapriya and Kadaknath

goats at the age of 3, 6, 9 and 12 months ranged from 3.2 to 4.1 kg, 5.3 to 6.26 kg, 9.85 to 10.2 kg and 12.9 to 13.5 kg, respectively. With respect to reproduction traits, the age at 1st kidding, and kidding interval varied from 395 to 440 days and 200 to 290 days respectively. Total distribution of types of birth of high prolific Bengal type goats were 75% singlet and 25% twins in primiparous goats, and 5% twins, 45% triplets, 40 % quadruplets and 10% quintuplets in multiparous Black Bengal goats. It was found that there was no selection practiced towards any special traits in male and female Black Bengal goats in the surveyed villages.

Women members of farmers' family played a proactive role (90%) in the rearing of goats whereas involvement of male members of the family was just 10%. Further, children of the

family also played supportive role in grazing and kid rearing.

Survey indicated that majority of farmers kept their goats confined during night only (51% and 49%), during both day and night. Grazing was practiced by 32% of farmers while others stall-fed the goats with resources available with them.

In order to improve the reproductive performance of Black Bengal goats in the experimental goat unit of main campus of the institute and to study the basis of high fecundity rates, Bengal type goats with high fecundity rate were procured from the farmers, and the research works are underway (Fig. 18.10).

Fig. 18.10. Quintuplets in institute goat farm

Development of Herb-based Calf-care Mix for the Production of Disease-free Calf

A field trial on effect of herb based calf-care mixture was conducted in two villages of Sheikhpura district and one village of Patna district involving 108 calves (Fig. 18.11). These calves were divided into four groups to find out the optimal dose by oral administration of calf-care mix at weekly (Group 1), fortnightly (Group 2), monthly (Group 3) interval along with a group of untreated control (Group 4) animals. The haematological, serum biochemical parameters were studied using commercial biochemical kits.

In the present study, a significant increase in RBC count, haemoglobin concentration, total protein and albumin was noticed in calves on 90th and 180th days of sampling in all treatment groups. Besides, significant elevation in superoxide dismutase and glutathione peroxidise enzymes was noted.

Fig. 18.11. Field trial at Sheikhpura

The animals which were given calf-care mix gained body weight at a faster rate than non-treated control animals. Calves in Group I with weekly administration of calf-care mix gained weight at 11.1 kg on first month to 43.71 kg on sixth month, which showed higher increase in body weight than other two groups (Group 2 & 3) wherein supplementation was fortnightly and monthly basis (Table 18.8). As such the liver enzymes and indicators of renal health were well within the physiological limits which suggest the toxicological safety of the calf-care mix in all groups. During the period of trial, all owners of calves were asked to observe for development of any illness or abnormality. Interestingly, none of owner came across any illness even of mild nature. Whereas during the winter months, control animals suffered with non-specific illnesses and 3 animals died even after treatment.

Table 18.8. Body weight gain of calves fed calf care mix at different interval

Groups	First month gain (kg)	Second month gain (kg)	Six month gain (kg)
G-I—Weekly	11.10	11.80	43.71
G-II —Fortnightly	8.97	13.02	38.64
G-III—Monthly	11.95	11.84	30.40
G-IV— Control	1.19	1.26	9.82

Effect of Feeding Sundried Sweet Potato on Growth of Crossbred (T x D) Pigs

Sweet potato *(Ipomoea batatas)* grown in institute farm recorded an average yield of 41.6 t/ha. Chemical analysis indicated that raw sweet potato contains about 66% moisture, 1.13% protein, 0.97% fat, 4.2% fibre, 6.1% sugar and 0.45% ash, whereas boiled sweet potato contained 1.03% protein, 1.1%

fat, 1.3% fibre and 0.41% ash (Fig. 18.12).Crossbred pigs Tamworth x Deshi (Fig. 18.13) were under feeding regime with dried sweet potato with replacement of maize in concentrate feed. A feeding trial with 24 crossbred (T x D) pigs comprising twelve female and twelve male pigs divided into four groups with each group contains 3 male and 3 female pigs of 80 days age with average body weight of 28 kg were assigned four treatments. Experiment conducted on replacement of maize with sundried sweet potato (SSP) at the rate of T_1 (0%, Control), T_2 (25%), T_3 (35%) and T_4 (50%), respectively. The feed was offered twice daily at the rate of 2.25 kg/pig/day, on dry matter basis with half of the quantity in morning and half at evening. During 75 days trial it was observed that all the groups differed significantly (P = 0.01) though initial body weight was non-significant. Maximum weight gain was observed in T_3 followed by T_4, T_1 and T_2 (Table 18.9). Same trend was followed in average daily gain also. The maximum weight gain with SSP up to level of 35% may be due to maximum availability of digestible carbohydrate in diet along with protein. It may be inferred from the above experiment that sundried sweet potato is better option for replacement of maize and up to 35% may be incorporated in pig feed with maximum weight gain.

Fig. 18.12. Sliced sweet potato ready for sun drying and boiling

Fig. 18.13. Experimental pigs

Table 18.9. Growth performance of crossbred (T x D) pigs at institute farm at Ranchi.

Parameters	T_1 (Control) (0% BSP)	T_2 (20% BSP)	T_3 (40% BSP)	T_4 (60% BSP)	CV (%)
Initial body weight(kg)	31.4± 0.22	31.2± .34	31.0± 0.28	31.2± 0.33	2.377
Final body weight (kg)	54.2± 0.34^{a*}	59.0± 0.28^{b}	61.6± 0.54^{c}	65.2± 0.33^{d}	1.603
Average daily gain (kg)	0.38± 0.01^{a}	0.46± 0.01^{b}	0.51±0.1^{c}	0.57± 0.01^{d}	5.129
Total body weight gain (kg)	22.8± 0.44^{a}	27.8± 0.59^{b}	30.6± 0.73^{c}	34.0± 0.56^{d}	5.121

*Values with different superscripts are significantly different at 1% level

Impact of Phytase Enzyme Supplements on Egg Production Performance Poultry Birds

During one year trial period the growth rate and egg production and other performance of the Divyan Red, Kaveri, Vanaraja and Gramapriya varieties of poultry birds were recorded at institute poultry research centre (Fig. 18.14). Body weights of male birds were more than the female birds in all stages of growth in all the varieties (Table 18.10). An experiment with phytase enzyme was also carried out with 100 each of Divyan Red, Kaveri, Gramapriya and Vanaraja poultry birds. Supplementation with phytase @15gm/100kg of feed was provided to experimental group of 50 birds of each variety and a diet without phytase enzyme was given to control group with 50 birds. Average growth rate of 17.21% was recorded in phytase supplemented birds than control group. Vanaraja and Gramapriya recorded maximum growth rate followed by Divyan Red and Kaveri. It indicates that phytase enzyme supplementation in ration of poultry birds has a beneficial effect on growth performance in variety of birds.

Fig. 18.14. Kaveri and Divyan Red poultry birds.

Table 18.10. Egg production performance of different poultry birds at different ages

Attributes	Divyan Red	Kaveri	Gramapriya	Vanaraja
Age at first egg (in days)	171.15 ± 0.75	165.33± 0.71	172.21± 0.76	171.23± 0.79
Egg production/year/hen (no)	145.75 ± 1.27	150.56± 1.55	152.55± 1.49	154.36± 1.48
Egg weight 40 weeks (g)	55.07 ± 0.28	52.22± 0.24	54.26± 0.23	52.29± 0.22
Egg weight 72 weeks (g)	63.05 ± 0.31	58.57± 0.34	62.13± 0.31	63.25± 0.32
Mean egg weight (g)	60.09 ± 0.51	57.55± 0.53	61.11± 0.54	59.78± 0.52
Percentage of broken eggs	10.02 ± 0.24	8.97± 0.21	9.14± 0.29	8.77± 0.27

Isolation and Morphological Characterization of *Fusarium* Species from Degnala Disease affected Region

Microscopical characterization of *Fusarium*

Mycelia suspected to be *Fusarium* sp. were identified by microscopic examination of spores. The cultures of fungus were stained with Lactophenol cotton blue stain and visualized under microscope. Septate hyphae, conidiophores, phialides, macroconidia, and microconidia were observed microscopically. The fungus produces spore which include macroconidia and microconidia. The macroconidia are nearly straight, slender and thin-walled with three to four septa (Fig. 18.15). They were produced from short condiophores. Microconidia are one or two celled, oval to kidney-shaped.

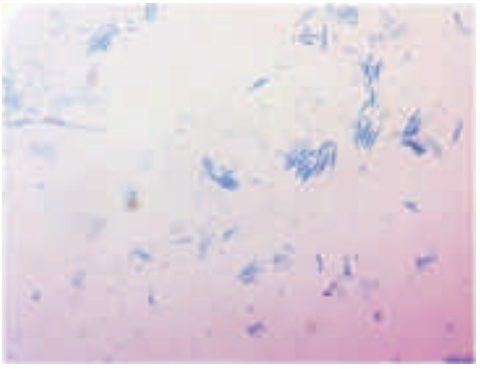


Fig. 18.15. Characteristic sickle-shaped macroconidia of *Fusarium* spp.

Molecular characterization of *Fusarium* spp.

The *Fusarium* species were grown on PDA agar and their genomic DNA extraction was optimized using beta mercapto—ethanol. The genomic DNA of Fusarium species was subjected to amplification of *Fusarium* specific translation elongation factor 1α (EF—1α) gene by PCR. Reaction condition for PCR was optimized using varied concentration of PCR reagents and different annealing temperature for specific amplification of *Fusarium* specific gene. PCR for translation elongation factor 1α (EF—1α) gene of *Fusarium* was carried out using forward primer: 5′— ATGGGTAAGGARGACAAGAC—3′ and reverse primer: 5′— GGARGTACCAGTSATCATGTT—3′. The product was subjected to gel electrophoresis along with 100bp marker to identify specific amplicon. A band of 706 bp was obtained which was specific to translation elongation factor 1α (EF—1α) gene of *Fusarium*. A total of three isolates were found to give specific amplification of translation elongation factor 1α (EF—1α) gene.

Epidemiological Study of Respiratory Viral Diseases in Calves

Out of 46 calves examined during the study period, 11 (23.9%) calves were affected with respiratory disease, 15 (32.6%) with diarrhea, 6 (13%) with naval ill, 3 with scabies (6.5%), 9 with pyrexia of unknown origin (19.5%) and two calves were affected with injury related illnesses. Nasal swab

samples were collected from calves showing signs such as nasal discharge, coughing and respiratory distress. Post mortem was conducted for nine dead bovine calves with signs of the respiratory disease and samples of lungs, trachea and intestines were collected. The predominant gross findings in such cases were edema and congestion of lungs, frothy fluid in trachea and bronchial tree, mild fibrin deposition on pleural surface and discrete areas of consolidation in lungs particularly in apical and middle lobes and in few cases suppurative pneumonia was found. Bronchial lymph nodes were enlarged in few cases. Histologically, the most prominent signs were present in lungs characterized by congestion of blood vessels, peribronchial infilteration of neutrophils and lymphocytes, bronchioles were plugged with neutroplilic and lymphocytic exudate, alveolar oedema, necrosis of lung parenchyma and infiltration of lymphocytes, fibrosis and oedema of septa. In bronchial lymph node congestion of capsular blood vessels, presence of few macrophages and mild lymphoid depletion was seen. (Fig. 18.16 & 18.17)

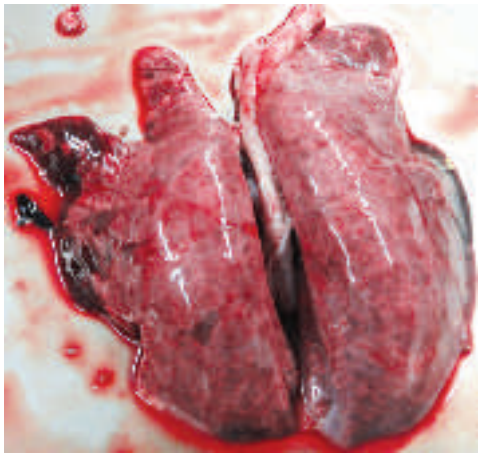


Fig: 18.16. Lungs, H &E, 10 X: bronchiole plugged with neutroplilic exudate, peribronchial infiltration of lymphoid tissue, congestion of peribronchial vessels and alveolar edema.

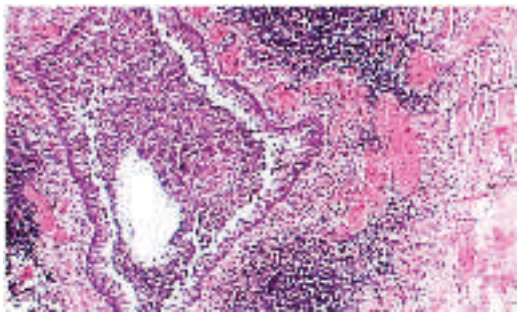


Fig. 18.17. Edema of lungs with consolidation of apical and cardiac lobes,

FISHERIES

Composite Fish Culture

An experiment was conducted to evaluate growth, survival and recovery percentage of different fishes in the mix culture system. Stunted fingerlings of *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Ctenopharyngodon idella*, and *Puntius gonionotus* at the combination of 35:30:20:7:8 were stocked at the rate of 10,000 numbers /ha. Commercially available sinking pelleted supplementary diet was provided @ 2% of the body weight having 22% crude protein and broadcasting feeding was followed for feeding the fish. The highest average body weight was recorded in case of grass carp (2.5 kg) and maximum recovery percentage of 93.25% was recorded for *Labeo rohita* (Fig. 18.18). Total fish production was recorded at 5.01 t/ha/yr.

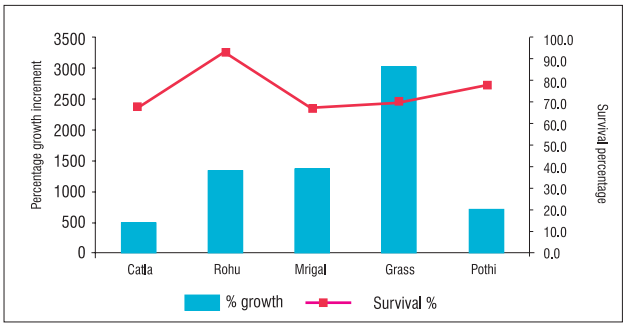


Fig. 18.18. Growth and survival of different fishes in mix culture system

Optimization of Production Efficiency in Livestock–Fish Integrated Farming System

Integrated fish farming not only promotes utilization of land area vertically or horizontally but also recycles livestock waste and by—products as fish food. 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 form more than 50% of the total input costs.

Plankton analysis

The current investigation have shown that the annual average plankton density was recorded to be the highest in fish—pig intigration (938.54 no./lit) follwed by fish—goat (812.17 no./lit.) and fish—poultry (811.46 no./lit.) integrations (Fig.

18.19). The monthly variation in plankton density is shown in Fig. 18.20. The lowest plankton density was observed in the month of November among all integration system due to peak winter.

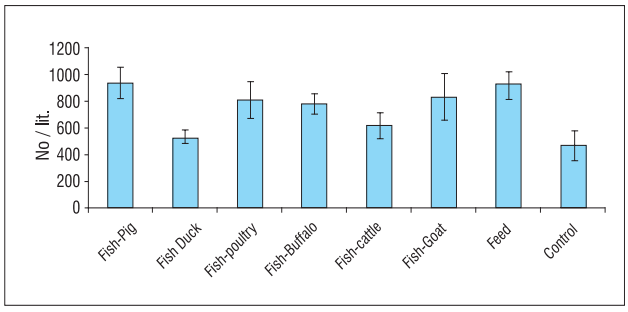


Fig.18.19. Annual average plankton density under different fish-livestock based integrated fish farming systems.

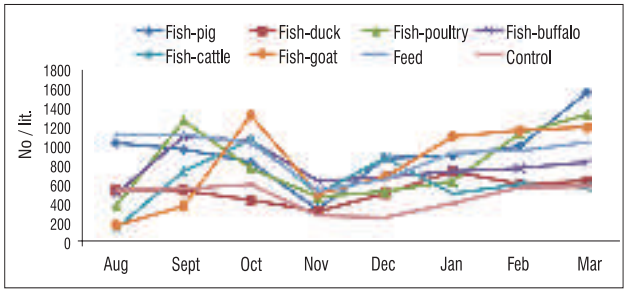


Fig. 18.20. Monthly variation in plankton density in different fish–livestock based integrated farming systems.

Occurrence of fish food organisms

The most abundant and frequently recorded planktonic organisms were Rotifers, Copepods, Cladocerans, Diatoms, Blue Green algae, Chlorophytes, Euglenoids and Dinoflagellates etc. Abundance of plankton is generally associated with application 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. Some of the representative species of plankton recorded during sampling are presented in Fig. 18.21.

Primary productivity and water quality parameters

Primary productivity and water quality of a fish pond play vital role in integrated aquaculture system. Fig. 18.22 illustrates the primary productivity (GPP, NPP) of pond water

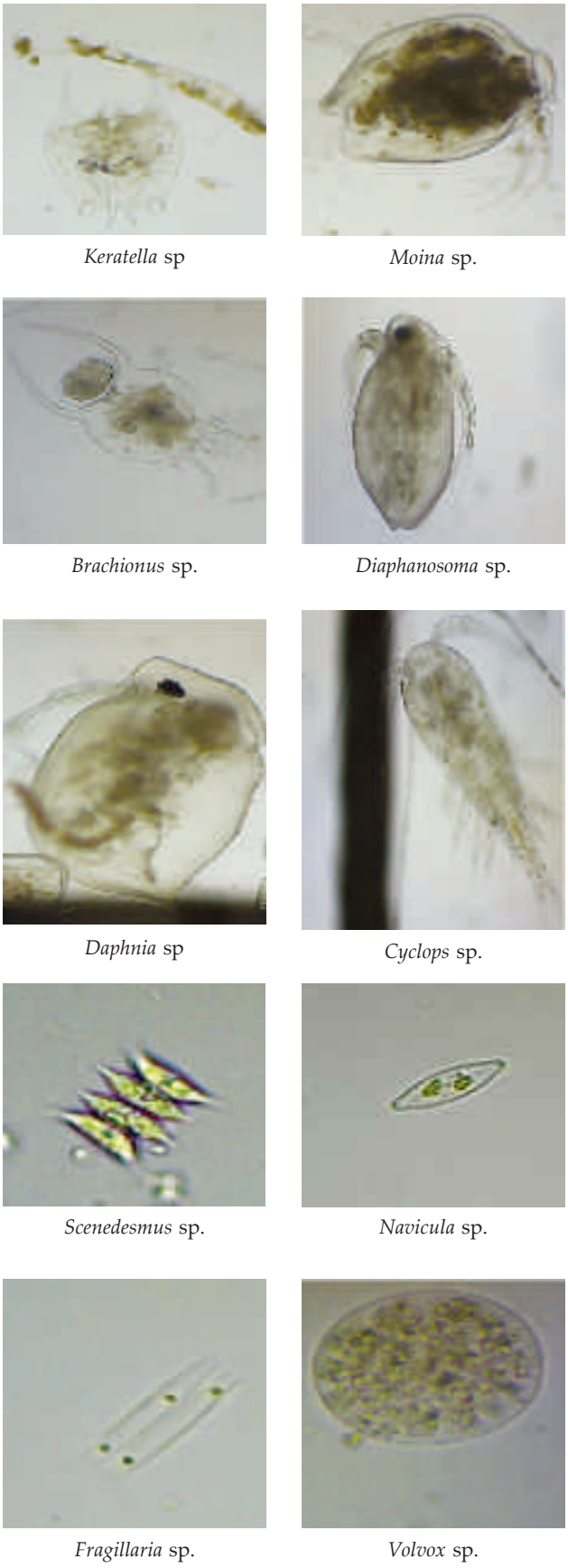


Fig. 18.21. Different species of Phyto and Zoo plankton

under different integrations. Gross primary productivity (GPP) and Net primary productivity (NPP) was estimated to be highest in fish—pig integration (0.27g C/m^3/h^1) followed by the fish—poultry (0.236g C/m^3/h^1) and fish—buffalo (0.191g C/m^3/h^1). Respiration quotient (RQ) was also recorded maximum in fish—pig pond and rest of the integrations showed almost similar results.

Water quality parameters in different fish—livestock based integrated farming systems are given in Fig. 18.22 and Fig. 18.23. From the present investigations the water quality parameters like total ammonium nitrogen (NH_3—N), nitrite (NO_2—N), nitrate (NO_3—N) and (phosphate) PO_4^{-2} content were estimated to be maximum in fish—pig pond, i.e., 0.119 ppm, 0.466 ppm, 2.65 ppm and 0.96 ppm, respectively. Moreover, in all other integrations these parameters recorded to be optimum required for freshwater aquaculture system.

Alkalinity and hardness were within the acceptable limit in all the ponds. Hence it can be assumed that livestock based integration has not significantly deteriorated water quality parameters when used in prescribed quantity.

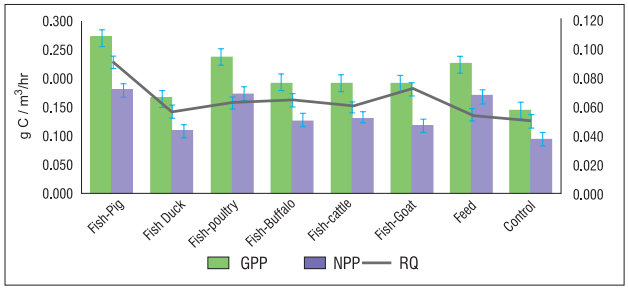


Fig. 18.22. GPP, NPP and RQ in different livestock-fish based integrated farming systems

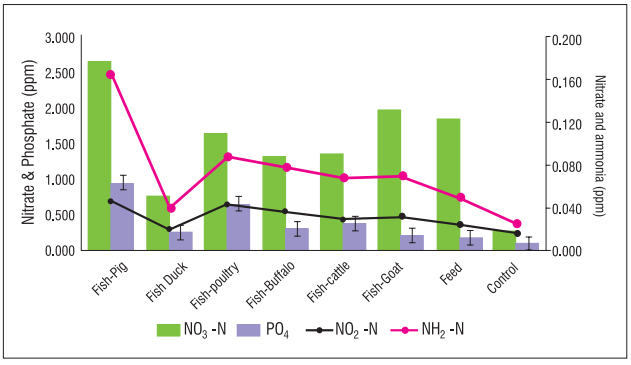


Fig. 18.23. Nitrite, Ammonia, Nitrate and Phosphate (in ppm) content in different livestock-fish based integrated farming systems

The pH of pond water in all the integrations ranged between 7.35—8.65 (Fig. 18.24) and no abrupt changes in pH was recorded. Dissolved oxygen was almost maintained between 6.05—8.77 ppm which is ideal for fish survival and growth.

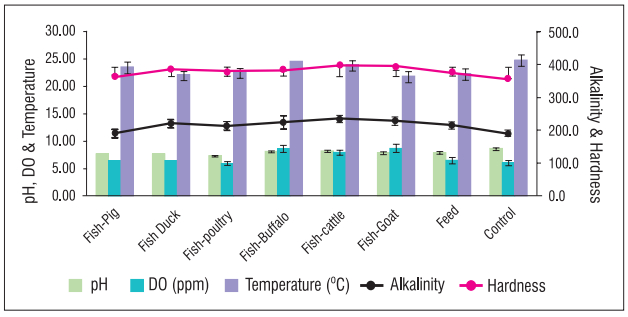


Fig. 18.24. Temperature, pH and DO in different livestock-fish based integrated farming systems

Microbial assessment of IFS pond

Heterotrophic bacterial count was estimated for animal manure, pond water, sediment and fishes raised under IFS. It was higher during summer than winter season. Among all integrations, bacterial density in fish—pig pond water was maximum (2.6x104 CFU/ml) during summer phase as compared to winter phase (2.05x103 CFU/ml) (Fig. 18.25). Pond sediment from all treatments subjected for microbial analysis has shown 10 times higher bacterial population than in water. Likewise, total bacterial count in pig manure was recorded the highest (9.50 x10^9 CFU/ml) and the lowest in cattle dung (6.30x 10^9 CFU/ml). Lower counts of heterotrophic bacteria have been recorded in control pond water, sediment and fish tissues not receiving any organic manure or concentrate feed.

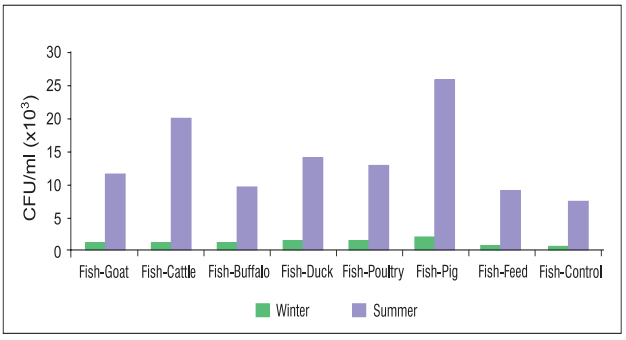


Fig. 18.25. Total bacterial count in pond water during winter and summer phase

National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) in Bihar

Under this project, five districts namely Patna, Vaishali, Samastipur, Darbhanga and Madhubani and 10 farms from each district (active fisheries sites) were selected after extensive survey in collaboration with State Fisheries Department, Govt. of Bihar. Fish tissues from farmers' field were collected and subjected for laboratory screening (DNA, RNA, cDNA and PCR) to detect the presence of target pathogen, i.e., Koi Herpes Virus (KHV) and Spring Viraemia of Carp Virus (SVCV). None of the sample was found to be PCR positive for KHV and SVCV. Under passive surveillance we could address some of the disease problems reported from farmer. There was frequent complaint of ectoparasites like *Argulus* sp. and *Lernaeae* sp. in carps followed by secondary infection of bacteria predominantly *Aeromonas* sp. During this year, we could conduct 4 awareness programme in different districts of Bihar with special focus on fish disease management. The disease monitoring network programme is now progressing at a better pace and more people are now getting acquainted and associated through this programme, which can be evident by their frequent personal contact, phone calls, visit to institute, enquiries from state officials etc. related to fish diseases and their management.

Growth performances and evaluation of *Puntius gonionotus* fingerlings fed on *azolla* incorporated diets

A 90 days feeding trial was conducted in rectangular FRP tanks with soil base for evaluating the growth performances of *Puntius gonionotus* fingerlings fed with pelleted feed containing varied levels of dried azolla (*Azolla pinnata*). A total of 180 fingerlings with average weight of 24.4 g were randomly distributed into 18 FRP tanks in groups of 10 and each tank was then randomly assigned to one of three replicates. The control feed contained 40% sesame meal, 20% mustard oil cake and rest of ingredient added based on required quantity. Dried azolla powder was incorporated into the feed at 10, 20, 30, 40 and 50% levels, replacing the sesame meal and mustard oil cake proportionally. The fish were fed 10% of body weight during the first month, followed by 7% during the second month and 5% during the last months (Table 18.11). At the end of rearing period, pecific growth rate of fish was recorded as 0.12, 0.16, 0.18, 0.22, 0.20 and 0.13 in T_0, T_1, T_2, T_3, T_4 and T_5 treatments respectively. It is observed that the growth rate of fishes fed with 30% azolla mixture in T_3 was highest followed by T_4.

Table 18.11. Growth performances parameters of *Puntius gonionotus* fingerlings

Treatments	Initial weight (g)	Final weight (g)	SGR (%/day)	BWG
T_0	257.0	290.1	0.1206	3.967
T_1	260.0	311.1	0.1617	5.467
T_2	255.0	324.4	0.1794	6.267
T_3	253.0	340.2	0.2228	8.000
T_4	250.0	328.3	0.2001	7.000
T_5	253.0	310.4	0.1300	4.300

T_0—control, T_1—10% Azolla , T_2—20% Azolla , T_3—30% Azolla , T_4—40% Azolla , T_5—50% Azolla ,

Integrated Fish Farming Models to Improve upon the Fish Productivity

Six integrated farming system models were developed and the fish productivity was compared with control (without integration). It was observed that cattle-fish resulted into the highest productivity of 4.96 t/ha/yr, followed by goat-fish integration (4.14 t/ha/yr). The data also revealed that the fish rearing with concentrate feed was able to increase a fish yield only by 400 kg/ha as compared to productivity of cattle-fish integration. Resource poor farmers of the region could therefore, adopt these technologies of integrated fish farming (Fig. 18.26).

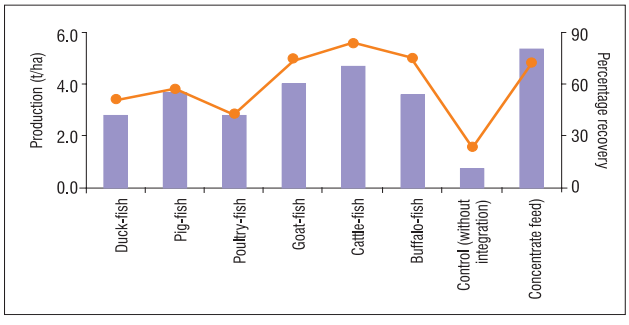


Fig. 18.26. Fish productivity under different fish integrated system

19. Transfer of Technology

Rice-Fallow Management in Eastern Plateau and Hill Region

Technology demonstration on improved paddy cultivation practices

Keeping in view the predictions about normal rainfall during monsoon of 2016, technology demonstration on Direct Seeded Rice (DSR), green manuring and azolla application was undertaken in Hundru and Chhota Ghagra villages of Ranchi with the objective to maximize the paddy yield under rice-fallow system. Demonstration on application of Sesbania as green manure before paddy growing season was carried out in four farmers' fields covering an area of 1.0 ha **(Fig. 19.1)**. The average yield of paddy (Hybrid Arize— Tez Gold) with green manuring was recorded at 8.11±1.86 t/ha as compared to 7.06 ± 1.91 t/ha in case of fields with no green manuring. Application of azolla in paddy was demonstrated in 12 farmers' fields covering an area of 2.5 ha. The average yield of azolla treated fields was recorded to be 7.53 ± 1.42 t/ha which was 6.51% higher than that of control fields. Demonstrations on DSR (variety Swarna Shreya) were carried out in four farmers' fields covering an area of 0.8 ha. The yield of paddy ranged between 7.81 to 8.68 t/ha in case of DSR as compared to 8.43 to 9.81 t/ha in case of transplanted paddy indicating better performance of transplanted paddy under normal rainfall scenario.

Technology Demonstration on Vegetable Cultivation in Rice-Fallow System

Hundru village, Ranchi

With the increased water availability from the water resource development activities of the project, cultivation of second crop after harvesting of paddy was possible in the rice—fallow systems of the Eastern Plateau and Hill Region. Demonstrations on off-season cultivation of bottle gourd (cv Swarna Sneha) were conducted in 12 farmers' fields covering an area of 1.1 ha (Fig. 19.2). The yield of off-season bottle gourd ranged between 10.63 to 13.48 t/ha with total paddy equivalent yield of the sequence ranging between 19.42 to 23.17 t/ha. The yield of main season bottle gourd ranged between 13.41 to 16.32 t/ha with total paddy equivalent yield of the sequence ranging between 17.48 to 19.98 t/ha.

With the access to irrigation water through open wells, the area under *kharif* vegetables increased from 73 ha in 2013 to 83 ha in 2016 (15.8% increase). During the *rabi* and summer season, area under vegetable crops increased by 58.8 and 39.7%, respectively (Fig. 19.3). This was

a. Direct seeded rice

b. Application of Azolla in paddy fields

Fig. 19.1. Demonstration of improved paddy cultivation techniques in farmers' fields

Fig. 19.2. Off-season cultivation of bottlegourd after paddy

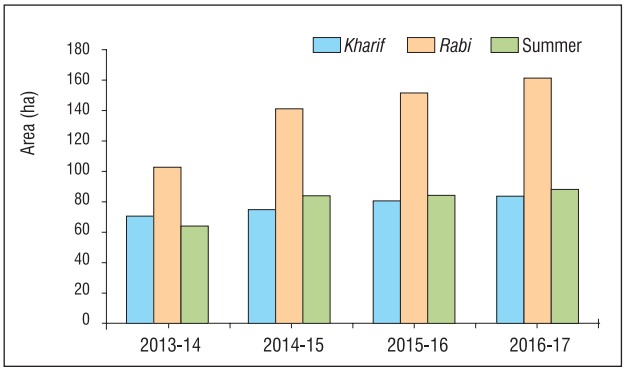


Fig. 19.3. Uptake of vegetable crops in Hundru and Chhotaghagra villages from 2013 to 2016

possible mainly because of increased availability of irrigation water from the check dam. With the introduction of better technologies and providing access to irrigation water, the areas remained fallow earlier in the project had largely given way to more profitable vegetables by 2016. Even in the areas where farmers did not have access to the water from the dug wells or the newly constructed check dam, availability of electric pump from the project helped to irrigate their fields from the far flowing Swarnrekha River, consequently increasing the area under summer vegetable cultivation. Access to irrigation water provided opportunity for crop diversification, wherein farmers could grow 12 types of vegetables as compared to 2 to 3 types before the inception of the project

Jiddu village, Ormanjhi

The interventions were undertaken during 2015-16 to improve the productivity of rice fallow where enhancement of irrigation water availability is not possible. Based on the learnings on success of *rabi* crops under rainfed conditions during 2015-16, demonstration of chickpea cultivation was made in 25 farmers fields in Jiddu village covering an area of 1.0 ha (Fig. 19.4). The yield of chickpea grain ranged between 0.43 to 0.88 tonnes per ha (7 farmers). However, majority of farmers (12 numbers) preferred to harvest their crops at green pod stage which fetches higher price in the market. Farmers could earn Rs. 5665 to Rs. 6438 per 400 m^2 area by selling chickpea plants at green pod stage in the local market during the period of peak demand.

Fig. 19.4. Chickpea cultivation in rice-fallow

Saraitoli village, Ranchi

The cluster based integrated farming system approach in farmers participatory mode was undertaken for enhancing the productivity of rice—fallows in Saraitoli village (Fig. 19.5). Focus was on improving the livelihood of the farming community through capacity building and empowering them for efficient utilization of available natural resources. The farming system comprising 'paddy + vegetables + lac + poultry + goat' established in 0.30 ha area generated net income of Rs. 31,300

Fig. 19.5. Drip irrigated cabbage at farmers field in Saraitoli village

/year with B: C ratio of 4.25. Another farming system 'paddy + vegetables + lac + fish + duck + cow'generated a net return of Rs. 45,400 /year with B: C ratio of 3.94, while in the 'paddy + vegetables + lac + poultry + goat' generated net returns of Rs. 47,400 /year with B: C ratio 5.36 from 0.42 ha. Among the different farming system models, comparatively higher net returns (Rs. 61,210/year) was obtained from 0.6 ha area wherein 'paddy—vegetable—mustard—lac—poultry' system was fallowed. This system resulted in the B:C ratio 3.32. Because of the comparatively lower labour requirement and higher net returns, the lac based farming systems were widely adopted by the farming community.

Solar pumping, drip and sprinkler irrigation in Madhubani district of Bihar

The concept of collective farming has been introduced in Bhagwatipur and Mauahi villages of the Madhubani district wherein farmers can pool their resources like implements, equipments, expertise and labour. All the agricultural operations from land preparation to marketing of the produce are carried out collectively by the participating farmers. Collective farming is helping the farmers to manage agricultural inputs, farm activities in timely and efficient manner. The following activities were taken under the project

- Providing access to groundwater for improving irrigation during dry season (Oct to May) through interventions on solar pumping systems.
- Demonstrations on use of solar pumping systems for pumping groundwater through tube wells and efficient use in the fields for wheat and vegetable cultivation.
- Livelihood improvement of 26 households through increasing area under dry season cultivation with the introduction of drip and sprinkler irrigations systems installed on 4 ha area for vegetable and wheat production.
- Training for capacity building of farmers on the aspects of nursery growing in protrays (Fig. 19.6), vegetable cultivation on raised bed and application of plastic mulching for water conservation and weed control at four experimental sites in two villages (Fig. 19.7).
- Growing of vegetable nursery in protrays by participating families to produce healthy nursery for improved production. Community nursery raising is practiced to get the better returns on investment. Farmers of 4 collective groups are raising nursery in protrays.
- Capacity building of the famers on the aspects of maintenance of drip and sprinkler irrigation systems to make them self-confident in managing these systems. Hands-on-practice type of participatory training were conducted on fertigation of vegetable crops using ventury system (Fig. 19.8).

Fig. 19.6. Training of farmers on portray nursery raising of

Fig. 19.7. Capacity building of farmers on polythene mulching on raised beds

Fig. 19.8. Training of women farmers on maintenance of drip and sprinkler irrigation systems

- Low cost 'drum kit drip' irrigation systems demonstrated in two collective farming groups at Bhagwatipur and Mauahi villages (Fig. 19.9).
- Technology of pheromone traps for control of insects and pests in vegetable crops was demonstrated on the fields of 24 farmers in the villages.

Fig. 19.9. Low cost drum kit drip irrigation systems in Bhagwatipur village of Madhubani district

Mera Gaon Mera Gaurav (MGMG)

During 2016-17 thirty four villages of four districts were covered under *Mera Gaon Mera Gaurav* and 336 farmers were benefitted in the Jharkhand state.

Technology dissemination	Participant/ beneficiaries
Training and demonstration of preservation of fruits and vegetables	54
Information related to crop management practices, i.e., weed control, fertilizer application pest and disease management of *kharif* crops like Rice and Arhar	17
Meeting conducted for Attracting Rural Youth in Agriculture to make them aware of "ARYA Scheme"	10
Weed management in rice crop	28
Scientific cultivation of rice through zero tillage	28
Information related to animal health and management	17
Tomato processing	25
Animal health camp	30
Azolla application in rice field, Micronutrient management in vegetables, Insect pest management in vegetable.	22
Rice mat nursery	83
Seasonal and off-seasonal solanaceous and leguminous vegetables, insect pest management	22
Total	336

Four teams of scientist at ICAR-RCER, RC Ranchi adopted 20 villages in the radius of 50—100 km to take up the extension, demonstration and out-scaling of the technologies under the *Mera Gaon Mera Gaurav* programme. These teams conducted 15 visits to the selected villages to understand the problems faced by the farming community and provided on-farm solutions, trainings and conducted demonstrations on several technologies (Fig. 19.10). Range of technologies disseminated during the field visits are depicted in Table 19.1.

Table 19.1. Technologies demonstrated at village level

Technology	Number of villages
Nursery raising of vegetable seedlings in portrays	10
Low poly tunnel cultivation of cucurbits for early cropping	10
Good agriculture practices for winter vegetable crops,	10
Use of *Trichoderma* for soil borne disease management	5
Training on mushroom cultivation	5
Awareness programs for pest management practices	10
Use of drip irrigation for increasing water productivity	6
Management of soil fertility	10
Seed treatment before sowing	10
Processing and preservation of tomato and jackfruit	5
Training on propagation of fruit crops, layout of field, pruning and management in fruit crops.	5

Fig. 19.10. Farmers' scientist interaction and field visit under MGMG

Distribution of inputs

- Provided leaflets on cultivation of vegetables, mushroom, water harvesting etc.
- Early and powdery mildew resistant lines of peas
- Seeds of solanaceous, cucurbitaceous and leguminous vegetables.
- *Trichoderma* for seed treatment
- *Azolla* for transplanted rice
- Distribution of pruning tool (secateurs) and mango plants

Consultancy, Patents and Commercialization of Technology

Table 19.2. Certificate of registration obtained under PPV&FRA

Name of varieties/ crops	Registration number	Certificate number
Swarna Mukti (Garden pea)	REG/2014/2131	258 of 2015
Swarna Baibhav (Tomato)	REG/2012/383	99 of 2016
Swarna Mani (Brinjal)	REG/2012/107	189 of 2014
Swarna Pratibha (Brinjal)	REG/2012/108	192 of 2014
Swarna Shyamali (Brinjal)	REG/2012/109	188 of 2014
Swarna Shree (Brinjal)	REG/2012/106	196 of 2014
Swarna Vijaya (Tomato)	REG/2013/1094	650 of 2014

Table 19.3. IC number registration obtained from NBPGR

Crops	Released variety	IC number	Date of registration
Tomato	Swarna Kanchan	IC620354	08-09-2016
Tomato	Swarna Anmol	IC620355	08-09-2016
Tomato	Swarna Ratan	IC620356	08-09-2016
Capsicum	Swarna Atulya	IC620357	08-09-2016
Bottle gourd	Swarna Sneha	IC620358	08-09-2016
Brinjal	Swarna Mohit	IC620649	04.10.2016
Brinjal	HAB-381	IC620650	04.10.2016
Brinjal	Swarna Mani	IC620651	04.10.2016

Table 19.4. Material Transfer Agreement

Host institute/ provider of the material	Recipient of the material & address	Material/plant variety	Date
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	Welcome Crop Science PVT. Ltd. No. 12, KHB Industrail Area, Yelahanka New Town, Banglore 560064	Tomato: Swarna Lalima, Swarna Naveen, Swarna Anmol, Swarna Baibhav, Swarna Vijaya Brinjal: Swarna Shree, Swarna Shyamali, Swarna Ajay, Swarna Pratibha	10.09.2016
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	AICRP on Vegetable Crop. Department of Hort. Dr. Rajendra Prasad, Central Agriculture University, Pusa Samastipur, 848125	Tomato: Swarna Lalima, Swarna Naveen, Swarna Kanchan Pointed gourd: HAP-2-,6,79,92,111, and Swarna Rekha, Swarna Alaukik, Swarna Suruchi	16.09.2016
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	IARI, Division of Fruit & Hort. Technology, New Delhi, 110012	Mango (15 Varieties)	21.09.2016
ICAR Research Complex for Eastern Region, Research Centre, Ranchi of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001	ICAR-RC-NEH Region, Manipur Centre, Lamphelpat-795004	Swarna Pratibha and Swarna Shyamali (Brinjal)	14.02.2017

Training and Awareness Programmes, Animal Health Care and Field Day Organized

Training programmes, awareness programmes, animal health care and field day organized by the institutes are depicted in Table 19.5 to 19.8.

Table 19.5. Training programmes

Name of training programmes	Duration	No. of Partic-ipant
Poultry rearing and disease prevention: Technology Infor-mation. Sponsored by ICAR NRC, (Litchi)	16-18 February, 2017	25
Modern techniques in poultry farming under rural backdrop	15-17 March, 2017	25
Ornamental fish culture and management for the up-lift-ment of rural livelihood. Spon-sored by ICAR NRC (Litchi)	27 June - 1 July, 2016	28
Recent advances in livestock fish integrated farming. Sponsored by Govt. of Bihar	6-15 Feb., 2017 1- 10 March, 2017 20- 29 March, 2017	81
Improved agricultural imple-ments and machinery for skill up-gradation under CRP on FM	22-24 Decem-ber 2016	92
Ghehoon utpadan ki unnat krishi takneek under SRFSI project participated	9 September, 2016	26
Techniques and management of Mushroom production	15-19 Novem-ber, 2016	27
Scientific methods of produc-tion of seasonal vegetables	21-25 Nov., 2016	25
Insect and disease manage-ment in vegetables & fruit crops	09-13 Janu-ary, 2017	25
Techniques and management of mushroom production	27 Feb. - 01 March, 2017	23

Table 19.6. Awareness programmes

Place	Date	Partici-pant
Awareness programme on fish diseases		
Parsa village, Patna	29 July, 2016	35
Sarairanjan vill.e, Samastipur	31 August, 2016	56
ICAR-RCER, Patna	8 Feb., 2017	63
Simra village, Patna	22 March, 2017	78
Awareness programme on animal health & production		
Pachoura Village, Nalanda	22 October, 2016	200
Gonpura Panchayat, East Champaran	23December,2016	150
Vill.- Bakhri Nazir, East Champaran	21 March, 2017	75
Vill.-Damodarpur, Mehsi Block, East Champaran	21 March, 2017	50
Ujhilpur, Mehsi, District East Champaran	25 March, 2017	150

Table 19.7. Animal health camp

Venue	Date	Program	Stake-holders
Darhaut, Jehanabad	19 Sep-tember, 2016	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 60 animals
Kurwa viallge, Jehanabad	20, Sep-tember, 2 016	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 110 animals
Senduari village, Vaishali	26 Sep-tember, 2016	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 178 animals
Badshapur village, Seikhpura	6 October 2016	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 90 animals
Ekraman village, Seikhpura	5 October 2016	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 70 animals
Village Saraitoli, Ranchi Jharkhand	21 Janu-ary, 2017	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 120 animals
Village Gargali vil-lage, Mandu Block, Rampur District, Jharkhand	22 Janu-ary, .2017	Animal Health Camp: Treatment and Diagnosis	Approxi-mately 54 animals

Table 19.8. Field Days

Place		Date	No of par-ticipants
Korahia (Jainagar)	Madhubani	15 Novem-ber, 2016	95
Sukhet (Jhanjharpur)		16 Novem-ber, 2016	39
Mauahi (Babubarhi)		17 Novem-ber, 2016	19
Sukhet (Jhanjharpur)		27 March, 2016	66
Korahia (Jainagar)		28, March 2016	58

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

Animal health camps were organized at different villages of Bihar and Jharkhand. Pre-tested questionnaire for data collection were used to record secondary data from farmers. The study was conducted in two villages of Vaishali district under — Zone-I, two villages of Sheikhpura district

in Zone IIIB of agro-climatic zone of Bihar, Ramgarh and Ranchi in Jharkhand (Fig. 19.11). All the villages chosen were away for any Government veterinary hospital. Follow-up camps after six month were organized in two villages (Darhaut, Kurwa) of Jehanabad district of Zone IIIA. Three camps were also organized in two villages (Senduari (N 25° 44′ 32.2′′ E: 085° 16′ 40.5″) under Hajipur block and Sanshad Adarsh Gram Village Mansurpur (N: 25o 46′ 34.1′′ E: 085 o 15′ 40.3′′) under Block: Bhagwanpur) of Vaishali district with KVK Vaishali. First health camps in two villages (Ekraman village (25°04′20.6″N 85°54′10.3″E) and Badshapur village (25°10′38.3″N 85°48′00.7″E) of Sheikhpura district (Fig. 19.12) in IIIB were also completed in association with KVK Sheikhpura. In Jharkhand two animal health camps were taken up in one village each (Saraitoli village and Gargali village under Mandu block) of Ranchi and Ramgarh districts. Around 700 cows and buffaloes were given general health care and reproductive health care. Vaccination, deworming, pregnancy diagnosis was carried out in reported animals. Specific cases of mastitis, suspected brucellosis and abortion and suspected IBR were also investigated. Non-specific infertility was treated with suitable medicines.

Fig. 19.11. Animal health Camp in Sariatoli, Ranchi

Fig. 19.12. Animal health camp at Sheikhpura

Advisory were provide to farmers and technology of CMT and dry cow therapy and for vaccination against PPR in goats

Linkages

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

International Collaborations

Research areas	Collaborating institutes
Conservation Agriculture	CIMMYT
Climate resilient cropping systems	CIMMYT
Improving water use for dry season agriculture	CIMMYT
Sustainable and resilient farming system intensification for EIGP	CIMMYT
Development of submergence tolerance rice varieties for flood plain and flood prone areas of eastern region	IRRI
Development of drought tolerance rice varieties for eastern region	IRRI
Restoration of degraded lands, water congested areas and carbon sequestration	World Agroforestry Centre
Developing suitable pulse varieties of lentil, grass pea and pigeonpeafor drought tolerance in eastern states	ICARDA
Small ruminants improvement and production system	ILRI

Other Collaborations

Research areas	Collaborating institutes/ Regional Centres
Integrated Farming System	IVRI RC, Kolkata; CSWCRTI, Koraput; IARI RS, Pusa (Bihar); CIFRI; CPRS RS, Patna, IIFSR, Modipuram and NBSS&LUP, Nagpur
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. Training and Capacity Building

Training on General Administration and Management

A three day Capacity Building Programme on "General Administration and Management" was organized during December 14-16, 2016 at ICAR Research Complex for Eastern Region, Patna. More than 35 participants from various ICAR institutes participated in the programme (Fig. 20.1). Sessions were taken on various topics including good governance, processing of cases under CAS, DPC constitution and its proceedings, assessment cases of technical staffs in ICAR system etc., apart from various other topics. All the participants actively interacted with the faculties during the entire course of programme.

Fig. 20.1. Capacity Building Programme on "General Administration & Management

Table 20.1. Category-wise details of trainings attended by employees during 2016-17

Category	Total No. of Employees	No. of trainings planned for 2016-17 as per ATP	No. of employees undergone training during April 2016-March 2017	% realization of trainings planned during 2016-17
Scientist	60	11	10	90.9
Technical	55+12*	14	5	35.7
Administrative & Finance	24	7	13	100
SSS	79	20	20	100
Total	163+12	52	48	92.23

*Including KVK, Buxar & Ramgarh

Winter School

ICAR sponsored 21-days Winter School on "Optimization of production efficiency of fish-livestock integrated farming" conducted at ICAR Research Complex for Eastern Region from 17.11.2016 to 07.12.2016 (Fig. 20.2).

Fig. 20.2. Inaugural session of winter school

Education and training of staff undertaken in India/abroad

- Dhakar, M.K. attended the Summer School Training on "Canopy Architecture Management in Fruit Trees for Conservation and Utilization of Natural Resources in Changing Climate" at ICAR-NRC, Litchi, Muzaffarpur from 11th July, 2016 to 31th July, 2016.
- Mali, S.S. attended Winter School on "Assessing natural resource management, climate risk and environmental sustainability using simulation models" organized at 'Indian Institute of Soil Science, Bhopal, Madhya Pradesh, during 8-28th November, 2016.
- Sarkar, P.K. attended Summer School on 'Livelihood and climate change mitigation and adaptation through agroforestry' organized at Central Arid Zone Research Institute, Jodhpur, Rajasthan, during 3-23th August, 2016.
- Shinde, R. attended CAFT training on "Soil, air and water pollution and mitigation strategies" at PAU Ludhiana during 2-22th November, 2016.
- Mohanty, Snatashree attended Winter School on "Current Trends in Molecular Diagnosis for Better Health Management in Aquaculture" at CIFA, Bhubaneswar, Odisha, during 15th February 07th March, 2017)

Details of HRD programmes undergone by KVK personnel

S. No.	Name of programme	Name of course	Name of KVK personnel and designation	Date and Duration	Organized by
1.	Workshop	Interface workshop on contingent plan on *Kharif*	Indrajeet, S.M.S.(Ag. Extension)	24/05/16	Directorate of Agriculture, Ranchi
2.	Short course	Principles and production techniques of hybrid seeds in vegetables	Dharamjit Kherwar, S.M.S. (Horticulure)	27/09/2019-08 /10/2016	ICAR-IIVR, Varanasi
3.	Workshop	Workshop on Rice seed production in Jharkhand'.	V. Dwivedi P.C. & D.K. Raghav, S.M.S. (Plant Protection)	06/01/2017	ICAR-CRURRS, Hazaribag
4.	Capacity building training	Training-cum-workshop on Micro irrigation for improving water use efficiency and productivity	Dharamjit Kherwar, S.M.S. (Horticulure)	18/01/2017-20/01/2017	BAU, Ranchi
5	Workshop	Cluster frontlie demonstration	D.K. Raghav, S.M.S.(Plant Protectiion)	19/07/16	ATARI, Zone II, Kolkata
6	Training cum workshop	Production and application of bio fertilizers for suistanable agriculture	Indrajeet, S.M.S.(Ag. Extension)	07/02/17 to 06/02/17	BAU, Ranchi

HRD fund allocation and utilization

S. No.	RE 2016-17 for HRD			Actual expenditure 2016-17 for HRD	% Utilization
	Plan	Non plan	Total		
	(Rs. in Lakh)			(Rs. in Lakh)	2016-17
1	3.15	—	3.15	3.15	100

21. Events Organized

Brainstorming session on 'Agroforestry for Rehabilitation of Water Congested Ecologies for the Eastern Region'

A brainstorming session on 'Agroforestry for Rehabilitation of Water-Congested Ecologies for the Eastern Region' was organized jointly by National Academy of Agricultural Sciences, New Delhi and ICAR- Research Complex for Eastern Region, Patna on 5th April 2016 at Patna. Dr. J.S. Samra, Ex-DDG (NRM), ICAR & CEO, NRAA was the Chairman of the session, Dr. P.L. Gautam, Vice Chancellor, Career Point University, H.P, was the Guest of Honour and Dr. Gurbachan Singh, Chairman, ASRB, New Delhi was the Chief Guest. The purpose of the session was to discuss about the water congested ecologies, wastelands and demand supply gap of fodders and fuel wood in different eastern states, integration of woody perennials and livestock for ensuring sustainability and doubling income of farmers of the region, inventorization of diverse water ecologies, studies on ET potential of suitable tree crops for biodrainage, establishment of seed and seedling bank of MPTs/shrubs suitable for shelter belt, boundary planting, wind break, diversification in aquatic crops and assessment of ecosystem services rendered by waterlogged ecologies etc. Around 65 delegates from various ICAR institutes eastern states, Department of Agriculture, Cooperation & Farmers Welfare, GOI, World Agroforestry Research Centre, SAUs, and CIMMYT participated in the event.

Second Green Revolution Meet

The Second Green Revolution Meet was organized by the institute at Patna on 3rd May 2016. Shri Vijoy Prakash, IAS, APC, Govt. of Bihar graced the occasion as Chief Guest and Dr R.C. Srivastava, Vice Chancellor, RAU, Pusa and Dr. A.K. Singh, Vice Chancellor, BAU, Sabour were the Guests of Honour. The Chief Guest, in his remarks emphasized on tackling management issues for enhancing agriculture production in eastern India. He solicited the need for exploiting natural resources, introducing new technologies, proper management and imparting creativity and innovation. He strongly emphasized that the research should not only focus on cereals and other food crops, but it should also expand its base in animal and fish productivity. He stressed on the need for diversification during the second green revolution with more attention on newer foods, millets, small ruminants etc. Dr B.P. Bhatt, Director, ICAR RCER emphasized on the need for bringing about synergy among the different implementing agencies involved in agriculture development in eastern India. The meeting was attended by the Directors and scientists of the ICAR institutes, SAUs, CGIAR institutes and State Government Officials of the Eastern States.

Fig. 21.1. Brainstrorming session at ICAR RCER, Patna

Fig. 21.2. Interaction during Second Green Revolution meet

Krishi Bagwani Exhibition-cum-Kisan Gosthi

Krishi Bagwani Exhibition-cum-Kisan Goshthi was organized jointly by ICAR Research Complex for Eastern Region, Patna, Hindustan, Kishan Unnati Manch and National Horticulture Board, New Delhi at ICAR-RCER, Patna during 28-29 May, 2016. Shri Radha Mohan Singh, Union Minister of Agriculture and Farmers Welfare inaugurated the event. In his address, he urged the farmers to diversify the existing farming practices with due importance to livestock, fisheries and allied activities of agriculture. Hon'ble Minister advised the women farmers to make self-help groups to diversify production systems. He also appreciated the efforts of Hindustan Group for organizing the programmes, especially in the field of micro-irrigation, floriculture, mushroom cultivation, duckery, etc. for farmers' benefit. Fifteen ICAR institutes, SAUs and NGOs depicted their exhibits/ technologies in exhibition stalls and more than 300 farmers participated in the programme.

Fig. 21.3. Address by Hon'ble Union Minister of Agriculture and Farmers' Welfare

Interface Meeting on Contingency Planning for Bihar-*Kharif* 2016

An interface meeting on Contingency planning for Bihar-*Kharif* 2016 was organized jointly by Central Research Institute for Dryland Agriculture (ICAR-CRIDA), Hyderabad and ICAR-Research Complex for Eastern Region, Patna at Patna on 30th May, 2016. The meeting was attended by the Scientists of ICAR institutes, KVKs, SAUs and CGIAR institutes of Bihar. Dr. Ch. Srinivasa Rao, Director, CRIDA, Hyderabad said that the district based contingency plans have been prepared for 614 districts in the country including 38 districts of Bihar and emphasized that the implementation of the intervention for the contingency planning should be situation specific. Dr. Rao also emphasized

Fig. 21.4. Interface meeting on contigency planning

that there is a need to create awareness among the farmers and line departments about preparedness to overcome drought or drought like situations.

State Coordination Committee Meeting of 2nd Green Revolution of Jharkhand

A state coordination committee meeting of Second Green Revolution was organized at Nepal House, Ranchi on 7th June, 2016 under the Chairmanship of Dr. Nitin Madan Kulkarni, Secretary, Department of Agriculture, Animal Husbandry and Sugarcane Development, Govt. of Jharkhand. Scientists from ICAR institutes, SAUs and Officials from State Government attended the meeting. Issues related to research, policy and development of the state were discussed thoroughly.

Fig. 21.5. State Coordinatin Committee meeting of Jharkhand

Review Meeting on Basic Slag Project

A meeting on basic slag project was held on 8th June, 2016 at ICAR RCER, Research Centre, Ranchi to review the progress and future course of action of the research project on "Participatory evaluation of basic slag" being undertaken by the institute. The meeting was Chaired by Sri Jatashankar Choudhary, Director, Agriculture, Govt. of

Fig. 21.6. Review meeting on basic slag project at Ranchi

Jharkhand and attended by Director and scientists of ICAR RCER, Dr. J.K. Saha, Head, Environmental Science, IISS, Bhopal, Dr. Arvind Kumar, Assistant Professor, BAU, Ranchi and Mr. Sandeep Kumar, representative from Tata Steel.

Visit of Union Minister of Micro, Small and Medium Enterprises

Hon'ble Union Minister of State of Micro, Small and Medium Enterprises Shri Giriraj Singh visited ICAR Research Complex for Eastern Region, Patna on 14th June, 2016. He visited the experimental farms and interacted with the scientists. Hon'ble Minister urged the scientists to work for the farmers and to disseminate the developed technologies to the farmers' fields. He also advised to cultivate drumstick (*Moringa oleifera*) and use it as fodder for cattle, goat and poultry to reduce the feed cost. Scientists of the institute, entrepreneurs and representatives from NABARD, Coconut Development Board, Punjab National Bank, State Fishery Department and 50 progressive farmers of Bihar participated in the interaction session.

Fig. 21.7. Interaction with Union Minister of State of Micro, Small and Medium Enterprises Shri Giriraj Singh

International Yoga Day

The institute organized YOGA day on 21st June, 2016 at ICAR RCER, Patna. Shri R. S. Gandhi and his team from Art of Living, Patna was the mentor

Fig. 21.8. Yoga Day celebration in the institute

of the programme. Director, Scientists, Technical staff of the institute and Central Industrial Security Force (CISF), Patna Airport also participated in the programme.

Research Advisory Committee Meeting

XIVth Research Advisory Committee Meeting of the Institute was held during 22-23th June, 2016 at ICAR RCER, Patna under the Chairmanship of Dr. A. N. Mukhopadhyay, Ex-Vice Chancellor, AAU, Jorhat and members Dr. Ashwani Kumar, Ex-Director of Indian Institute of Water Management, Bhubaneswar, Prof (Dr.) Dipak De, Professor and Head, Dept. of Extension Education, Institute of Agri. Sci., BHU, Varanasi, Dr. Gopal Nath Tiwari, Professor, Centre of Energy Studies, I.I.T, New Delhi 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. 21.9. Chairman of RAC interacting with scientists

Steering Committee Meeting of 2nd Green Revolution

A Steering Committee Meeting of Second Green Revolution was held at ICAR Research Complex for Eastern Region, Patna on 27th June, 2016. Shri Radha Mohan Singh, Hon'ble Minister of Agriculture & Farmers Welfare, Govt. of India inaugurated the programme as the Chief Guest. Dr. J.S. Sandhu, DDG, Crop Science, ICAR chaired the session. At the outset the Chief Guest inaugurated the Second Green Revolution Cell at the institute. In his inaugural address, he stated that the coordination and convergence between different agricultural activities, being implemented in different Eastern states will expedite the overall agricultural development in the region. The Chief Guest urged the scientists to initiate the work on the impact of climate change and to develop and popularize climate smart technologies since it could badly affect the food production system in Eastern Gangetic Plains. There is also need to rehabilitate the waterlogged areas through integrated farming system approach, he added. Chief Guest further suggested that the co-ordination committees shall also be constituted at district level so as to have the better linkages and coordination for implementation of various programme of government of India.

Other dignitaries present were Vice Chancellors of OUAT, Bhubaneswar, RAU, Pusa and BCKV, Kalyani, West Bengal, Directors of various ICAR institutes of eastern region, Governing Body member of ICAR, CGIAR, CYMMIT and IRRI representatives, Bayers Crop Science member, Principal Secretary, Govt. of Bihar, State Govt. Officials, Scientists and Farmer representative of Eastern region.

Fig. 21.10. Hon'ble Union Minister of Agriculture and Farmers' Welfare addressing the scientists

Academia-Industry Interaction Meet for Eastern Region

An Academia-Industry Interaction Meet for Eastern Region was organized at ICAR Research Complex for Eastern Region, Patna on 28th June, 2016 in collaboration with CIAE, Bhopal. The meet was inaugurated by Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture & Farmers' Welfare. Hon'ble Minister in his inaugural address appealed to researchers, extension workers and industry to accelerate efforts for development and application of cost effective farm tools and implements in Eastern States. He emphasized on application of solar energy technology in irrigation and household. Hon'ble Minister also inaugurated Farm Machinery Resource Centre (FMRC) at ICAR RCER, Patna. Shri Vijoy Prakash, APC, Govt. of Bihar in his remarks appealed to the manufactures to provide satisfactory after sales service of agricultural machinery in rural areas. Other dignitaries present were Dr. K.K. Singh, Director, CIAE, Bhopal, Dr. V.N. Kale, Addl. Commissioner, DOAC, New Delhi, Dr. B.P. Bhatt, Director, ICAR RCER, Patna and around 90 participants from Bihar, Jharkhand, Odisha, West Bengal and Manufactures from M/S Mahindra and Mahindra, M/S V.S.T. Tillers and Tractors Limited, M/S Maa Shyama Agro Industries M/S Lemken India Agro Equipment Pvt. Ltd., and National Agro Industries including scientists participated in the meet.

Fig. 21.11. Hon'ble Union Minister of Agriculture and Farmers' Welfare interacting with participants

Crop Manager - A web based app Launched

Hon'ble Union Minister of Agriculture & Farmers' Welfare, Govt. of India, Shri Radha Mohan Singh launched Crop Manager for Rice Based System (CMRS) - A web based app for better Crop and Nutrient Management for Bihar farmers on 28th June, 2016 at ICAR Research Com-

Fig. 21.12. Hon'ble Union Minister of Agriculture and Farmers' Welfare launching "Crop Manager App"

plex for Eastern Region, Patna. Hon'ble Minister congratulated the scientists of different institutes involved in the development of this app and also expressed his happiness that it is equipped to provide recommendations to both irrigated and rainfed ecosystem. He also stated that the app could be linked with Soil Health scheme for bringing access to new technologies to rural India. Guest of Honour, Shri Vijoy Prakash, APC, Govt. of Bihar, released the Crop Manager Brochure to mark the launch of CMRS for Bihar farmers and also assured to provide all help in dissemination of the app throughout the state. CMRS was adapted, evaluated, and verified in Bihar through collaboration of IRRI with the ICAR Research Complex for Eastern Region, Patna; Bihar Agricultural University, Sabour, Rajendra Agricultural University, Pusa, International donors Bill and Melinda Gates Foundation, Catholic Relief Services (CRS), and other CGIAR centers of India.

Institute Research Council Meeting

The Institute Research Council Meeting was held during 21–22th July, 2016 under the Chairmanship of the Director, ICAR RCER, Patna to review the ongoing projects, to discuss and to approve new projects to be taken up by the scientists of the institute and its centers. All the Heads of Divisions presented the achievements of various projects of their respective division and centers for the year 2015-16. There was a thorough discussion on the ongoing research projects as well as new projects with the house. Accordingly, 10 new projects were finalized.

Fig. 21.13. Institute Research Council meeting

Parthenium Awareness Week

The 11th '*Parthenium* Awareness Week' from 16-12th August, 2016 was observed at the ICAR RCER Research Centre, Ranchi during which awareness was created among the staff of the centre and among the students and staff of schools nearby the research centre. Farmers who had visited the campus were also briefed about the ill effects of *Parthenium* (carrot grass) by the scientific and technical staff of the institute. The information poster and leaflets mentioning the harmful effects of *Parthenium* on health of humans, animals and crops were also shared with the visitors and school staff. On 19th August, 2016 all the staff of the centre participated in eradication of *Parthenium* from the farm and the area surrounding the office building. On 22nd August, 2016 a team of few staff members of the research centre visited nearby school 'Immaculate Heart Of Mary Middle School' located in Plandu, Ranchi for creating *Parthenium* awareness among the students and staff of the school.

Fig. 21.14. Celebrating ***Parthenium*** awarness week

XXIII ICAR Regional Committee Meeting-IV

XXIII ICAR Regional Committee Meeting –IV was organized at ICAR Research Complex for Eastern Region, Patna during 26-27th August, 2016. The meeting was chaired by Dr. Trilochan Mohapatra, Secretary DARE & DG, ICAR, New Delhi. Other dignitaries from ICAR Headquarter including AS& FA, DARE/ICAR, DDGs, Governing body members, DG, UPCAR, Vice Chancellors, ADGs, Directors and scientists of various ICAR

Fig. 21.15. Secretary, DARE & DG, ICAR addressing to the participants during the meeting

institutes, Deans and Directors of SAUs, State Dept. Officials of Bihar, Jharkhand and UP participated in the meeting.

Dr. Trilochan Mohapatra, Secretary DARE & DG, ICAR inaugurated the meeting. He emphasized that there is a lot of potential in Jharkhand, Bihar and Uttar Pradesh for agricultural development which needs to be harnessed with concerted efforts of scientists and development departments. He also emphasized on effective planning to help two fold increase of farmer's income within 2022 in order to fulfill the vision of India. Dr. J.S. Sindhu, DDG, Crop Science and Nodal Officer of the regional committee emphasized that Bihar and Jharkhand have vast potential in growing pulses and vegetables but some constraints like fragmented land, water logging condition, soil degradation, natural calamities like flood, drought, non-availability of quality seed, green fodder and poor marketing are hindering the growth of agricultural production. Shri Vijoy Prakash, IAS, APC, Govt of Bihar, also discussed the problems of agriculture production in Bihar. He further said that research should be focused more on millets, oilseeds, pulses and on small animals like goat, rabbits, pig and rodents etc. for the improvement of livelihood of small farmers of Bihar and Jharkhand. In the technical session, the various issues regarding agriculture, horticulture, farm mechanization, livestock, fisheries and education were discussed. Six publications of IVRI, Izatnagar, ATARI Kanpur, IGFRI, Jhansi, ICAR-RCER, Patna and BAU, Ranchi were also released by the Chief Guest and other dignitaries.

Awareness Programme on Fish Health Management

An awareness programme on Fish Health Management under the project 'National Surveillance Programme on Aquatic Animal Diseases' was organised by ICAR-RCER, Patna at Sarai Ranjan, Samastipur, Bihar, on 31st August, 2016 to sensitize fish farmers about the fish diseases and its management strategies. Various topics such as prophylactic measures like healthy fish seed, use of potassium permanganate, lime, probiotics, maintaining optimum water quality parameters, feeding practices and better management practices etc. were discussed to avoid disease incidents. Farmers were also made aware of different schemes and government programme available in Bihar. Shri Sanath Kumar (DFO), Samastipur, Dr. Kamal Sarma, Pr. Scientist, Snatashree Mohanty and Ravi Kumar, Scientists, ICAR-RCER, Patna and more than 60 fish farmers participated in the programme.

Her Excellency Hon'ble Governor of Jharkhand visited ICAR RCER, Research Centre, Ranchi

Smt. Draupadi Murmu, Her Excellency Hon'ble Governor of Jharkhand visited Research Centre, Ranchi of ICAR Research Complex for Eastern Region on 9th September, 2016. During the visit in the experimental farm of the centre, a brief highlight was made regarding different promising technologies developed by the centre and also had an interaction with the scientists. Her Excellency also planted a seedling of Kalptaru (*Adansonia digitata*) in the experimental farm. The Hon'ble Governor expressed her happiness regarding the activities of the centre. She emphasized on the need for close association between resource poor farmers and the institutions. She also stressed upon the need

Fig. 21.16. Her Excellency Hon'ble Governor of Jharkhand interacting with Scientists at RC, Ranchi

for strong linkage with KVKs and other line departments like ITDA for effective transfer of the technologies in the farmers' fields.

Mid-term Review Workshop of ACIAR-ICAR Collaborative Project

A mid-term review meeting of ACIAR funded project was held from 26–29th September, 2016 at ICAR RCER, Patna to review the progress and future action to be taken for the project titled 'Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains'. The meeting was attended by the members of ACIAR, University of Queensland, Australia, CSIRO, Australia, IWMI, Nepal, BRRI, Bangladesh, Dept. of Irrigation, Nepal, International Developmental Enterprises (IDE), Nepal, Groundwater Resource Development Board, Nepal, UBKV, West Bengal, CDHI, West Bengal, SAKHI, Bihar, Director, Heads and project associated scientists of the institute.

In the four days meeting, progress, problems faced, risks, key success and challenges and activity planning for the next year of all the partners of respective regions were discussed thoroughly not only in the field of biophysical area but social issues related with the interventions.

The review meeting was followed by stakeholders meeting on 30th Sept, 2016 wherein the Director, ICAR RCER, Scientists from SAUs, State Department Officials, members from NSC, NGOs, farmers from various parts of Bihar, members of different company firms participated in the meeting. The purpose of the meeting was to create awareness about agricultural water management and it scaling up for the benefit of farming community.

Fig. 21.17. Mid-term review meeting of ACIAR project

Swachhta Pakhwada

Swachhta Pakhwara was celebrated at the institute during 16-31st May and 16 to 31st October, 2016. It started with an oath taking ceremony in which the *Swachh Bharat* pledge was administered to all the scientific, technical, administrative, supportive staff etc. Following this a cleanliness drive was held in the institute campus, where the staff of the centre cleaned the campus and surrounding areas. The compost pits were repaired and the staff were encouraged to segregate the non-degradable and biodegradable waste.

Segregation of biodegradable and non biodegradable waste both at the centre and in the farms was initiated as a part of swachhata abhiyaan. Different color garbage bins; red for non-biodegradable waste and green for biodegradable waste were put in all the laboratories and common areas including sale counter and canteen.

Fig. 21.18. Swachhta Abhiyan at the campus

At Research Centre, Ranchi, Mr. Dinesh Mishra, Senior Regional Editor of Hindustan newspaper, delivered a lecture on the 'Importance of Cleanliness' on 27th May, 2016. He encouraged all to participate in cleanliness mission wholeheartedly. A visit to Saraitoli village was carried out on 28th May, 2016 in which the villagers were encouraged to maintain cleanliness in the village and recycling of wastes.

World Soil Day

World Soil Day was celebrated at ICAR Research Complex for Eastern Region, Patna on 5th December 2016. Shri Sanjeev Chaurasia, MLA, Digha Constituency was the Chief Guest. He appreciated the efforts of ICAR RCER for its contribution towards holistic development for farmers. Dr. B.P. Bhatt, Director, ICAR RCER in his welcome speech sensitized the farmers regarding the importance

Fig. 21.19. Shri Sanjeev Chaurasia, MLA addressing to the farmers on World Soil Day

Fig. 21.20. Interface meeting on livestock and poultry

of soil testing, judicious use of chemical fertilizers and efficient use of farm resources to maximize the crop production without deteriorating the soil health. Field demonstration was carried out for the collection of soil sample along with farmers' scientist interaction sessions. Around 50 no. of farmers of Karai, Simra, Badipur, Dimra, Bikram, Dehri, Naubatpur and Mahungupur participated in this programme.

World Soil Day cum pre-*Rabi* Mela was also celebrated at its KVK, Ramgarh, in which 252 farmers including 48 women farmers from all the blocks in the Ramgarh District had participated. Shri. Amrender Kumar Gupta, Member, Regional Advisory Committee, NABARD was the Chief Guest of the function. On this occasion, a Kisan Ghosti (Farmers-Scientists Interaction Programme) and an exhibition was also organized in which the technologies developed by the ICAR-RCER Research Centre, Ranchi were displayed along with the activities of the NGOs based at Ramgarh, Support and Srijan Foundation.

Interface Meeting on "Documentation of Technologies and Development of Road map for Livestock and Poultry Sectors in Eastern Region"

An interface meeting on "Documentation of technologies and development of road map for livestock and poultry sectors in Eastern region" was convened on December 19, 2016, under the chairmanship of Dr. H. Rahman, DDG, Animal Science, ICAR, New Delhi at ICAR Research Complex for Eastern Region, Patna, for ushering livestock productivity and to bring out state specific recommendations for Eastern region. Scientists from ICAR institutes and State Agriculture Universities participated in the meeting.

The deliberation in the meeting was primarily centred on improving productivity of different species of livestock and poultry reared by farmers in the Eastern region. The challenges confronted in the Eastern region in augmenting the productivity, and the possible solutions available with ICAR and SAUs with the technologies developed by these institutions were discussed.

Training on Improved Agricultural Implements and Machinery

A three-day workshop-cum- training programme was organized at ICAR Research Complex for Eastern Region, Patna during 22 - 24th December, 2016. Shri Radha Mohan Singh, Union Minister of Agriculture and Farmers Welfare presided over the valedictory function. In his address, he informed that Farm Machinery Resource Centre was established on 28th June 2016 at Patna with

Fig. 21.21. Hon'ble Union Minister distributing the certificate to the farmers

the mandate to make available improved farm equipments to farmers besides imparting training on their manufacturing, repair and maintenance. The trained farmers can start microenterprises and provide employment in their respective locations. He also stressed that it is the responsibility of manufacturers and research and development organizations to make technologies available to the farmers. During the workshop, working knowledge on use and maintenance of different instruments and tools used in agriculture such as tractor, zero till seed drill, manual weeder, power weeder, reaper etc. was given by subject matter experts of farm machinery. A total no. of 87 farmers from Patna and East Champaran districts took part in this programme.

First meeting of Institute Management Committee of National Research Centre on Integrated Farming, Motihari

The first meeting of IMC of NRC-IF was held at ICAR-RCER, Patna on 27th Dec, 2016 under the Chairmanship of Dr. B.P. Bhatt, Director, ICAR RCER, Patna and OSD, NRC- IF. Other members present were Dr. S. Bhaskar, ADG (AAF&CC), ICAR, New Delhi, Director (Fisheries), Govt. of Bihar, Dr. A. Dey, Head, DLFM, ICAR-RCER, Patna, Dr. V.K. Mishra, Head, CSSRI RRS, Lucknow, Sh. U.K. Saxena, F&AO and Sh. Alok Kumar, AO(P), ICAR-RCER, Patna. Head of Divisions and Scientists of the ICAR-RCER, Patna also attended the meeting. A thorough discussion was held on various topics like budgets, construction work of Office-cum-Laboratory Building, boundary wall, farm area, and other important issues etc.

Fig. 21.22. IMC meeting of NRC-IF

Institute Foundation day

ICAR Research Complex for Eastern Region, Patna celebrated its 17th Foundation Day at Research Centre, Ranchi on 22nd February 2017. Her Excellency Hon'ble Governor of Jharkhand, Smt Draupadi Murmu graced the occasion as Chief Guest. During the programme, Hon'ble Governor felicitated progressive farmers from seven eastern states, press and media representatives and employees of the institute, for their outstanding work in the respective areas. On this occasion 'Foundation Day Lecture' was also delivered by Dr Parvinder Kaushal, Hon'ble Vice Chancellor, Birsa Agricultural University, Ranchi. An exhibition to demonstrate the latest technologies in agriculture was also organized on the occasion wherein different ICAR Institutes, KVK, SAU, input dealers and agri- entrepreneurs displayed their technologies. Farmers-scientists interaction was also organized during the event, in which, more than 300 farmers from all the seven eastern states (Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern Uttar Pradesh and West Bengal) participated in the event.

Fig. 21.23. Lightning of lamp on the occasion of foundation day

Annual Review-cum-Workshop on Real Time Mango Pest dynamics Surveillance

Under the NICRA project two days "Annual Review-cum-Workshop on Real Time Mango Pest Surveillance" was organized at ICAR-Research Complex for Eastern Region, Research Centre, Ranchi during 6-7 December, 2016. All the centres (ICAR-RCER, Ranchi; CISH, Lucknow; IIHR, Bengaluru; FRS, Sangareddy; AES, Paria and RFRS, Vengurla) PIs and Co-PIs of project on "Mango Pest" attended the meeting.

Workshop on Horticulture based Production System

One day workshop on Horticulture Based Production System was organised under AICRP on Fruit Crops (TSP) at Mandu on 22.3.2017. A total of 127 farmers participated in the workshop. During the workshop the farmers were trained and informed on the aspects of propagation of fruit crops, training and pruning of fruits trees, intercropping under newly established orchards, and planning and lay out of a fruit orchard.

Fig. 21.24. Workshop on horticulture based production system

Van Mahotsav

The Van Mahotsav was celebrated at ICAR RCER,RC, Ranchi during 14-16July, 2016.During this programme large scale tree plantation was carried out at Farm II of the centre in which more than 1000 trees of *Sagwan, Mahogani, Karanj,Lakshmitaru* and *Bahera* were transplanted by all the scientific, technical and administrative staff of the centre.

Fig. 21.25. Van mahotsav celebration at RC,Ranchi

Bihar State Coordination Committee Meeting for Doubling Farmers' Income by 2022 Organised

Bihar State Coordination Committee Meeting for Doubling Farmers' Income by 2022 was held at ICAR Research Complex for Eastern Region, Patna on March 23, 2017 under the chairmanship of Dr. A. K Singh, Vice- Chancellor, BAU, Sabour. The purpose of the meeting was to discuss existing productivity, income level and infrastructural facilities in Bihar so as to suggest specific technology modules along with all possible combinations of the enterprises suited to different ecological sub-regions as well as for different socio-economic backgrounds within the state which would be helpful for doubling farming incomes by 2022. During the meeting, systematic discussion related to agriculture and allied sectors *i.e.* crop, horticulture, animal husbandry, fisheries, agroforestry, value addition, food processing, marketing etc. was held and the experts presented their views/ inputs through presentations, ideas etc. in their respective areas.

Officials from State Agriculture Department, Fisheries Department, National Horticulture Board, Ministry of Food Processing Industries, Kaushlya Foundation, representative form CIMMYT, scientists from SAU, CAU and ICAR institutes of the region participated in the meeting.

Fig. 21.26. State coordination committee meeting for doubling farmers' income.

कृषि शिक्षा दिवस

भारतीय कृषि अनुसंधान परिषद पटना ने "कृषि शिक्षा दिवस" धूम-धाम से मनाया गया। इस कार्यक्रम का उद्घाटन डॉ जे एस मिश्र ने किया। इस अवसर पर बोलते हुए डॉ मिश्र ने कहा की कृषि में देश सेवा के साथ–साथ रोजगार की असीम संभावनाएं है। कृषि की पढ़ाई अपेक्षाकृत सस्ती एवं सरल भी है। इस कार्यक्रम में डॉ एस. के. सिंह, डॉ अभय कुमार ने भी अपने विचार रखे। विद्यालय से आए हुए शिक्षकों ने भी अपने विचार व्यक्त किए। कार्यक्रम का संचालन डॉ अनिल कुमार सिंह, प्रधान वैज्ञानिक ने किया। इस कार्यक्रम में विद्यालयों के छात्र व छात्राओं ने भाग लिया, इसका उद्देश्य विद्यालयों के छात्र व छात्राओं की कृषि के प्रति अभिरुचि जागृत कराना था। कृषि में छात्राओं का रुझान उत्साहवर्धक रहा। इस कार्यक्रम में कृषि संबन्धित ज्ञान वर्धक एवं रोचक जानकारी के साथ-साथ, वाद-विवाद प्रतियोगिता का सफलतापूर्वक आयोजन किया गया। वाद-विवाद प्रतियोगिता का संचालन डॉ अनिल कुमार सिंह, डॉ रीना कमल एवं डॉ तारकेश्वर ने किया। स्कूली छात्र व छात्राओं को प्रक्षेत्र भ्रमण वेदप्रकाश जी ने करवाया।

चित्र. 21.27अ. कृषि शिक्षा दिवस पर आयोजित कार्यक्रम

चित्र. 21.27ब. स्कूली छात्रों का प्रक्षेत्र भ्रमण

राजभाषा हिंदी का वार्षिक प्रतिवेदन

वर्ष 2016-17 के दौरान भा.कृ.अनु. प. का पूर्वी अनुसंधान परिसर, पटना में राजभाषा हिंदी के प्रागामी प्रयोग से सम्बंधित चारों तिमाही की तिमाही प्रतिवेदन, समय पर निदेशक एवम् सदस्य सचिव, राजभाषा कार्यान्वयन समिति, कृषि भवन, नई दिल्ली को प्रेषित की गयी।

- अर्धवार्षिक हिन्दी पत्रिका 'अक्षय खेती' के वर्ष 2016 के दोनों अंकों का प्रकाशन किया गया ।
- 14 सितम्बर से 13 अक्टूबर 2016 के दौरान "हिंदी चेतना मास-2016" का सफल आयोजन किया गया, हिंदी चेतना मास-2016 के दौरान विभिन्न वर्गों के कर्मचारियों के लिए विभिन्न प्रतियोगिताओं एवं कार्यक्रमों आयोजन किया गया जिसमें सभी वर्गों के अधिकारियों एवं कर्मचारियों ने उत्साहपूर्वक भाग लिया और आयोजन को सफल बनाया।
- "हिंदी चेतना मास-2016 के दौरान "हिन्दी की छांव तले अन्नदाताओ के सजग प्रहरी" कार्यक्रम का सफल आयोजन 23.09.2016 को हुआ जिसमें कृषि पत्रकारिता से जुड़े हुए प्रिंट एवं इलैक्ट्रोनिक मीडिया से जुड़े लोगों ने भाग लिया।
- तकनीकी एवं प्रशासनिक वर्ग के लिए तीन दिवसीय हिंदी कार्यशाला का आयोजन 19.09.2016 से 21.09.2016 के दौरान किया गया जिसमें संस्थान के कर्मचारियों ने रुचिपूर्वक भाग लिया।
- "हिंदी में वैज्ञानिक लेखन" पर के लिए तीन दिवसीय कार्यशाला का सफल आयोजन 3 से 5 अक्टूबर, 2016 के दौरान किया गया जिसमे संस्थान के सभी वर्गों के अधिकारियों एवं कर्मचारियों ने उत्साहपूर्वक भाग लिया।

चित्र. 21.28. मुख्यालय पटना (ऊपर) एवं रांची केन्द्र (नीचे) में 'हिन्दी चेतना मास' का आयोजन

22. Krishi Vigyan Kendra

Krishi Vigyan Kendra, Buxar

Cluster Demonstration on Oil Seed & Pulses

Cluster demonstrations on oilseed and pulses were organized during *kharif* and *rabi* seasons of 2016-17 under the National Food Security Mission (NFSM) and National Mission on Oilseed and Oil Palm (NMOOP) funded by the Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation, Govt. of India (Fig. 22.1 & 22.2). All demonstrations were done on the cluster approach emphasizing on rice fallow and new released varieties. Farmers were advised to adopt the good agronomic practices, balanced fertilization, and follow the IPM practices to reduce the cost of cultivation and better economic returns. The details of crop, variety, area, beneficiaries and demonstration sites are as given in Table 22.1.

Fig. 22.1. Cluster demonstration on oilseeds

Fig. 22.2. Cluster demonstration on pulses

Seed Hub Programme

In the year 2016 Ministry of Agriculture and Farmers Welfare started programme on "Creation of seed hubs for increasing indigenous production of pulses in India" under the National Food Security Mission. In this project quality seed of different pulse crops has to be produced by each seed hub and supply quality seed to the farmers. KVK, Buxar have started the seed production of chickpea under the seed hub programme (Fig. 22.3). Under participatory seed production mode chickpea seed production was started in 36 farmers fields during *rabi* season covering an area of 20.12 ha and 6.0 ha at KVK, farm. The target of seed production in *rabi* season of 2016-17 was 500 quintal of chickpea seed.

Fig. 22.3. Chickpea seed production in farmers' field in Buxar

Scientific Advisory Committee Meeting

The 7th Scientific Advisory Committee Meeting of KVK Buxar was held on 27th February, 2017 at Training Hall of KVK, Buxar under the chairman-

Table 22.1. Details of demonstrations on oilseeds and pulses

Sl. No.	Name of demonstration	Area (ha)	No. of beneficiaries	Place
1.	NA 2/BSMR-736/LRG-41 + seed treatment with fungicides, insecticides and Rhizobium + micronutrient (Mo + B)+ IPM (termite and pod borer)	50.0	129	Ahirouli, Majhariya, Kamarpur, Dalsagar, Milki, Dumri, Jaso, Ramobarria, Sarimpur, Kamhariya, Jogiya, Kritpura
2.	Biofertilizer + Integrated pest management	30.0	86	Sarenja. Simri, Sarav, Divan Ka Badka Gaon, Kukurah, Pandeypatti, Sahiyar, Baruna, Mahdah, Atrouna, Chanvath
3.	Lentil HUL 57+ seed treatment with fungicides, insecticides and Rhizobium + spray of *Trichoderma*	30.0	72	Sahiyar, Fatehpur, Hukha, Atrouna, Kukurah, Bijhora, Pandeypatti, Itahari
4.	HUDP 15 + seed treatment with Biofertilizer (Rhizobium+PSB)	20.0	84	Vishrampur, Fatehpur, Hukha, Basav khurd, Dafa Dihri, Kesath, Kusrupa, Dhanuadih, Dhansoi, Tetarhar
5.	Pusa Mustard 28 +seed treatment and sulphur application @ 20 kg/ha	30	85	Simri, Jagdishpur, Sahiyar, Rajapur, Kukurah, Bocsa, fatehpur, Gurudasmathia, Bocsara, Dahiyav, Jigna, Kesath, Sarenja, Palia, Chunni
6.	Sunflower Var. NSFH-145+ Integrated nutrient management	20	106	Vishrampur, Bharchakiya, Chunnni, Milki, Hukha, Badki Basouli, Kathar, Atrouna

ship of the Director, ICAR-Research Complex for Eastern Region, Patna (Fig. 22.4 & 22.5). The meeting was chaired by Sh. R.P. Singh, Member of Governing Body, ICAR, New Delhi. Scientists from ICAR-RCER, SAUs, CIMMYT, NABARD, State Government Officials and progressive farmers of the district were also present.

Fig. 22.4. View of 7th SAC Meeting of KVK Buxar

Fig. 22.5. KVK Farm visited by GB Member Shri R.P. Singh

Community Nursery

Farmers of Buxar district are continuously facing the aberrant weather and erratic rainfall (delay in monsoon), hence forced to transplant 50-55 days age old nursery. In NICRA project, KVK, Buxar, started demonstration of community nursery of five drought tolerant paddy variety *viz.* Sabour Adrhajal, Rajendra Sweta, Rajendra Kashturi, Sahbhagidhan and Naveen at 7 days interval in 3 steps at an area of 1000 m² (Fig. 22.6) paddy were among 20 farmers and transplanted in 6 ha area. As a result, farmers were able to transplant paddy in time.

Fig. 22.6. View of community nursery of paddy

Technology Demonstration under NICRA

Table 22.2. Natural Resource Management

Name of intervention undertaken	No. of activities under-taken	No of units	Area (ha)	No of farm-ers covered / benefitted	Remarks
Construction of new water storage tanks	02	02	6.20	05	Convergence by the MNREGA
Construction of new check dam	02	02	7.80	16	Community approach by shramdaan
In-situ moisture conserva-tion practices	42	47	360	45	Raising bund height around the rice field, Sowing of Paddy var. BPT5204 & Rajendra Sweta through DSR and Wheat var. HD2967 & HD2985 sowing through happy seeder
Vermi-compost making	05	05	1.50	05	Compost making of crop residue & cow dung
Green manuring	01	01	3.0	25	Demonstration of green gram variety IPM-2-3 to maintain soil fertility of rice- potato crop rotation.
Soil test based nutrient application	102	102	16.75	152	Soil test based recommendation through soil health card in paddy nursery to crop, Soil health card distributed based on rice- wheat crop manage-ment in paddy crop and Recommended soil test based fertilizer for lentil, mustard and wheat crop.
Crop residue management	06	06	26.50	76	Wheat through Happy seeder

Table 22.3. Crop Management

Name of intervention undertaken	Area (ha)	No of farm-ers covered / benefitted	Remarks
Drought tolerant paddy varieties	0.5	02	Paddy variety Sabaur Ardhajal transplanted at last week of July
Scented paddy variety	1.50	04	Paddy variety Rajendra Kashturi
Short duration varieties of paddy	0.06	06	Raising community nursery
	2.00	2	Paddy variety Sahbhagi transplanted at last week of July
	7.25	03	Paddy variety Rajendra Sweta transplanted at last week of July
Crop diversification	0.38	05	Production of pigeonpea
	1.00	06	Production of madua seed
Direct seeded rice	1.50	03	Paddy sowing through Zero till drill var. BPT5204 & Rajendra Sweta
Nutrient management	2.25	07	Fertilizer dose recommendation through Rice -wheat crop manager
Nutrient management	0.52	03	Application of $ZnSO_4$ in paddy crop for control for khaira disease
Mustard demonstration	2.00	13	Demonstration of mustard var. Pusa 28 sowing 1st week of Oct.-Nov. germination 65-70 %
Late sown wheat with im-proved variety	1.00	03	Late sown wheat var. HD2985
Timely sown high yield-ing wheat variety	3.00	04	Wheat var. HD2967 sowing through happy seeder
Lentil demonstration	8.00	25	Lentil var. HUL 57 sowing at last week of October to 1st week of No-vember
Chickpea demonstration	4.00	17	Chickpea var. Pusa 256 sown in 1st week of November
Pest and disease manage-ment	56	35	Attack of stem borer in paddy field
	0.15	02	Application of organic insecticides in pigeonpea control of leaf folder

Table 22.4. Livestock and fisheries

Name of intervention undertaken	Numbers under taken	No of units	Area covered (ha)	No of farmers covered / benefitted	Remarks
De-worming of animals	60	60	-	43	(25 small ruminant animals)
Animal health check-up	02	02	288 Animals treated	87	An animal health camp organised to diagnose repeat breeding, anoestrus and parasitic problems after flood. 42 animal treated (Endo parasite, Ecto parasite, milk yield problem, feed problem, act.) with how many indigenous cow
Fodder production	01	01	1.00	16	Fodder production of MP chari
Improved shelters	03	03	3.00	03	For backyard poultry production.
Fish production	03	03	0.15	03	Fish production polyculture

Table 22.5. Institutional interventions

Name of intervention undertaken	No of units	Area covered (ha)	No of farmers covered / benefitted	Remarks
Custom hiring for timely operations	03	5.5	03	Sowing of paddy through zero till drill seeder (19.06.2016). Application of insecticide against of stem borer.
Community nursery	03	0.15	22	Raising community nursery paddy var. Sahbhagi, Rajendra Sweta, Sabour Ardhjal
Seed bank	04	2.0	04	Production of chickpea seed, BGM547, wheat HD2967
Community irrigation (in *kharif* crop)	02	55	65	Constructed 2 check dam by NICRA project in 2015-16 which helped the farmer to irrigate (1st, 2nd & 3rd irrigation) paddy from the stored water.
Custom hiring for timely operations	06	2.5	06	Wheat sowing through happy seeder.

Table 22.6. Capacity building

Thematic area	No. of courses	No. of beneficiaries		
		Males	Females	Total
Natural resource management	02	50	-	50
Resource conservation technologies	02	62	-	62
Importance of deep summer ploughing	02	29	-	29
Pest and disease management in onion	01	23	-	23

Diagnostic Visit of Animal Health Camp

KVK, Buxar organized animal health camp on 24-25th September, 2016 in NICRA project adopted village "Kukurah"(Fig. 22.7). Some parts of Kukurah village was severely affected by the flood of river Ganga. After receding of flood livestock was infested by endo and ecto parasite and some liver, digestive and deworming problems occured. In animal health camp skin problem, deworming and digestion problems were diagnosed in cow, buffalo and goat. The total number of 245 animals of 70 farmers were diagnosed and treated. Post survey (20 days after treatment) all treated animals were free from parasitic infection, digestive problem and found health.

Fig. 22.7. Animal health camp at Kukurah (Buxar)

Training Programmes Organized

Following trainings were conducted for rural youth and farmers

Table 22.7. Training programme for rural youth

Topic	Beneficiaries
Seed production technology of *rabi* pulses (Chickpea & Lentil)	20
Seed production of *rabi* pulses (Lentil & Chickpea)	18
Integrated farming system	20
Vermicompost production	20
Mushroom production	20

Table 22.8. Training programme for extension functionaries

Topic	Beneficiaries
Seed production of paddy	20
Resource conservation techniques rice-wheat cropping system	20

Table 22.9. Sponsored training programme for farmers and farm women

Topic	Beneficiaries
Advance technology for horticultural crop production under Mukhyamantri Bagwani Misssion Yojna	170

Table 22.10. On campus training programme for practicing farmers

Topic	Date	Beneficiaries
Seed production technology of mustard	7/02/17 to 8/02/17	20
Seed production technology of fodder crop	9/02/17 to 10/02/17	20
Seed production of *rabi* pulses	13/02/17 to 14/02/17	20
Seed production of wheat	23/02/17 to 24/02/17	20

Table 22.11. Off- campus training programme for practicing farmers

Topic	Date	Beneficiaries
Nursery management of paddy	25/07/16 to 26/07/16	20
Crop residue management through rotavator mould board plough & harrow for sustainable soil health	28/7/16 & 29/7/16	40
Integrated crop management for sustainable rice production	29/7/16 to 30/7/16	20
Nature of damage and control measures of storage insects and pests	01/08/16 to 02/08/16	20
Method and importance of DSP	01/08/16 & 02/08/16	21
Soil borne diseases, their symptoms and management through summer ploughing	04-05/08/16	20
Methods of bunding and its importance	05/08/15 & 06/08/16	23
Insect & disease of summer vegetable and their management.	06-07/08/16	27
High technical management of fruits & vegetable crops	07-08/08/16	20
Integrated crop production technology for pigeonpea	08/08/16 to 09/08/16	20
Application methods and precaution during uses of chemical	08-09/08/16	24
Methods of rain water harvesting and their role in live saving irrigation	09/08/16 & 10/08/16	20
Improved management techniques for rice nursery production	10-11/08/16	20
Scientific cultivation & its management of guava.	10-11/08/16	20
Methods of soil & water sampling	12/08/16 & 13/08/16	25
Insects and diseases of rice nursery and control measures.	12-13/08/16	22
Production technology of direct seeded rice	23/08/16 to 24/08/16	21
Application of bio fertilizer in cereal & pulses crop	23/08/16 & 24/08/16	20
Crop production techniques for pearl millets and sorghum	29/08/16 to 30/08/16	20
Integrated nutrient management in rice	29/08/16 & 29/08/16	22
Seed production technology of maize	29/08/16 to 30/08/16	20
Scientific cultivation of cucumber & capsicum	29-30/08/16	20
Organic farming and crop production	31/08/16 to 1/09/16	22
Scientific cultivation of ginger & turmeric	31/08/16 & 01/09/16	20
Nutrient management through LCC in wheat crop	31/08/16 & 01/09/16	21

Topic	Date	Beneficiaries
Integrated faring system	02/09/16 to 03/09/16	20
Integrated nutrient management in potato	03/09/16 & 05/09/16	22
Seed production of okra	8/09/16 to 9/09/16	20
Application of sulphur in oil seed and pulses	08/09/16 & 09/09/16	34
Nursery production of tomato & brinjal through scientific cultivation	27-28/09/16	20
Seed production of pigeonpea	26//09/16 and 29/09/16	20
Integrated nutrient management in cauliflower	28/10/16 29/10/16	21
Integrated nutrient management in wheat	02/11/16 03/11/16	20
Integrated crop management for rapeseed and mustard production	4/11/16 to 05/11/16	20
Productive management of *kharif* onion	10-11/11/16	20
Integrated crop management for *rabi* pulse production	16/11/16 to 17/11/16	20
Scientific cultivation and management of banana	15-16/11/16	20
Integrated crop management for wheat production	21/11/16 to 22/11/16	20
Resource conservation technology in rice-wheat cropping system	23/11/16 to 24/11/16	20
Production technology of berseem and oat	5/12/16 to 05/12/16	21
Weed management in wheat	7/12/16 to 08/12/16	23
Weed management in *rabi* season pulses crop	15/12/16 to 16/12/16	20
Water management in wheat	28/12/16 to 29/12/16	20
Production technique of drought tolerant variety of wheat	28/12/16 to 29/12/16	20
Foliar application of urea & micronutrient in pulses	28/12/16 29/12/16	21
Foliar application of micronutrient in fruit plant	30/12/16 30/12/16	23
Quality seed production techniques of potato	30/12/16 to 31/12/16	20
Seed production of tomato	3/01/17 to 4/01/17	20
Water management in *rabi* pulses	03/01/17 & 04/01/17	20
Seed production of chickpea	27/01/17 to 28/01/17	20
Seed production technology of lentil	30/01/17 to 31/01/17	20
Method of foliar application of micronutrient in cereal, pulses and fruit plant crop	30/01/17 31/01/17	21
Nutrient management through LCC in wheat crop	02/02/17 03/02/17	23
Seed production technology of potato	3/02/17 to 4/02/17	20
Crop diversification through high value crop production	14/02/17 to 15/02/17	20
Integrated nutrient management in onion	27/01/17 28/02/17	23
Water management in sunflower	06/03/17 to 07/03/17	20
Quantity seed production of garden pea	20/03/17 to 21/03/17	20
Method and importance of DSP	20/03/17 21/03/17	20
Seed production of tomato	22/03/17 to 23/03/17	20
Methods of bunding and its importance	24/03/17 to 27/03/17	22
Seed production of onion	24/03/17 and 29/03/17	20

Table 12. Front Line Demonstrations

Topic	Area (ha)	Beneficiaries	Place
Demonstration of improved varieties of rice var. Rajendra Kusturi and Rajendra Sweta	20.0	55	Pavni, Bocsa, Mahdah, Sondhila, Rajapur, Jagdishpur, Rahtua, Karahasi, Nihalpur
Demonstration *kharif* onion var. Agrifound Dark Red	1.0	9	Dalsagar, Naya Bhojpur, Purana Bhojpur, Govindpur
Demonstration of pearl millet (JKBH 676)	10.0	25	Simri, Chotka Rajpur, Pavni, Surodha
Demonstration of zero tillage sowing wheat (var. HD 2967)	10.0	25	Kukurah, Pavni, Sonpa, Kathrai, Basoli, Dhansoi, Kanoli, Chousa, Jogiya, Bhatwalia

Topic	Area (ha)	Beneficiaries	Place
Demonstration of summer moongbean (var. IPM 2-3)	10.0	25	Kathrai, Kukurah, Kuchriya, Fatehpur, Atrouna, Jagdishpur, Maniya, Mahdah, Barri
Demonstration of spring season okra (var. Arka Anamika/ DND 777)	3.0	29	Lalganj, Gopalpur, Majhvari, Kukurah, Bharchakiya, Rampur, Kesath
Demonstration of vegetable cowpea (var. Kashi Kanchan)	3.0	45	Kesath, Mathia, Lalganj, Pavni, Bocsa
Demonstration of oyster mushroom			Kamarpur, Kukurah, Kusrupa, Dullahpur, Kathar khurd
Demonstration of BGA in rice field	4	10	Mahdah, Kukurah, Jagdishpur
Demonstration of Pro-tray	1000 piece	28	Simri, Dalsagar, Naya Bhojpur, Purana, Bhojpur
Demonstration of rice straw decomposer	300 ml	3	Mahdah, Kukurah

Table 13. On-farm Trials

Topic	Area (ha)	Beneficiaries	Place
Effect of chemical weed management on growth and yield of direct seeded rice	1.0	10	Mahdah, Bocsa, Jagdishpur
Effect of chemical weed management on growth and yield of zero till sown lentil	1.0	10	Mahdah, Sahiyar, Fatehpur
Assessment of the suitable wheat cultivars in late sown condition in district Buxar.	0.6	8	Pavni, Chunni, Sondhila
To assess the yield performance of garden pea variety.	0.6	8	Dalsagar, Pavni, Sondhila
Effect of zinc on growth and yield of rice in rice–wheat cropping system.	1.0	10	Kukurah, Mahdah, Jagdishpur
Effect of nutrient management practice on yield and yield attributing character of lentil.	1.0	10	Bocsa, Fatehpur, Darahpur

Table 14. Station Trials

Topic	Area (ha)	No. of Replication	Place
Evaluation of conservation agricultural practice under rice-fallow system of Bihar	0.40	3	KVK farm
Optimising the moisture regimes for higher yield in wheat	0.40	5	KVK farm
Participatory varietal selection (PVS) trial (DSR & transplanted)	0.50	3	KVK farm
Head to head trial	0.25	3	KVK farm and 2 farmers field (Pavni and Kukurah)
Evaluation of rice genotypes for aerobic and drought conditions	0.25	3	KVK farm and 2 farmers field (Vishrampur and Dakaich)

Seed Production

Krishi Vigyan Kendra, Buxar produced certified and truthfully labeled seeds of various crop varieties as depicted in below:

Table 15. Seed Production programme

Crop	Variety	Quantity
Paddy (Certified seed)	BPT 5204	5.0
	Rajendra Kasturi	1.2
	Rajendra Sweta	1.0
	MTU 7029	3.3
Paddy (TL seed)	CR 909	0.2
	Swarn Shreya	0.2
	Sabour Ardhjal	0.2
Wheat (Certified seed)	HD 2967	1.5
Wheat (TL seed)	HD 3118	0.1
Mustard (TL seed)	Pusa Mustard 28	0.1
Chickpea (TL seed)	BGM 547	7.0

World Soil Health Day

World Soil Health Day was celebrated on 5th December 2016 at KVK Buxar (Fig. 22.8). Fifty soil health cards were distributed among the practicing farmers of the district. In this programme total number of 60 farmers and 10 officials of line department were present.

Fig. 22.8. Soil health card distribution during soil health day

Rabi Kisan Gosthi-sah-Kisan Mela

Two days *rabi* Kisan Gosthi sah Kisan Mela was organized during 25-26th March, 2017 at KVK Buxar. Hon'ble Member of Parliament, Shri Ashwani Kumar Chaubey inaugurated the programme (Fig. 22.9). Around 750 progressive farmers, Block Agriculture Officer, Agriculture Coordinator, Kisan Salahkar and other line department officers participated in the programme. One training manual entitled "Krishak Prakshikshan Pustika" was released by the Chief Guest.

Fig. 22.9. Address by Sri Ashwani Kumar, Hon'ble MP

Krishak Chaupal

Two Kissan Chaupals were organized in the district to advice the seasonal best management practices for *kharif, rabi,* & *zaid* crops and horticultural crops at village level (Fig. 22.10) SMSs of KVK, Buxar interacted with more than 100 progressive farmers on various crop management. Block Agriculture officer and MP of the district were also present in the meeting.

Fig. 22.10. Farmers scientist interaction during kisan chaupal

KVK Farm Visit by School Children

Under ambitious programme of ICAR "**ARYA**", KVK, Buxar has organized a programme for school students of intermediate levels at their farm to popularize the agricultural technologies and their impact on Indian economy where 65% population are dependent on agriculture. The school children of Cambridge Public school and DAV Public School visited the KVK Buxar (Fig. 22.11). The SMSs of KVK, Buxar interacted with the students about the rice cum duck farming, Integrated Farming System, vermi-composting and farm implements and made emphasis on Attraction of Rural Youth in Agricultural Research Services and employment in their allied sectors.

Fig. 22.11. Visit of school children at KVK, Buxar under ARYA

Krishi Vigyan Kendra, Ramgarh

Since its inception, efforts have been made for development of farm of the KVK. Water harvesting structures have been rejuvenated to ensure the water availability during non-monsoon period. The KVK has three major water harvesting bodies and four numbers of wells. The farms have been developed in to research plots through construction of farm roads and field bunds. KVK also has full fledged demonstration-cum-production units of duck and goat production. A total of 7.2 acre area in the farm has been planted with different fruits, MPTs and timber species for conducting on-farm trials on horticulture and agro-forestry. During the year 2015-16, on-farm demonstrations on off-season cultivation of sponge guard, bitter gourd, cucumber, bottle gourd and watermelon with mulching and poly tunnel cultivation technology, improved cultivation practices of rice, ragi, arhar, maize, vegetable soybean, turmeric, mustard, chickpea, linseed, wheat, fruit based multitier cropping system, high density orcharding of guava and lemon was made.

On Campus trainings

Subject	Thematic Area	No. of courses	No of farmers
Crop Production	Weed Management	1	26
	Crop Diversification & Integrated Farming	2	44
	Seed production	1	20
	Integrated Crop Management	1	20
Horticulture	Production of low volume and high value crops	1	20
	Cultivation of Vegetable	2	52
	Layout and Management of Orchards	2	40
	Cultivation of Fruit & Agro-forestry	3	67
	Spice Production and Management technology	1	20
Soil Health and Fertility Management	Soil fertility management and Water Conservation & micronutrients deficiency	3	72
Livestock Production and Management	Piggery Management	1	25
Plant Protection	Integrated Pest and Disease Management	2	69
	Bio-control of pests and diseases & Production of bio control agents and bio pesticides	2	65
	Stored pest Management	1	25
Capacity Building and Group Dynamics	Leadership development	3	76
	Mobilization of social capital	1	25
	Credit linkage & Cashless Importance	3	75
	Total		

Rural Youth (On campus/Off campus)

Thematic Area	No. of Courses	Grand Total
Mushroom Production	6	150
Vermi-culture	1	25
Soil and water conservation	1	25
Training and pruning of orchards	1	40

Off Campus trainings

Subject	Thematic Area	No. of courses	No of farmers
Crop Production	Integrated Farming	2	50
	Seed production	4	112
	Cultivation of cereal crops	2	66
Horticulture	Off-season vegetables	1	20
	Nursery raising	3	72
	Cultivation of Vegetable	7	160
Soil Health and Fertility Management	Bio-fertilizer production	2	57
	Integrated Nutrient Management and Production, use of organic inputs	2	109
	Nutrient Use Efficiency	2	50
Livestock Production and Management	Piggery Management	1	25

Subject	Thematic Area	No. of courses	No of farmers
Plant Protection	Integrated Pest Management & Integrated Disease Management	9	360
	Bio-control of pests and diseases	4	107
	Production of bio control agents and bio pesticides	4	89
Capacity Building and Group Dynamics	Income generation activities for empowerment of rural Women	3	76
	Leadership development	1	25
	Formation and Management of SHGs	3	170
	Group dynamics	3	53
	Cashless importance	1	25

Vocational Training Programmes for Rural Youth /Details of Training Programmes for Rural Youth

Crop / Enterprise	Identified Thrust Area	Training title*	Duration (days)	Total
Mushroom Production	Mushroom production	Oyster mushroom cultivation	5 days	56

Sponsored Training Programmes

Title	Thematic area	Month	Sponsoring Agency	Total
Effective execution of small lift irrigation system and water management	Water management	Feb 17	TSRDS, BOKARO	25
Vegetable cultivation	Vegetable cultivation	Feb 17	TSRDS, BOKARO	26
Advanced irrigation technology and prevention of soil erosion	Land & water management	March 17	TSRDS, BOKARO	25

Extension Functionary Training

Topic	Total	
Productivity enhancement in field crops	6	506

Cluster Demonstrations

Crop	Area (ha)	No of farmers	Village
Sesame	20.0	61	Sarla, Sondeha, Jorakaram, Chamrom, chapri
Niger	20.0	51	Talatand, Bariyatu, Chapri, Jangi, Uchring
Pigeonpea	30.0	273	Jobla, Tiliya, Sarlakala, Oradeah, jorakaram, Sondeha, Kumhardaga, Bargown, Semra, Harkapathar, pipratand, Harwae, Murudeah
Horse gram	20.0	85	Chapri, Badkachumba, Mandudeah, Bariyatu, Jobla
Chick pa	20.0	67	Sankul, Jamira, Bhuiadeah, gegda, Bargown
Linseed	20.0	44	Gegda, Pochra, Budhakhap, Bariyatu, Sarla kala, Mandu
Green gram	10.0	30	Sarla kala, Bariyatu, Sarla khurd, Hullu, Soso
Mustard	30.0	70	Jamira, Gegda, Jobla, Pochra,

Kisan Mela-cum-Awareness Programme on 'Pradhan Mantri Phasal Bima Yojana'

One day Kisan mela and awareness programme on "Pradhan Mantri Phasal Bima Yojana" was organized by Krishi Vigyan Kendra, Ramgarh at Mandu on 4th April, 2016. Sri Jayant Sinha, Hon'ble Minister of State for Finance, Govt. of India and Member of Parliament, Hazaribagh, graced the occasion as Chief Guest (Fig. 22.12). This event was organized in collaboration with ICAR-Agricultural

Fig 22.12. Awareness program on 'Pradhan Mantri Fasal Bima Yojna'

Technology Application Research Institute, Kolkata in which more than 600 farmers, representatives from NGOs from Ramgarh district of Jharkhand participated. The Minister also visited exhibitions stalls of ICAR institutes and other agencies and interacted with the scientists and development officials. A Kisan gosthi was also organized on this occasion.

World Soil Day

The Krishi Vigyan Kendra, Ramgarh organized a World Soil Day cum pre-*Rabi* Mela at its premises in Ramgarh, Jharkhand on 5th December 2016 in which 252 farmers, including 48 women farmers, from all the blocks in the Ramgarh district participated. Shri Amrender Kumar Gupta, Member, Regional Advisory Committee, NABARD was the Chief Guest of the function. On this occasion, a Kisan Ghosti (Farmers—Scientists Interaction Programme) was organised in which the scientists of institute interacted with the farmers and discussed the issues raised by the farmers. During this event, an exhibition was also organized to showcase the technologies developed by the institute, NGOs and Support and Srijan Foundation.

Extension Activities (including activities of FLD programmes)

Nature of Extension Activity	No. of activities	Farmers			Extension Officials			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Field Day	6	71	130	201	18	4	22	89	134	223
Kisan Mela cum Exhibition	3	639	473	1112	38	4	42	677	477	1154
Kisan Ghosthi	6	180	43	223	13	—	13	193	43	236
Exhibition	—	—	—	—	—	—	—	—	—	—
Film Show	—	—	—	—	—	—	—	—	—	—
-Method Demonstrations	3	15	15	30	5	—	5	20	15	35
-Farmers Seminar	3	151	—	151	15	—	15	166	—	166
Workshop	1	80	70	150	10	5	15	90	75	165
Group meetings	—	—	—	—	—	—	—	—	—	—
Lectures delivered as resource persons	26	751	285	1036	120	11	131	771	296	1167
Advisory Services	386	291	386	677	48	19	59	339	405	744
Scientific visit to farmers field	96	497	409	906	—	—	—	497	407	906
Farmers visit to KVK	567	238	386	624	78	32	110	416	368	784
Diagnostic visits	58	260	197	457	—	—	—	260	197	457
Exposure visits	1	—	45	45	—	—	—	—	45	45
Ex-trainees Sammelan	—	—	—	—	—	—	—	—	—	—
Soil health camp	1	201	47	248	3	1	04	204	48	252
Animal health camp	2	80	120	200	5	—	5	85	120	205
Agri mobile clinic	—	—	—	—	—	—	—	—	—	—
Soil test campaigns	—	—	—	—	—	—	—	—	—	—
Farm Science Club Conveners meet	—	—	—	—	—	—	—	—	—	—
Self Help Group Conveners meetings	10	—	179	179	5	—	5	—	184	184
Mahila Mandals Conveners meetings	—	—	—	—	—	—	—	—	—	—
Celebration of important days (Jai Kisan Jai Vigyan Divas)23/12/16 &24/12/16	2	13	24	37	5	—	5	18	24	42
PMFBY(04/04/16)	1	437	223	650	28	6	34	465	229	694
Swachta Pakhwara (16 May -30 May 2016)	12	148	32	180	5	—	5	153	32	185
International Yoga Day (21/6/16)	1	25	3	28	8	2	10	33	5	38
Rastrabhasha Jagrukta Diwas (4/10/16)	1	25	—	25	5	3	8	30	3	33
Samvidhan Diwas (26/11/16)	1	5	—	5	7	—	7	12	—	12
Awareness to school children on cashless transaction and cleanliness(21/01/17)	1	16	8	24	5	—	5	21	8	29
P M Krishi Sichai Yojna ((17/2/17)	1	32	18	50	9	—	9	41	18	59
International Womans Day (8/3/17)	1	—	14	14	7	—	7	7	14	21
Exposure visit of ATMA Ranchi farmers to KVK, Ramgarh	1	58	17	75	4	—	4	62	17	79
	1191	4213	3124	7327	441	87	520	4649	3164	7915

23. Awards and Recognitions

- B.P. Bhatt **M. S. Swaminathan National Award** for the biennial 2015-17 towards outstanding contribution in Hill Agricultural Research, conferred by ICAR Research Complex for NEH Region, Meghalay.
- B.P. Bhatt **Plaque of Recognition** 2016, conferred by CIMMYT & BISA towards contribution in the field of Conservation Agriculture.
- Rakesh Kumar **ICAR-Fakhruddin Ali Ahmad Award 2015** for Outstanding Research in Tribal Farming System on 16 July 2016 in New Delhi
- U.R. Sangle, Santosh Kumar and J.S. Mishra Commendation certificate for the poster presentation entitled "Antagonistic properties of *Trichoderma* spp. restricted due to *Fusarium* sp. –A unique case" in 6th international conference "Plant, Pathogens and People" during 23-27, February, 2016 at NASC Complex, New Delhi, India.
- Santosh Kumar and S. K. Dwivedi **Young Scientist Award** by Society for Upliftment of Rural Economy during National conference on "Rural livelihood security through innovative agri-entrepreneurship" during 12-13 March, 2016 at Patna.
- Sahana Basu, S. Suman, P.P. Singh, S. K. Dwivedi, Santosh Kumar, A.K.Singh and Gautam Kumar **Best paper** in poster presentation entitled "Impact of terminal heat stress on selected wheat genotypes in eastern Indo-Gangetic plain" in national conference on "Rural livelihood security through innovative agri-entrepreneurship" during 12-13 March, 2016 at Patna.
- Sunny Kumari, S. K. Dwivedi, Santosh Kumar, Ved Prakash, A. K. Singh and Gautam Kumar **Best paper** in poster presentation entitled "Effect of sowing windows on plant growth, physiological and yield of wheat genotypes in eastern Indo-Gangetic plain" in first national conference on "Rural livelihood security through innovative agri-entrepreneurship" during 12-13 March, 2016 at Patna.
- S.K. Dwivedi **Certificate of Excellence** for the best research proposal formulation and presentation during CAFT 2017, 8-28 March 2017, at IARI, New Delhi.
- S.K. Dwivedi **Certificate of Appreciation** for peer reviewer of the journal "Biodiversitas, journal of biological diversity" in year 2016.
- J.S. Mishra '**ISWS Gold Medal 2014'** from Indian Society of Weed Science in biennial conference during 1-3 March, 2017 at MPUAT, Udaipur.
- Manibhushan **Best paper** presentation award in the international conference on Agriculture, Horticulture and Plant Sciences from 25-26 June, 2016 at New Delhi organized by Academic Research Journals (IJTA), New Delhi.
- Manibhushan **Associate fellow of society award** given by Society for Upliftment of Rural Economy, Varanasi in the national conference on Rural Livelihood Security through Innovative Agri-enterpreneurship held from 12-13 March, 2016 at ICAR-CPRS, Patna.
- Reena Kumari Kamal **Certificate of Excellence** awarded by "International Journal of Livestock Research" in recognition of an outstanding contribution to quality of the Journal for the year 2016-17.
- Bhavana, P. Best paper for excellent paper presentation at "National Symposium on Recent Trends in Biopolymers" organized by Society for advancement of Natural Resins and Gums & ICAR- IINRG, Ranchi organized at ICAR-IINRG, Ranchi during February 17-18, 2017.
- Pankaj Kumar Best article award, International Journal of Agricultural Science and Research
- Ujjwal Kumar ISEE Fellow Award in recognition of outstanding contributions in the fields of Extension Education during Indian Society of Extension Education (ISEE) National Seminar on "Information and Communication Management Concerning Climate Smart Agriculture for Sustainable Development and Poverty Alleviation" held during November, 28-30, 2016 at Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior.

- Chakrabarti, A. Reviewer Excellence Award from Indian Journal of Animal Research.
- Chakrabarti, A. Reviewer Excellence Award from Indian Journal of Agricultural Research.
- Chakrabarti, A. Reviewer Excellence Award from Legume Research- An International Journal.
- Choudhary J.S. Best Paper Award in National Symposium on "Recent Trends in Polymers" organized by SANRG & ICAR-IINRG, Ranchi during February 17-18, 2017.
- Jha, B.K. Outstanding Interdisciplinary Team Research Award for Excellent Team Work conferred in the 'National conference on Innovative and Current Advances in Agriculture & Allied Sciences (ICAAAS-2016)' during December 10-11, 2016, organized by Society for Scientific Development in Agriculture and Technology, Meerut (U.P), India.
- Mali, S.S. Best Research Paper award of the 'Indian Journal of Soil Conservation' for 2016 in Conference on Farmers First for Conserving Soil and Water Resources in North Eastern Region (FFCSWR-2017) organized by IASWC, Deharadun during February 9-11, 2017.
- Shinde, R. Best paper award in National Symposium on Recent Trends in Biopolymers organized by Society for advancement of Natural Resins and Gums & ICAR IINRG, Ranchi from Feb 17-18, 2017 at IINRG, Ranchi.
- **Ganesh Shankar Vidyarthi Hindi Patrika Puraskar 2014-15** for Hindi Patrakarita "*Akshay Kheti*", conferred by Indian Council of Agricultural Research, New Delhi
- Haris, A.A.; Chhabra, V.; Bhatt, B.P. and Sikka, A.K Best Paper Award- 2016, conferred by Association of Agrometeorologists, Anand, Gujarat for the research paper entitled **"Yield and duration of potato crop in Bihar under projected climate scenario"**. Published in the Journal of Agrometeorology Vol. 17(1): 67-73.

Fig. 23.1. Dr. B.P. Bhatt receiving the award from the Hon'ble Secy. (DARE) and DG, ICAR

Fig. 23.2. Dr. Rakesh Kumar receiving the award from the Hon'ble Minister of Agriculture and Farmers' Welfare, Govt. of India

Fig. 23.3. Dr. J.S. Mishra receiving the ISWS Gold Medal

Fig. 23.4. Dr. Ujjwal Kumar receiving the ISEE Fellow Award

24. Seminars & Symposia

Participation in Conference/Seminar/ workshops/Symposia/Meetings

Bharati, R.C. and Kumar, Ujjwal Evaluation & Planning meeting of SRFSI project at Khush Alaya, Ghoom, Darjeeling, West Bengal from 17th - 21st September, 2016.

Bharati, R.C. Kisan Mela 2016 held at Dr. Rajendra Prasad Central Agricultural University Pusa from 3rd -5th December, 2016.

Bharati, R.C. Second Zonal Group Meeting of Farmers FIRST project held at ICAR Research Complex for Eastern Region, Patna in collaboration with ATARI, Kolkatta on 22nd February, 2017.

Bharati, R.C. Workshop of Nodal Officers of ICAR Research Data Repository for Knowledge Management held at A.P. Sindde Symposium Hall, NASC Complex, New Delhi from 24-25th January, 2017.

Bhavana, P. Seminar on "Rajya me bhoogarb jal ki sthithi evam jalchazzan" at IINRG, Ranchi on 1st February, 2017.

Bhavana, P.; Sarkar, P.K.; Singh, A.K.; Dhakar, M.K.; Gutam, S.; Kumar, P.R. Workshop on "Intellectual property rights in agricultural biotechnology" at IINRG, Ranchi on 24th September, 2016.

Bhavana, P.; Shinde, R.; Choudhary, J.S.; Singh, A.K. National Symposium on "Recent trends in Biopolymers" organized by SANRAG & IINRG, Ranchi at IINRG, Ranchi on 17-18th February, 2017.

Chakrabarti, A. 3rd International water convention at India Habitat Centre, New Delhi during 20-22nd April, 2016.

Chakrabarti, A. 4th Joint International Conference on Environmental Science and Climate change at Karunya University, Coimbatore during 7-9th December, 2016.

Chakrabarti, A. International Seminar and 48th Regional Science conference on "Rural habitat, Institutions and development: Changing Nature and Challenges" at Tripura University, Agartala, Tripura during 5-7th January, 2017.

Chakrabarti, A. International Seminar and Youth Convention on "Digitalization and Rural Development in North East India: Issues, Challenges and way forward" at Assam University, Silchar during 13-15th February, 2017.

Chandra, N.; Kumar, Abhay and Kumar, Ujjwal. Bihar State Coordination Committee Meeting for Doubling Farmers' Income by 2022 organized at ICAR Research Complex for Eastern Region, Patna on 23rd March, 2017.

Chandran, P.C. Review meeting & workshop on "Network Project on Animal Genetic Resources – Characterization of Purnea Cattle" at BAIF, Pune on 6th May, 2016.

Chandran, P.C. Review meeting & workshop on "Network Project on Buffalo Improvement" at GADVASU, Ludhiana on 4th July, 2016.

Das, B. and Choudhary, J.S. Consolidated "Review Meeting of the NICRA project" held at NASC, New Delhi during 9-10th December, 2016.

Das, B. and Sarkar, P.K. Brainstorming session on "Agro-forestry for rehabilitation of water congested ecologies in the eastern states" Organized at ICAR Research Complex for Eastern Region, Patna on 5th April, 2016.

Das, B. National Workshop on "Sustainable Mango Production: Challenges under Changing Climate in Tropics and Subtropics-cum-Mango Diversity Show" at ICAR-CISH, Regional Research Centre, Malda, West Bengal during 18-19th June, 2016.

Das, B. State Level Seminar on "Plant Architecture and Flower Regulation in Mango" organized at ICAR-IIHR, Central Horticultural Experiment Station, Bhubaneswar, Odisha on 18th March, 2017.

Das, B. Vth International Symposium on "Lychee, longan and other Sapindaceae fruits" at BAU, Sabour, Bihar during 31st May to 3rd June, 2016.

Das, B.; Gutam, S.; Maurya, S.; Mali, S.S. and Choudhary, J.S. Annual Review-cum-Workshop on "Real time mango pest surveillance" under NICRA project organized at ICAR-Research Complex for Eastern Region, Ranchi during 6-7th December, 2016.

Dhakar, M.K. IV Group Workers "Meeting of AICRP on Fruits", held at ICAR-IIHR, Bengaluru during 4-7th January, 2017.

Dhakar, M.K. National seminar on "Enhancing Productivity of Fruit Crops – Mitigating major Challenges" held at ICAR-IIHR, Bengaluru on 8th January, 2017.

Dwivedi, S.K. Participated in the CAFT 2017 training at Division of Biochemistry, IARI, New Delhi during 8-28th March 2017.

Kumar, Abhay and Kumar, Ujjwal. First Steering Committee Meeting of Second Green Revolution organized at Patna on 27th June, 2016.

Kumar, Abhay and Kumar, Ujjwal. Brainstorming session on "Agroforestry for Rehabilitation of Water-Congested Ecologies for the Eastern Region" jointly organized by National Academy of Agricultural Sciences, New Delhi and ICAR- Research Complex for Eastern Region, Patna at ICAR- RCER, Patna on 5th April, 2016.

Kumar, P.R. National Seed Seminar organized at ICAR-IARI, New Delhi during 28-30th January, 2017.

Kumar, Sanjeev and Rao, K.K. Workshop on "Potential application of quantitative analysis tools in farming systems using farm Design" organized by IIFSR, Modipuram during 17-18th March, 2017

Kumar, Sanjeev, National Seminar on "Promotion and popuralisation of rural Bio-Technological Intervention for development of socio- economic in Agriculture" organized by Gramin Vikas Kendra, Biharsharif, Nalanda during 14-15 February, 2017

Kumar, Sanjeev IV Biennial Workshop of AICRP-IFS at SKUAT, Jammu during 20-23 December, 2016.

Kumar, Santosh Annual Review and planning workshop, Stress-Tolerant Rice for Africa and South Asia (STRASA Phase 3) held at Bhubaneswar, Odisha during 25-27 April, 2016.

Kumar, Santosh 51st Annual Rice Research Group meeting, held at IGKV, Raipur, Chhattisgarh during 2-5th April, 2016.

Kumar, Ujjwal. ISEE National Seminar on "Information and Communication Management Concerning Climate Smart Agriculture for Sustainable Development and Poverty Alleviation"at RVS Krishi Viswavidyalaya, Gwalior on 28-30th November, 2016.

Kumar, Ujjwal. Mid Term Review Meeting of SRFSI project at Alipurduwar, West Bengal on 7-8th February, 2017.

Kumar, Ujjwal. Review Meeting on "Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains" at ICAR-RCER, Patna during 26-29th September, 2016.

Mali, S.S. Follow up meeting of "IWMI-ICAR Steering Committee to finalize the draft project proposals on drought and flood" held during 1-2nd August, 2016 at IWMI, New Delhi.

Mali, S.S. Index Based Flood Insurance Workshop: Testing Business Model in Agricultural Risk Management. IWMI, New Delhi (India) on 8th March, 2017.

Mali, S.S. Nagar stariyahindi sangosthi on "Rajya me Bhugarbha Jal ki Stithi Evam Jalchhajan" organised at ICAR-IINRG, Namkum, Ranchi on 1st March, 2017.

Manibhushan. Consultation meeting on "Identification of wetland for notifying under wetland (Conservation and Management) Rules, 2010 of Environment (P) Act 1986" organized by BSWDA at hotel Chanakya, Patna on 29th April 29, 2016.

Manibhushan. International conference on "Agriculture, Horticulture and Plant Sciences" at Hans hotel, Barakhamba Road, New Delhi from 25-26th June, 2016.

Manibhushan. Training cum workshop on "Potential application of quantitative analysis tools in farming system using Farm Design" at IIFSR, Modipuram, Meerut from 17-18th March, 2017.

Maurya, S. XVIII Annual Workshop of "AICRP-Mushroom" held at ICAR-DMR, Solan during 9-10th June, 2016.

Mishra J.S. Workshop on strategizing pulse production in rice-fallow areas in Eastern India held at Bhubaneshwar on 7th October, 2016.

Mishra, J.S. and Kumar, Santosh "Review Meeting for Foreign Aided Projects under NRM Division, ICAR, held at Pusa, New Delhi on 9th August, 2016, and 18th January 2017.

Mishra, J.S. Biennial Conference of the Indian Society of Weed Science on "Doubling Farmers' Income by 2022: The Role of Weed Science", MPUA&T, Udaipur, India during 1-3rd March, 2017.

Mishra, J.S. Mid-term review meeting of CRP on CA and presented the research achievements of the project at ICAR NRM Division New Delhi on 25th October, 2016.

Mishra, J.S.; Singh, S.K.; Kumar, Sanjeev; Singh, A.K.; Kumar, Rakesh and Bhatt, B.P. 4th International Agronomy Congress on "Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to Achieve Zero Hunger Challenge" held at New Delhi during 22–26th November, 2016.

Naik, S.K. Meeting on "Technical advice and suggestion on use of chelated acidic soil conditioner for management of acid soils of Jharkhand" organized by Deptt. of Agriculture, Govt. of Jharkhand on 21st September, 2016.

Naik, S.K.; Jha, B.K. and Singh, A.K. Platinum Jubilee of HSI An International Meet, 7th Indian Horticulture Congress-2016, 15-18th November, 2016.

Sarkar, B. 11th Asia Pacific Conference on "Sustainable Energy & Environmental Technologies" at Patna during 6-10th March, 2017.

Sarkar, B. Annual review-cum-planning meet on "Systematic Approach to Research and Adoption of SRI (SARAS)", at Hotel Suryansh, Bhubaneswar from 16-17th July, 2016.

Sarkar, B. Brainstorming Workshop on "Precision Agriculture in Nutrient management- Present status and Future need in Eastern India", jointly organized by ICAR RCER,Patna, IPNI, CIMMYT and CCAFS at ICAR RCER Patna on 19th November, 2016.

Sarkar, B. Regional Workshop: Flood Index Insurance for Agricultural Development in South Asia, organized by IWMI held at Hotel Jaypee Siddharth, New Delhi, on 9th December, 2016.

Sarkar, B. Review meet on "Systematic Approach to Research and Adoption of SRI (SARAS)", at Hotel Suryansh, Bhubaneswar during 22-23th January, 2017.

Sarma, K. Annual review meeting under the project NSPAAD, at NBFGR, Lucknow from 27-29th May, 2016.

Sarma, K. Consultation Meeting on "Wetlands Identification and Assessment for Notification under Wetlands (Conservation and Management) Rules, 2010" organized by BSWDA at Hotel Chanakya, Patna on 29th April, 2016.

Sarma, K. Workshop on "Wise-use of Wetlands in Policy and Practice: Visualizing an Ecosystem Services-based Approach towards Achieving Sustainable Development Goals" at Kolkata organized by IWMI New Delhi on 8th December, 2016.

Shinde, R. and Singh, A.K. ICAR-DAC Interface meeting on contingency planning (Enhancing the preparedness of Agricultural contingencies for Jharkhand: Kharif 2016) at Krishi Bhavan, Ranchi on 24th May, 2016.

Singh, A.K. Steering committee meeting on Second Green Revolution at Nepal House, Ranchi under the Chairmanship of Secretary, Dept. of Agriculture, Animal Husbandry & Sugarcane Development, Govt. of Jharkhand on 7th June, 2016.

Singh, A.K. 11th Scientific Advisory Committee meeting of KVK, Gumla Vikash Bharti Bishunpur held on 21st March, 2017.

Singh, A.K. 42nd Meeting of RAC, Central Tasar Research and Training Institute, Piska Nagri, Ranchi during 27-28th January, 2017.

Singh, A.K. Awareness programme for implementation of NHB schemes at Divyayan KVK, Morabadi Ranchi on 7th March, 2017.

Singh, A.K. First Steering Committee Meeting of "Second Green Revolution" held at ICAR Research Complex for Eastern Region, Patna on 27th June, 2016.

Singh, A.K. Preliminary meeting of "Second Green Revolution" at ICAR Research Complex for Eastern Region, Patna on 3rd May, 2016.

Singh, A.K. Special Meeting of Stakeholders for FPOs' Promotion under GOI's PRODUCE Scheme of NABARD at NABARD Ranchi on 30th December, 2016.

Singh, A.K. Workshop on "Balanced fertilization - Key to sustainable Agriculture" organized by Fertilizer Association of India -Eastern Region at Ramakrishna Mission Vivekananda University, Morabadi, Ranchi on 10th January, 2017.

Singh, A.K. XXXIV Group Meeting of AICRP (VC) at IARI, New Delhi on 13th May, 2016.

Singh, A.K.; Das B. and Dhakar, M.K. XXIII meeting of "ICAR Regional Committee No. IV held at ICAR RCER, Patna during 26-27th August, 2016.

Singh, Mandhata. Lentil Workshop at ICRISAT, Hyderabad on 11th April 11, 2016.

Singh, Mandhata. National Workshop on CFLD and seed production at ICAR , New Delhi, during 16-17th May, , 2016.

Singh, S.K. Mid-term review meet of Systematic Approach to Research and Adoption of SRI project at CRPF Group Centre, Langjing, Imphal during 10-11th December, 2016.

Singh, S.K. Annual review cum planning meeting of Systematic Approach to Research and Adoption of SRI project at Bhubaneswar on 16-17th July, 2016.

Research Paper Presented in Conferences/ Seminars/Symposia

Bhavana, P., Singh, A. K., Prajapati, G. K. and Thamilrasi, K. (2017). Characterization of bacterial wilt resistance in brinjal using molecular tools. Paper presented in 'National Symposium on Recent Trends in Biopolymers' organized by Society for advancement of Natural Resins and Gums & ICAR IINRG, Ranchi at IINRG, Ranchi during 17-18th February, 2017.

Chakrabarti, A. (2016). Incidence of Maggot wound in crossbred pig in an organized farm. Paper presented in the International Conference on Integrating Climate, Crop, Ecology- The Emerging areas of Agriculture, Horticulture, Livestock, Fishery, Forestry, Biodiversity and policy issues, At Jawaharlal Nehru University, New Delhi on 4th June, 2016.

Chandra, N.; Singh, A.K. and Bharati, R.C. (2016). Agri-entrepreneurship: Key to Farmers' Prosperity, Paper presented in National Conference on Rural Livelihood Security through Innovative Agri-entrepreneurship, Souvenir, 12-13th March, 2016 at ICAR Central Potato Research station, Patna, Bihar, India

Choudhary, A. K., Kumar, Jitendra, Gupta, Sunanda, Sultana, Rafat and Singh, I. S. (2016). Breeding for Adaptive Traits in Pulses. Lead paper presented in the National Conference on Bringing Self Sufficiency in Pulses for Eastern India. August 05-06, 2016 at Bihar Agricultural University, sabour, Bhagalpur (Bihar), India and published in the Souvenir & Abstract Book (ISBN 978-93-85516-73-3) of the Conference, pp: 36-43.

Choudhary, J.S., Moanaro, Das, B., Singh, A.K. and Bhatt, B.P. (2017). DNA barcoding and population genetic structure of Bactrocera zonata (Diptera: Tephritidae) in India: Implications for its better management strategies. In: National Symposium on "Recent Trends in Polymers" organized by SANRG & ICAR-IINRG, Ranchi during 17-18 February, 2017.

Das, B. (2017). High density plantation vs low density plantation in mango: a comparative analysis. Presented in State Level Seminar on Plant Architecture and Flower Regulation in Mango ICAR-IIHR, Central Horticultural Experiment Station, Bhubaneswar, Odisha18th March, 2017

Das, B. (2016). Sustainable mango production in changing scenario of climate change. Presented in "National Workshop on Sustainable Mango Production: Challenges under Changing Climate in Tropics and Subtropics-cum-Mango Diversity Show" organized ICAR-CISH, Regional Research Centre, Malda, West Bengal during 18-19 June, 2016

Das, B., Nath Vishal and Dhakar M. K. (2016). An understanding into growth relationships in litchi cv. Shahi under plateau and hill region of eastern India. Paper presented in Vth International Symposium on Lychee, Longan and other Sapindaceae fruits organized by International Society of Horticultural Sciences and Bihar Agriculture University at BAU, Sabour during 31st May to 3rd June, 2016

Deokaran, Mandhata, Afroz Sultan, Bhatt, B. P., Prasad, R., Harigovind (2016). Assesment of soil health card with Mridaparishak held at IISS, Bhopal on 4-5th October, 2016

Dhakar, M.K., Choudhary, J.S., Mukherjee, D., Moanaro and Das, B. (2017) Influence of Biochemical Constituents and Fruit Traits against Fruit Fly [Bactrocera dorsalis (Hendel)] Infestation in Mango (Mangifera indica L.) Varieties. In: National Symposium on "Recent Trends in Polymers" organized by SANRAG & ICAR-IINRG, Ranchi during 17-18th February, 2017.

Jha, B.K, Mali,S.S and Naik,S.K. (2016). Effect of drip irrigation and bicolor polyethylene mulch on growth, yield, water productivity of Cabbage, Cauliflower and Broccoli. Paper presented in the 'Platinum Jubilee of HIS, An International Meet, 7th Indian Horticulture Congress-2016' organized by Horticulture Society of India at IARI, New Delhi during 15-18th November, 2016.

Kherwar, D., Usha, K., Srivastav, M., Singh, B., Sathyavathi, T and Sahoo, P (2016). Studies on genetic variability for yield and quality traits in guava (Psidium guajava L.). 7th Indian horticulture congress organised by horticulture society of India on 16-18th November, 2016. New Delhi, India.

Kumar Pankaj, Pandian S J., Kumari, R. R. and Dey, A. (2017). Ameliorative effects of feeding leaves of Murraya Koenigii on subclinical mastitis in bovine. 50th Annual Inaugural Golden Jubilee Conference of Indian Pharmacological Society, IGIMS, Patna 13-15th February 2017. pp 63.

Kumar, P. R. and Maurya, S. (2017). Seed quality enhancement of bitter gourd by priming and seed treatment with culture filtrate of Trichoderma. Paper presented in National Seed Seminar-2017 on "Food Security through Augmented Seed Supply under Climate Uncertainties" organized at ICAR-IARI, New Delhi during 28-30th January, 2017.

Kumar, P. R., Singh, C. B., Gupta, A. K. and Kumar, K. (2017). Quality status of wheat seed in eastern India and the early vegetative growth of wheat (Triticumaestivum L.) in relation to size of seed. Paper presented in National Seed Seminar on "Food Security through Augmented Seed Supply under Climate Uncertainties" organized at ICAR-IARI, New Delhi during 28-30th January, 2017.

Kumar, Ujjwal; Sarkar, Bikash and Bhatt, B. P. (2016). Improving Crop Productivity through Agricultural Vulnerability Study. Paper presented during ISEE National Seminar on "Information and Communication Management Concerning Climate Smart Agriculture for Sustainable Development and Poverty Alleviation", 28-30th, November 2016 at RVS Krishi Viswavidyalaya, Gwalior

Kumari, N., Sarkar, P. K. and Srivastava, A. (2016). Consumption pattern of weeds in Jharkhand: Providing food security to the tribals. Paper presented in UGC Sponsored National Seminar on Biodiversity, Taxonomy & Conservation, jointly organized by Department of Botany, KKM College, Pakur & P.G. Department of Botany, SKM University, Dumka during 6-7th May, 2016.

Mali, S.S. (2017). Hydrological response of microwatersheds in the Eastern plateau and hill region. Paper presented in Conference on 'Farmers First for Conserving Soil and Water Resources in North Eastern Region (FFCSWR-2017)' organized by Indian Association of Soil and Water Conservationists, Dehradun, Uttarakhand at AAU Campus, Khanapara, Guwahati, Assam, during 9-11th February, 2017.

Mali, S.S., Bhutia, T. L., Rahman, A., Kumar, A., Upadhyaya, A. and Manibhushan. (2016). Presented the progress report in the 'Mid-term review workshop' on 'Improving Water Use for Dry Season Agriculture by Marginal and Tenant Farmers in the Eastern Gangetic Plains' organized at ICAR-RCER, Patna during 26-29th September, 2016.

Mali, S.S., Jha, B.K., Naik, S.K. (2016). Effect of planting geometry and fertigation patterns on growth, yield and water use efficiency of tomato. Paper presented in 'First national conference on 'water and sustainable development' organized at Centre for Water Engineering and Management, Central University of Jharkhand, Ranchi during 8-9th January, 2016.

Mishra, J.S.; Kumar Rakesh; Kumar Ravikant; Rao K.K.; Singh, S.K.; Idris M.; Jha B.K.; Naik, S.K.; Mali, S.S. and Bhatt, B.P. (2016). Evaluation of pulses and oilseed under different crop establishment methods in rice-fallows of Eastern India. In: 4th International Agronomy Congress held at New Delhi, India during 22-26th November, 2016.

Naik, S. K. (2017). Nutrient management in vegetable crop. Paper presented in workshop on "Balanced fertilization-Key to Sustainable Agriculture" held at R. K. Mission Ashram, Morabadi, Ranchi, Jharkhand on 10th January, 2017.

Pan, R. S., Singh, A. K., Das, B., Naik, S.K. and Maurya, P. (2016). Swarna Safal: An Improved Vegetable Faba Bean Variety for Jharkhand, paper presented in 1st International Agrobiodiversity Congress held at New Delhi during 6-9th November, 2016.

Prabhakar, C.S., Hadapad, A.B., Choudhary, J.S., Kumari, M., Ray, S.N., Anil, Managanvi, Singh, R.S. and Hire, R.S. (2016). Distinct lineages and high diversity of Bactrocera caudata (Diptera: Tephritidae) Detected from India with mtCoI Gene Sequences. Paper presented in First Symposium of Tephritid Workers of Asia, Australia & Oceania (TAAO 2016), Palm Garden Hotel, Putrajaya, Malaysia, 15-18th August, 2016.

Raghav, D.K. and Singh, R.K. (2016). Assessment of weed management in direct seeded rice for increasing yield and productivity .International conference on Climate change adoption and biodiversity: Ecological sustainability and resource management for livelihood

security (ASA:ICCB-2016)on 8-10th December 2016 organized by Andman Science Association at ICAR-CIARI, Port Blair, Andaman and Nicobar Islands, India

Raghav, D.K. and Singh, R.K. (2016). Pre-harvested loss due to presence of burrow in field in rainfed area of rice agro-eco system of Chota Nagpur region of Jharkhand. International conference on Climate change adoption and biodiversity: Ecological sustainability and resource management for livelihood security (ASA:ICCB-2016)on 8-10th December 2016 organized by Andman Science Association at ICAR-CIARI, Port Blair, Andaman and Nicobar Islands, India

Raghav, D.K., Dwivedi, V and Singh, R.K. (2016). Comparative study of different pulse grain for spawn production of oysters mushroom, Pleurotus florida. International conference on Climate change adoption and biodiversity: Ecological sustainability and resource management for livelihood security(ASA:ICCB-2016)on 8-10th December 2016 organized by Andman Science Association at ICAR-CIARI, Port Blair, Andaman and Nicobar Islands, India

Raghav, D.K., Dwivwdi, V. Indrajeet, Dharmjeet and Choudhary, Jaipal; (2017). Emerging issue of disease and pest problem in vegetable growing area of paddy crop dominated rainfed agro-ecosystem of North Chota Nagpur Region (NCNR) of Jharkhand state" is accepted for oral presentation in 12th National Symposium on Biotic Stress Management Strategies: Challenges and Environmental Harmonisation'' to be held at UBKV, Cooch Behar (West Bengal) during 17-19th February, 2017.

Raghav, D.K., Singh, R.K., indrajeet and Dwivedi, V. (2016). Efficacy of new molecules on seasonal incidence of shoot and fruit borer Earias Vittella FAB on brinjal in rainfed area of North Chota Nagpur.National Conference on Harmony with Nature in context of resource conservation and climate change(HARMONY-2016) in 22-24th October 2016 organised by dept. of Zoology, Botany, Biotechnology& Geology, Vinoba Bhave University, Hazaribag in collabrotion with National Environmentalist Association. pp-179

Sarkar, P. K., Das, Bikash and Bhatt, B. P. (2016) Indian lilac (Melia azedarach L.) Based Agroforestry System: An Option for livelihood Security to Farmers of Eastern Plateau and Hill Region of India. Paper presented in "National Symposium on Agroforestry for environmental Challenges, Sustainable land use, Biodiversity conservation and rural livelihood options" held at ICAR- Central Agroforestry Research Institute, Jhansi, U.P. during 3-5th December, 2016.

Shinde, R., Maurya S. and Naik, S. K. (2017) Decomposition and Nutrient release of wheat and rice straw. Paper presented in National Symposium on Recent Trends in Biopolymers organized by Society for advancement of Natural Resins and Gums & ICAR-IINRG, Ranchi during 17-18th February, 2017.

Singh, A.K. (2016). Improving cold tolerance ability of late sown lentil through foliar application of Auxin and Zn. Published in Proceeding of 4th International Agronomy Congress on Sustainable Management of Natural Resources, Environment, Energy and livelihood security to achieve zero hunger challenge, New Delhi, pp. 27-28.

Singh, R.K and Raghav, D.K (2016). Pusa Hydrogel superabsorbent technology of efficient water utilization for present and future agriculture.National Conference on Harmony with Nature in context of resource conservation and climate change(HARMONY-2016) in 22-24 October 2016 organized by dept. of Zoology, Botany, Biotechnology& Geology, Vinoba Bhave University, Hazaribag in collaboration with National Environmentalist Association.pp-179

Singh, S.K. (2017). Integrated Approach of Bio-Fertilizer in Agriculture. In: National seminar on promotion and popularization of rural biotechnological intervention for development of socio economic in agriculture at Rajgir from 14-15th February, 2017.

25. Publications

Research Papers

Aishwath, O.P.; Singh, R.; Jha, B.K.; Ganeshamurthy, A.N. and Mehta, R.S. (2016). Liming influence on Fenugreek productivity including disease incidence and nutritional parameters of plant and soil under Typic Haplustalfs. *International Journal of Seed Spices*, **6**(2): 71-77.

Bhakta, N.; Kumar, Rahul; Mishra, J.S.; Prakash, Ved; Rao, K.K.; Yadav, Shikha; Jaiswal, K.K.; Kumar, S.S.; Sharma, B.K.; Sarma, Kamal; Sarkar, B. and Bhatt, B.P. (2017). Evaluation of rice varieties against multiple diseases under middle IGP of Bihar. *Journal of Pure and Applied Microbiology*, **11**(1): 335-342.

Bharati, R.C. (2016). Unequal Probability scheme for fruit count in a guava tree. *Journal of Agrisearch*, **3**(4): 254-256.

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.

Bhatt, B.P.; Moanaro and Sarkar, Bikash (2017). Fuelwood characteristics of some important trees and shrubs and emission of carbon dioxide in different states of Eastern India. *Energy Sources*, Part A: Recovery, Utilization, and Environmental Effects, **39**(4): 414-418. DOI: 10.1080/15567036.2016.1219792.

Bhatt, B.P.; Moanaro; Sapu, C. and Sarkar, B. (2017). Fuelwood characteristics of some firewood trees and shrubs of Eastern Himalaya India. *Energy Sources* Part-A, **39**(1): 47-50.

Bhatt, B.P.; Parmar, B.; Bordoloi, L.J. and Bhattacharyya, R. (2016). Characterization and evaluation of hedges and multipurpose trees for their leaf litter decomposition kinetics and nutrient release patterns in the Indian Himalayas. *International Journal of Bio-resource and Stress Management*, **7**(4) Special: 582-597.

Bhatt, B.P.; Parmar, B.; Bordoloi, L.J.; Benjamin and Bhattacharyya, R. (2016). Impact of agroforestry systems on soil and nutrient conservation in the eastern Himalayas, India. *International Journal of Bio-resource and Stress Management*, **7**(4) Special: 575-581.

Bhavana, P. and Singh, A.K. (2016). Biodiversity in brinjal germplasm against resistance to bacterial wilt. *Bangladesh Journal of Botany*, **45**(3): 737-739.

Bhavana, P.; Singh, A.K.; Prajapati, G.K. and Tamilarasi, K. (2016). Phenotypic and molecular characterization of bacterial wilt resistance in brinjal. *The Bioscan* (Supplement on Genetics & Plant breeding), **11**(3): 2019-2023.

Bhutia, T.L; Kamal, R.K; Mohanty, Snatashree and Kumar, Ujjwal. (2017). Constraints analysis in the crop-livestock farming systems of small and marginal farmers of Bihar. *SKUA&T Journal of Research*, **19**(1): 92-96.

Chakrabarti, A. (2016). Hermaphroditism in a crossbred pig: a case study. *International Journal of Agriculture Sciences*, **8**(36): 1744-1745.

Chakrabarti, A. (2016). Inherited posterior paralysis in crossbred pig – a case study. *International Journal of Environment, Ecology, Family and Urban Studies*, **6**(3): 1-2.

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

Chakrabarti, A.; Buragohain S.C. and Baruah, K.K. (2017). Digestion cum metabolism trial in broiler rabbit fed on sweet potato based ration. *International Journal of Applied and Natural Sciences*, **6**(2): 111-140.

Chakrabarti, A.; Buragohain, S.C. and Baruah, K.K. (2017). Carcass characteristics of broiler rabbit fed on sweet potato based ration. *International Journal of Agricultural Science and Research*, **7**(1): 347-358.

Chakrabarti, A.; Buragohain, S.C. and Baruah, K.K. (2017). Chemical composition and gross energy content of sweet potato in north eastern hill region of India. *International Journal of Agricultural Science and Research*, **7**(2): 135-142.

Chakrabarti, A.; Buragohain, S.C.; Baruah, K.K. and Sarmah, B.C. (2017). Effect of sweet potato based ration on physiological and blood profile of broiler rabbit. *International Journal of Botany and Research*, **7**(1): 1-18.

Chakrabarti, A.; Dey, A. and Gupta, J.J. (2017). Malocclusion in Newzealand White Rabbit. *International Journal of Agricultural Science and Research*, 7(1): 275-276.

Chatterjee, D.; Kumar, Rakesh; Kuotsu, R. and Deka, B.C. (2016). Validation of traditional weed control method through common salt application in the hill region of Nagaland. *Current Science,* **110**(8): 1159-1167. DOI: 10.18520/cs/v110/i8/1459-1467.

Choudhary, J.S.; Naaz, N.; Prabhakar, C.S. and Moanaro (2016). Genetic analysis of oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae) populations based on mitochondrial *cox1* and *nad1* gene sequences from India and other Asian countries. *Genetica,***144**: 611–623.

Das, B. (2016). Root distribution pattern in two age groups of litchi plants growing under Alfisols of Eastern plateau and hill region of India. *Ecology, Environment and Conservation*, **22** (June Supplement): 67-73.

Das, B. and Dhakar, M.K. (2016). Effect of interstock on growth of vigorous mango cultivars under eastern plateau and hill region of India. *Vegetos-An International Journal of Plant Research*, **29**(3): 1-5.

Das, B. and Nath, Vishal. (2016). Performance of Traditional Mango Varieties from Different Parts of the Country under of Eastern Plateau and Hill Region. *Environment and Ecology*, **4**(C): 2010-2013.

Das, Bikash; Dhakar, M.K.; Sarkar, P.K.; Kumar, S.K.; Nath, Vishal; Dey, P.; Singh, A.K. and Bhatt, B.P. (2017). Performance of mango (*Mangifera indica*) based agri-horticultural systems under rainfed plateau conditions of eastern India. *Indian Journal of Agricultural Sciences*, **87**(4): 521-527.

Dayal, S.; Kumari, R.; Dey, A. and Kumar, B. (2016). PCR-SSCP of growth hormone gene and its association with body weight in Black Bengal goat**.** *Indian Journal of Animal Sciences,* **86**(11): 1283-1286.

Devi, Sarita; Kumar, Pankaj and Sharma, M.C. (2016). Correlation of Micro Minerals in Primary Hair-Plasma of Dogs. *Journal of Animal Research,* **6**(5): 1-6.

Dhakar, M.K. and Das, B. (2017). Standardization of grafting technique in litchi. *Indian Journal of Horticulture*, **74**(1): accepted

Dhakar, M.K.; Singh, A.K.; Singh, S.K.; Patel, V.B. and Pal, M. (2017). Induction of changes by nitrification inhibitor and nitrogen source on vegetative growth, physiological processes and biochemical constituents of Kinnow mandarin. *Indian Journal of Agricultural Sciences,* **87**(4): 479-484.

Dixit, B.; Ghosh, K.K.; Fernandes, G.; Kumar, Pankaj; Gogoi, P.; Kumar, Manish. (2016). Dual Nuclease Activity of a Cas2 protein in CRISPR-Cas subtype I-B of *Leptospira interrogans. FEBS Letter,* **590**(7): 1002–1016.

Dwivedi, S.K.; Basu, Sahana; Kumar, Santosh; Kumar, Gautam; Ved, Prakash; Kumar, Sanjeev; Mishra, J.S.; Bhatt, B.P.; Malviya, N.; Singh, G.P. and Arora, A. (2017). Heat stress induced impairment of starch mobilisation regulates pollen viability and grain yield in wheat: Study in Eastern Indo-Gangetic Plains. *Field Crops Research*, **206**: 106-114.

Dwivedi, S.K.; Bhakta, N.; Kumar, Santosh and Mishra, J.S. (2017). Characterization of submerged tolerant elite rice genotypes having improved physiological traits and oxidative defence system grown under rainfed lowland ecosystem of eastern Indo-Gangetic Plains. *Agricultural Research*. DOI:10.1007/s40003-017-0258-6

Dwivedi, S.K; Arora, A. and Kumar, S. (2017). Paclobutrazol-induced alleviation of water-deficit damage in relation to photosynthetic characteristics and expression of stress markers in contrasting wheat genotypes. *Photosynthetica,* **55**(2): 351-359.

Dwivedi, S.K; Arora, A. Singh, V.P. and Singh, G.P. (2017). Induction of water deficit stress tolerance in wheat due to exogenous application of Plant Growth Regulators: membrane stability, water relation and photosynthesis. *Photosynthetica*, DOI: 10.1007/s11099-017-0695-2.

Dwivedi, S.K; Arora, A.; Singh, V.P.; Sairam, R.K. and Bhattacharya, R.C. (2016). Effect of sodium nitroprusside on differential activity of antioxidantsand expression of SAGs in relation to vase life of gladiolus cut flowers. *Scientia Horticulturae,* **210**: 158-165.

Dwivedi, S.K; Kumar, S.; Prakash, V.; Mishra, J.S.; Singh, S.S. and Kumar, S. (2017). Influence of elevated CO_2 and temperature on physiological traits and yield attributes of heat tolerant wheat genotype Halna grown inside open top chambers. *Indian Journal of Plant Physiol*ogy, **22**: 94-100. DOI. 10.1007/s40502-016-0280-x

Dwivedi, S.K; Kumar, S; Kumar, R; Ved Prakash; Rao, K.K; Samal, S.K; Yadav, S; Jaiswal, K.K; Kumar, S.S; Sharma, B.K. 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 Science,* **6**(4):195-202.

Govindarajan, Vijayakumar; Pandian, S.J.; Venkatesakumar, E.; Kathirvel, S.; Subramanian, M. and Dharmaceelan, S. (2016). Endoscopic diagnosis of megaesophagus in a buffalo. *Buffalo Bulletin*, **25**(2): 147-150

Gupta, J.J. and Dey, A. (2016). Nutritive value and economics of fodder production of different maize (*Zea mays*) varieties during winter season. *Indian Journal of Animal Nutrition*, **33**(2): 212-215.

Gupta, J.J.; Dey, A.; Bhatt, B.P. and Barari, S.K. (2016). Potential yield and nutritive value of promising forages of eastern India. *Range Management and Agroforestry,* **37**(2): 248-251.

Gupta, J.J.; Dey, A.; Dayal, S. and Barari, S.K. (2016). Performance of Heifer fed on total mixed ration. *Indian Veterinary Journal,* **93**(8): 29-31.

Jeet, S.; Singh, J.P. and Kumar, Rakesh (2017). Production potential and nutrient uptake of QPM hybrids as influenced by nitrogen and sulphur fertilization. *Journal of AgriSearch,* **4**(1): 27-30. http://dx.doi.org/10.21921/jas.v4i1.7415.

Jha, B.K and Chakraborti, A. (2017). Back yard poultry farming as a source of livelihood in Tribal village: An economic appraisal. *International Journal of Agricultural Sciences*, **7**(1): 267-274.

Kamal, R.; Dey, A.; Mondal, K.G. (2016). Impact of Environmental Stressors on the Performance of Backyard Poultry. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.*, 1-6. doi:10.1007/s40011-016-0741-z.

Kumar, Hemant; Priya, Priti; Singh, Nena; Kumar, Mukesh; Choudhary, Binod Kumar; Kumar, Lokendra; Singh, Indu Shekhar and Kumar, Nitish (2016). RAPD and ISSR marker-based comparative evaluation of genetic diversity among Indian germplasms of *Euryale ferox*: An aquatic food plant. *Applied Biochemistry and Biotechnology*, *DOI 10.1007/s12010-016-2171-z***.**

Kumar, A.; Patil, N.S. and Kumar, Rakesh (2016). Effect of irrigation schedules and fertility levels on growth, yield and economics of *Jatropha* (*Jatropha curcas* L.) under South Gujarat condition. *Environment & Ecology,* **34**(4D): 2561-2565.

Kumar, A.; Patil, N.S. and Kumar, Rakesh (2016). Production potential and quality of *Jatropha* (*Jatropha curcas* L.) as influenced by irrigation schedules and fertility levels. *Ecology, Environment and Conservation,* **22**(4): 1835-1840.

Kumar, A.; Patil, N.S. and Kumar, Rakesh (2016). Productivity, water use efficiency and nutrient content of *Jatropha (Jatropha curcas* L.) as influenced by varying irrigation scheduling and fertility levels. *International Journal of Agricultural and Statistical Sciences*, **12**(S1): 261-266.

Kumar, A.; Sen, A. and Kumar, Rakesh (2016). Micronutrient fortification in crop to enhance growth, yield and quality of aromatic rice. *Journal of Environmental Biology,* **37**(5): 973-977.

Kumar, A.; Sen, A.; Kumar, Rakesh and Upadhyay, P.K. (2016). Effect of zinc, iron and manganese levels on growth attributes and grain yield of rice. *Ecology, Environment and Conservation,* **22**(2): 729-734.

Kumar, Anjani; Singh, R.K.P. and Abhay Kumar (2016). Rural labour employment and their livelihoods in Bihar: Micro-level evidences from selected villages. *Indian Journal of Labour Economics.* DOI 10.1007/s41027-016-0034-3.

Kumar, Anjani; Singh, R.K.P.; Kumar, Abhay; Betne, Rajeev and Singh, K.M. (2016). Adoption of Modern Rice Cultivation Practices in Bihar, India: Micro-level Evidences from Village-Level Studies. *Agricultural Research.* DOI 10.1007/s40003-016-0234-6.

Kumar, B.; Prasad, S. and Kumar, Rakesh (2016). Efficacy of herbicide in weed management practices to maximize the productivity and profitability of transplanted rice. *Environment & Ecology,* **34**(4B): 2143-2147.

Kumar, L.; Singh, A.K. and Bhatt, B.P. (2016). Nutritional status of recently developed Makhana (Gorgon Nut) variety- Swarna Vaidehi. *Journal of AgriSearch*, **3**(4): 199-2015.

Kumar, M.; Kumar, Rakesh; Meena, K.L.; Rajkhowa, D.J. and Kumar, A. (2016). Productivity enhancement of rice through crop establishment techniques for livelihood improvement in Eastern Himalayas. *Oryza,* **53**(3): 300-308.

Kumar, P.; Singh, Y. and Kumar, Rakesh (2016). Productivity, profitability, nutrient uptake and soil health of boro rice as influenced by cultivars and herbicides. *International Journal of Agricultural and Statistical Sciences,* **12**(S1): 177-183.

Kumar, R.; Kumawat, N.; Kumar, S.; Kumar, R.; Kumar, M.; Sah, R.P.; Kumar, U. and Kumar, A. (2017). Direct Seeded Rice: Research strategies and opportunities for water and weed management. *Oryza,* **53**(4): 354-365.

Kumar, Rakesh (2017). Production potential, quality and nutrient uptake of linseed as influenced by fertility levels and seeding rates under the foot hill condition of Nagaland. *Bangladesh Journal of Botany,* **46**(1): 67-71.

Kumar, Rakesh and Deka, B.C. (2016). Response of fertility levels and seeding rates on production potential and moisture use efficiency of linseed under foot hill condition of Nagaland. *Indian Journal of Hill Farming,* **29**(1): 1-5.

Kumar, Rakesh; Chatterjee, D.; Deka, B.C. and Ngachan, S.V. (2017). Validation of common salt application on productivity, profitability, nutrient uptake and soil health of upland rice (*Oryza sativa* L.) under shifting cultivation area of Nagaland. *Indian Journal of Traditional Knowledge,* **16**(2): 341-349.

Kumar, Rakesh; Chatterjee, D.; Deka, B.C.; Kumar, M.; Kuotsu, R.; Ao, M. and Ngachan, S.V. (2016). Weed management practices in upland direct seeded *Jhum* rice under the Eastern Himalayas. *Research on Crops,* **17**(2): 199-204. DOI:10.5958/2348-7542.2016.00035.8.

Kumar, Rakesh; Hangsing, N.; Ao, M.; Zeliang, P.K. and Deka, B.C. (2016). Exploration, collection and conservation of local maize germplasm of Nagaland. *Indian Journal of Hill Farming,* **29**(1):87-93.

Kumar, Rakesh; Hangsing, N.; Yhokha, K. and Deka, B.C. (2016).Evaluation of mungbean lines (*Vigna radiata* L.) for enhancing cropping intensity and productivity under rainfed condition of Nagaland. *Environment & Ecology,* **34**(4C): 2319-2323.

Kumar, Rakesh; Hangsing, N.; Zeliang, P.K. and Deka, B.C. (2016). Exploration, collection and conservation of local rice germplasm of Nagaland. *Environment & Ecology*, **34**(4D): 2514-2517.

Kumar, Rakesh; Hansing, N.; Deka, B.C. and Kumar, M. (2016). Evaluation of different sesame lines (*Sesamum indicum* L.) for enhancing the cropping intensity and productivity under foot hill condition of Nagaland. *Indian Journal of Hill Farming,* **29**(1): 29-35.

Kumar, Rakesh; Kumawat, N.; Kumar, S.; Singh, A.K. and Bohra, J.S. (2017). Effect of NPKS and Zn fertilization on growth, yield and quality of baby corn-A Review. *International Journal of Current Microbiology and Applied Sciences,* **6**(3): 1392-1428. https://doi.org/10.20546/ijcmas.2017.603.161.

Kumar, Rakesh; Yhokha, K.; Hangsing, N. and Deka, B.C. (2016). Effect of sowing dates on early maturing Indian mustard varieties *(Brassica juncea* L.) for enhancing cropping intensity and productivity under foot hill condition of Nagaland. *Environment & Ecology,* **34**(4C): 2005-2009.

Kumar, Rakesh; Yhokha, K.; Rajesha, G. and Deka, B.C. (2017). Performance of jobs tears lines (*Coix lacryma-jobi*) under foot hill condition of Nagaland. *Environment & Ecology*, **35**(1B): 440-444.

Kumar, S.; Kumar, Pankaj; Kumar, D. and Kumar, Pankaj (2016). Enterolithiasis resulting in diaphragm rupture in captive *Equus burchelli* on post mortem examination. *Indian Journal of Veterinary Pathology,* **40**(3): 287-289.

Kumar, S; Dwivedi, S.K; Kumar, R; Bhakta, N; Ved Prakash; Rao, K.K; Samal, S.K; Yadav, S; Jaiswal, K.K; Kumar, S.S; Sharma, B.K. and Mishra, J.S. (2017). Evaluation of Rice Genotypes for Resistance against False Smut of Rice (*Oryza sativa* L.) under Middle IGP of Bihar. *International journal of Current Microbiology and Applied Science,* **6**(4): 537-543.

Kumar, S; Mishra, J.S; Singh, A.K; Dwivedi, S.K; Singh, S.K; Singh, S.S; Haris, A.A; Mondal, S; Bhatt, B.P; Singh, S and Yadav, A. (2016). Response of rice (*Oryza sativa* L.) genotypes to weed management in rainfed ecosystems of eastern India. *Indian Journal of Agronomy*, **61**(1): 37-44.

Kumar, Santosh; Dwivedi, S.K.; Kumar, Rahul; Bhakta, N.; Prakash, Ved; Rao, K.K.; Kumar Rakesh; Yadav, Shikha; Choubey, A.K. and Mishra, J.S. (2017). Screening of different rice germplasm against multiple disease under submergence condition in middle Indo Gangetic Plain. *International Journal of Current Microbiology and Applied Sciences*, **6**(5): 335-339.

Kumari, R.; Dayal, S.; Kumar, S.; Chandran, P.C. and Dey, A. (2017). Genetic Polymorphism of Bone morphogenetic protein receptor type-1 gene in crossbred does of Bihar. *Indian Journal of Animal Sciences,* **87**(4): 130-132.

Mali, S.S. and Singh, D.K. (2016). Groundwater modelling for assessing the recharge potential and water table behaviour under varying levels of pumping and recharge. *Indian Journal of Soil Conservation*, **44**(2): 93-102.

Mali, S.S.; Jha, B.K.; Naik, S.K.; Singh, A.K. and Kumar, A. (2016). Effect of fertigation pattern and planting geometry on growth, yield and water productivity of tomato (*Solanum lycopersicum*). *Indian Journal of Agricultural Sciences,* **86**(9): 1208–1213.

Mali, S.S.; Naik, S.K. and Bhatt, B.P. (2016). Spatial variability in soil properties of mango orchards in Eastern Plateau and Hill region of India. *Vegetos- An International Journal of Plant Research*, **29**(3): 1-6. DOI: 10.4172/2229-4473.1000141.

Manibhushan (2016). Soil analysis including the status of ground water availability for increasing crop production. *International Journal of Tropical Agriculture*, **34**(5): 1399-1401.

Maurya, S.; Kumar, R.; Kumari, A. and Choudhary, J.S. (2016). First reports of *Alternaria* leaf blight in Bael (*Aegle marmelos* L.) from Eastern Plateau and Hill Region. *Journal of AgriSearch*, **3**: 248-250.

Mausam; Ray, P.K.; Dey, A.; Mohanty, S.; Kaushik, P.; Anjay, Sinha; Manju and Gupta, S.K. (2016). Isolation, Identification and Antibiotic Sensitivity Profiling of Methicillin Resistant *Staphylococcus aureus* from Bovine Milk in Bihar. *Journal of Pure and Applied Microbiology*, **10**(4): 3183-3188.

Meena, B.L.; Singh, A.K.; Phogat, B.S. and Sharma, H.B. (2016). Improving wheat and soil productivity through integrated nutrient management (INM) and efficient planting system (EPS). *Journal of AgriSearch,* **3**(3): 147-156.

Meena, M.S.; Singh, K.M.; Singh, R.K.P.; Kumar, Anjani; Kumar, Abhay and Chahal, V.P. (2017). Inequality and determinants of income among rural households in tribal dominated areas of Jharkhand. *Indian Journal of Agricultural Sciences,* **87**(1): 92–96.

Mishra, J.S.; Kumar, Rakesh and Rao, S.S. (2016). Performance of sweet sorghum *(Sorghum bicolor*) cultivars as a source of green fodder under varying levels of nitrogen in semi-arid tropical India. *Sugar Tech.*, DOI: 10.1007/s12355-016 -0506-2.

Mishra, J.S.; Singh, V.P. and Rao, S.S. (2016). Bioefficacy and phytotoxicity of pre- and post-emergence herbicides in rainy-season grain sorghum. *Indian Journal of Weed Science,* **48**(1):70-73.

Mishra, S.S.; Mohanty, S.; Chari, M.S. and Vardia. H.K. (2017). Biodiversity assessment of Kodar reservoir of Chhattisgarh. *International Journal of Fisheries and Aquatic Studies,* **5**(2): 425-429.

Moanaro and Choudhary, J.S. (2016). Influence of weather parameters on population dynamics of thrips and mites on summer season cowpea in Eastern Plateau and Hill region of India. *Journal of Agrometeorology,* **18**(2): 296-299.

Monalisa, S.; Singh, R.; Singh, K.P.; Sharma, A.K.; Saikumar, G.; Sylvester, L. and Ray, P.K. (2016). Prevalence and pathology of cysticercosis in slaughtered pigs of Rohilkhand region. *Indian Journal of Veterinary Pathology,* **40**(1): 69-71.

Mondal, S.; Kumar, S.; Haris, A.A.; Dwivedi, S.K.; Bhatt, B.P. and Mishra, J.S. (2016). Effect of different rice establishment methods on soil physical properties in drought-prone rainfed lowlands of Bihar, India. *Soil Research,* **54**: 997-1006. DOI:dx.doi.org/ 10.1071/ SR15346.

Mukherjee, D.; Singh, P.K.; Kumari, A.; Das, B. and Choudhary, J.S. (2016). Biology, morphology and seasonal population dynamics of mango leaf cutting weevil, *Deporaus marginatus* (Pascoe) (Coleoptera: Attelabidae). *Journal of Entomological Research*, **40**(3): 285-289.

Mukherjee, J.; Kumar, S. and Mondal, S. (2016). Surface energy flux and radiation interception in mustard in eastern India. *Journal of Agricultural Physics*, **15**(1): 10-107.

Naaz, N.; Choudhary, J.S.; Prabhakar, C.S.; Moanaro and Maurya, S. (2016). Identification and evaluation of cultivable gut bacteria associated with peach fruit fly, *Bactrocera zonata* (Diptera: Tephritidae). *Phytoparasitica*, **44**:165-176. DOI 10.1007/s12600-016-0518-1.

Naik, S.K.; Mali, S.S.; Das, B.; Bhatnagar, P.R.; Kumar, S. and Sikka, A.K. (2016). Rainwater harvesting using plastic-lined Doba technology for orchard establishment in the eastern plateau and hill region of India. *Current Science*, **111**(11): 1751-1753.

Naik, S.K.; Maurya, S. and Bhatt, B.P. (2016). Soil organic carbon stocks and fractions in different orchards of eastern plateau and hill region of India. *Agroforestry Systems*. DOI 10.1007/ s10457-016-9957-4.

Pan, R.S. and Singh, A.K. (2016). Stability of green pod yield and its components in faba bean (*Vicia faba* L.). *Indian Journal of Horticulture*, **73**(3): 371-375.

Pandian, S.J., and Kumar, Pankaj (2017). Echocardiographic evaluation of left ventricular function in black Bengal goat. *International Journal of Livestock Research*, **7**(2), 28–34. DOI:10.5455/ ijlr.20170130064548

Pandit, T.K.; Naik, S.K.; Patra, P.K.; Patra, P.K.; Dey, N.; Patra, P.K. and Das, D.K. (2017). Influence of organic manure and lime on cadmium mobility in soil and uptake by spinach (*Spinacia oleracea* L.). *Communications in Soil Science and Plant analysis*, **48**(4): 357-369. DOI: 10.1080/00103624.2016.1261886.

Prakash, Ved; Mishra, J.S.; Kumar, Rakesh; Kumar, R.; Kumar, S.; Dwivedi, S.K.; Rao, K.K. and Bhatt, B.P. (2017). Thermal utilization and heat use efficiency of sorghum cultivars in middle Indo-Gangetic Plains. *Journal of Agrometeorology*, **19**(1): 29-33.

Raghav, D.K.; Singh, Gitam; Agarwal, N.K.; Bhati, A.S. and Sharma, S.K. (2016). Cultivation of oyster mushroom (*Pleurotus florida*) in North Chotanagpur region of Jharkhand on locally available substract. *The Journal of Rural and Agriculture Research*, **16**(1): 50-52.

Raghav, D.K.; Singh, R.K. and Saha, P.B. (2016). Effect of sulphur and boron application on uptake and yield of linseed under rainfed conditions. *The EcoScan*: Special Issue, Vol. **IX**: 737-741.

Raghav, D.K.; Thakur, Amresh; Singh, A.K. and Singh, R.K. (2016). Impact of small ditches (Dhobha) on rainfed areas in Dumka district of Santhal Pargana, Jharkhand-A case study. *Journal of Soil and Water Conservation*, **15**(4): 356-360.

Rahman, A. and Bhatt, B.P. (2017). Scope and options of solar energy use in agriculture in Eastern region of India. *Journal of griSearch,* **4**(1): 76-79.

Ravishankar, M.; Pan, R.S.; Kaur, D.P.; Giri, R.R.; Verma, A.K.; Rathore, A.; Easdown, W. and Nair, R.M. (2016). Vegetable soybean. A crop with immense potential to improve human nutrition and diversify cropping systems in Eastern India. *Soybean Research*, **14**(2): 1-13.

Ray**,** P.K.; Desingu P.A.; Sethi, M.; Nagaleekar, V.K.; Singh, R. and Saikumar, G. (2016). Pathological investigation of an outbreak of pneumonic pasteurellosis in pigs. *Indian Journal of Veterinary Pathology*, **40**(1): 58-62.

Sacchi, S.; Maurya, S. and Choudhary, A.K. (2016). Antifungal efficacy of aqueous extracts of some spices against *Sclerotiumrolfsii. The Bioscan*, **11**: 1537-1540.

Sacchi, S.; Maurya, S. and Choudhary, A.K. (2016). Antifungal efficacy of garlic and ginger against *Sclerotium rolfsii*. *International Journal of Agricultural Sciences and Research*, **6**: 419-424.

Sadawarte, R.K.; Chakraborty, S.K.; Sadawarte, V.R.; Shah, Tasaduq H.; Naik, S.D.; Shenoy, L.; Landage, A.T. and Kumar, Tarkeshwar (2016). Biometric studies on Greater lizard fish *Saurida tumbil* (Bloch, 1795) along Ratnagiri coast of Maharashtra. *Indian Journal of Geo-Marine Sciences,* **45**(10): 1310-1316.

Sangle, U.R; Kumar, S. and Mishra, J.S. (2016). Effect of volatile metabolites released by different *Trichoderma* spp. on the growth of pathogen *Sclerotium Rolfsii* and effect on *Sclerotia* germination. *The Bioscan,* **11**(4): 2811-2816.

Sarkar, B.; Kumar, Rakesh; Mishra, J.S. and Bhatt, B.P. (2016). Comparative performance of different weeding tools in maize. *Indian Journal of Weed Science,* **48**(3): 330-332. DOI: 10.5958/0974-8164 .2016.00083.6.

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

Sarkar, Lopa; Biswal, S.K.; Panigrahi, R.K. and Sarkar, B. (2016). A comparative study to assess the removal efficiency of iron from drinking water using various activated charcoals. *Environment and Ecology*, **34**(3A): 1178-1183.

Saxena, K.B.; Tikle, A.N.; Kumar, R.V.; Choudhary, A.K. and Bahadur, Bir (2016). Nectarivore-aided Hybridization and its Exploitation for Productivity Enhancement in Pigeonpea. *International Journal of Scientific and Research Publications*, **6**(8): 321-331.

Shah, Tasaduq H.; Chakraborty, S.K.; Kumar, Tarkeshwar and Sadawarte, R.K. (2017). Patterns of sex ratio in the oil sardine, *Sardinella longiceps* Val. from Ratnagiri Maharashtra. *SKUAST Journal of Research*. **19**(1): 152-155.

Sharma, A. and Singh, A.K. (2016). Information needs of farm women for efficient farming in uttarakhand. *Journal of AgriSearch,* **3**(2): 122-126

Singh, A.K.; Singh, A.K.; Kumar, Rakesh; Prakash, V.; Sundaram, P.K. and Yadav, S.K. (2017). Indian Cereals Saga: Standpoint and Way Forward. *Journal of AgriSearch,* **4**(1):1-9. http://dx.doi.org/10.21921/jas.v4i1 .74 11.

Singh, A.K.; Yadav, R. and Khan, Y.J. (2016). Assessment of soil fertility augmenting potential of faba bean (*Vicia faba* L.) germplasm and their performance. *Journal of AgriSearch,* **3**(3): 136-141.

Singh, I.S. (2016). Dynamics of nutrients of an aquatic crop (E. ferox Salisb.) under different systems of cultivation- A review. *International Journal of Agricultural Sciences*. Accepted.

Singh, M.; Deokaran and Bhatt, B.P. (2016). Effect of Integrated nutrient management on soil fertility status and profitability of garden pea. *Journal of Krishi Vigyan*, **5**(1): 29-33.

Singh, M.; Deokaran, Mishra, J. S. and Bhatt B. P. (2017). Effect of crop establishment methods on crop yield, weed dynamics, profitability and nutrient uptake under rice-wheat cropping system of Indo-Gangetic plains of eastern India. *Ecology, Environment and Conservation,* **23**: 207-215.

Singh, M.; Deokaran; Mishra, J.S. and Bhatt, B.P. (2017). Effect of Sowing Methods and Sequential Application of Herbicides on Crop Growth, Nodulation, Weed Growth and Economics of Chickpea (*Cicer arietinum*). *Journal of Agri Search,* **4**(1): 36-40.

Singh, Mandhata; Deokaran and Bhatt, B.P. (2016). Effect of Integrated Nutrient Management on Soil Fertility Status, Productivity and Proitability of Garden Pea. *J. Krishi Vigyan*, **5**(1): 29-33. DOI: 10.5958/2349-4433.2016.00028.3.

Singh, Mandhata; Deokaran; Mishra, J.S. and Bhatt, B.P. (2017). Effect of Integrated nutrient management on production potential and quality of summer mungbean (*Vigna radiata* L.). *Journal of Krishi Vigyan*, **5**(2): 39-45.

Singh, Mandhata; Deokaran; Mishra, J.S. and Bhatt, B.P. (2017). Effect of crop establishment methods on crop yield, weed dynamics, profitability and nutrient uptake under rice-wheat cropping system in Indo-Gangetic Plains of Eastern India. *Ecology, Environment and Conservation*, **23** (Feb Suppl): S209-S217.

Singh, R.K. and Raghav, D.K. (2016). Study the effect of hydrogel superabsorbent technology on yield of aerobic rice and soil characteristics. *The Ecoscan*: Vol. **IX** (Spl issu): 737-741.

Singh, S.K. (2017). Enhancing crop and water productivity of rice and wheat through system of rice-wheat intensification in combination with application of micro irrigation. *Oryza,* **54**(1): 39-43.

Singh, S.K.; Abraham, T.; Kumar, R. and Kumar, Rakesh (2017). Response of crop establishment methods and split application of nitrogen on productivity of rice under irrigated ecosystem. *Environment & Ecology,* **35**(2A): 859-862.

Sridhar, J.; Chinna Babu, N.V.; Ghodke, A.; Kranthi, S.; Kranthi, K.R.; Singh, B.P.; Choudhary, J.S. and Krishna, M.S.R. (2016). Population genetic structure of cotton pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) using mitochondrial *cytochrome oxidase I (COI)* gene sequences from India. *Mitochondrial DNA Part A-DNA Mapping, Sequencing, and Analysis*. DOI: 10.1080/ 24701394.2016.1214727.

Yadav, P.K.; Singh, A.P.; Raha, P. and Singh, I.S. (2016). Integrated nutrient management of wheat under reduced tillage in rice-wheat cropping system and soil properties. *African Journal of Agricultural Science and Technology*, **4**(4): 677-682.

Yadav, R.; Singh, A.K.; Gangopadhyaya, K.K.; Singh, A.K.; Kumar, A. and Meena, B.L. (2016). Genetic variation of faba bean (*Vicia faba* L.) germplasm collection in Eastern India. *Journal of AgriSearch,* **3**(4): 206-211.

Yadav, S.K.; Verma, N.; Singh, A.K.; Singh, N.; Rana, S.C.; Ranga, S.S. and Kumar, K. (2016). Diversity and development in Faba bean. *Legume Research-An International Journal.* http://dx.doi.org/10.18805/lr.v0iOF.6200.

Books

Bhatt, B.P. and Das, Bikas (2017). *Baans ke vividh roop evam unka upyog*. Satish Serial Publishing House, New Delhi, pp. 115. **ISBN: 9789386200129.**

Kumar, P.R.; Singh, A.K.; Lal, S.K. and Yadav, S.K. (2017). *Fundamentals of Seed Certification*. Ambica Book Agency, Jaipur, pp. 276. **ISBN: 818711810-5**.

Singh, A.K., Mali, S.S., Das, B., Bhavana, P., Kumar, P.R., Sarkar, S. and Bhatt, B.P. (2016). *Approaches to Improve Agricultural Water Productivity*. Satish Serial Publishing House, New Delhi, pp. 297. **ISBN: 978-93-85055-80-5**.

Book Chapters

Bhatt, B.P. and Mishra, J.S. (2016). Prospects of bringing second green revolution in eastern India. Published as lead paper in the souvenir of 4th International Agronomy Congress on Sustainable Management of Natural Resources, Environment, Energy and livelihood security to achieve zero hunger challenge, New Delhi, pp. 22-36.

Bhattacharya, A.; Giri, S. and Kumar, P.R. (2016). Enterprise Diversification Options. *In:* Singh, A.K. et al. (eds.): *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp:175-188.

Bhavana, P. and Gutam, S. (2016). Crop improvement for water and heat stress. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, NewDelhi,ISBN978-93-85055-80-5,pp.211-223.

Chaudhary, J.S.; Maurya, S. and Mishra, J.S. (2016). Pest, disease and weed management. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp 225-249.

Choudhary, A.K. and Kumar, S. (2016). Genetic improvement for fusarium wilt resistance in lentil. *In:* Singh, et al. (eds.). *Scientific Lentil Production: Indian Perspectives*. Published by Society for Upliftment of Rural Economy, Varanasi, India, pp 59-72.

Das, B. and Dhakar, M.K. (2016). Fruit based production systems. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 89-109.

Das, B.; Dhakar, M.K.; Singh, A.K. and Kumar, S. (2016). Augmenting productivity of horticultural crops. *In:* Singh, A.K. et al. (eds.). *Agricultural Technology Application for Enhancing Productivity*. Published by Narendra Publishing House, Delhi, India, pp. 161-174.

Dhakar, M.K.; Mali, S.S. (2016). Irrigation Management in Fruit Crops in Approaches to improve agricultural water productivity. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp.1-13.

Dhakar, M.K.; Sarolia, D.K.; Soni, A.K. and Meena, C.P. (2017). Pilu (*Salvadora oleoides*). *In:* S.N. Ghosh (ed.). *Minor Fruits: Nutraceutical Importance and Cultivation Part III*. Published by Jaya Publishing House, New Delhi (India), pp 677-689.

Dwivedi, S.K; Kumar, S.; Prakash, Ved and Mishra, J.S. (2016). Rice Breeding for Effect of climate change on growth and physiology of Rice-Wheat genotypes. *In:* Bisht, J.K. et al. (eds.). *Conservation Agriculture: An Approach to Combat Climate Change in Indian Himalaya*. Published by Springer Science + Business Media, Singapore, pp. 527-543. DOI: 10.1007/978-981-10-2558-7_21.

Islam, A. and Naik, S.K. (2016). Climate change, Water and Agriculture. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp.15-32.

Jha, B.K.; Kumar, S. and Pan, R.S. (2016). Integrated Farming System. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 189-201.

Kumar, Bhumesh. Mishra, J.S.; Singh, V.P. and Sharma, A.R. (2016). Challenges of weed management under changing climate. *In:* Venkateswarlu,B. et al. (eds.). *Climate Resilient Agronomy*. Published by Indian Society of Agronomy, pp. 203-219.

Kumar, Rakesh and Meena, V.S. (2016). Towards the sustainable management of problematic soils in north eastern India. *In:* Bisht, J.K. et al. (eds.). *Conservation Agriculture: An Approach to Combat Climate Change in Indian Himalaya*. Published by Springer Science + Business Media, Singapore, pp: 339-ISBN: 978-981-10-2557-0 (Print) 978-981-10-25587(Online).

Kumar, Rakesh; Patra, M.K.; Thirugnanavel, A.; Chatterjee, D. and Deka, BC. (2016). Towards the natural resource management for resilient shifting cultivation system in eastern Himalayas. *In:* Bisht, J.K. et al. (eds.). *Conservation Agriculture: An Approach to Combat Climate Change in Indian Himalaya*. Published by Springer Science + Business Media, Singapore, pp: 409-436. ISBN: 978-981-10-2557-0(Print) 978-981-10-25587(Online)

Kumar, S.; Dwivedi, S.K.; Prakash, V.; Rao, K.K.; Samal, S.K.; Mishra, J.S.; and Kumar, A.; (2016). Diversity among rice landraces under static (Ex Situ) and dynamic (On-Farm) management: A case from north-western Indian Himalayas. *In:* Bisht, J.K. et al. (eds.). *Conservation Agriculture: An Approach to Combat Climate Change in Indian Himalaya*. Published by Springer Science + Business Media, Singapore, pp. 509-526. ISBN: 978-981-10-2557-0(Print) 978-981-10-25587(Online)

Kumar, S.; Kumar, J.; Sharma, J.P.; Nedunchezhian, M. and Sarkar, P.K. (2016). Crop Diversification Options. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 145-173.

Kumar, Sanjeev and Bhatt, B.P. (2016). Integrated farming system: A tool for agricultural sustainability and Enhancement in livelihood security for Small and marginal farmers. *In:* Singh, A.K. et. al. (eds.). *Agricultural Technology Application for Enhancing Productivity*. Published by Narendra Publishing House, Delhi, pp. 213-236.

Kumar, Santosh; Dwivedi, S.K.; Prakash, Ved; Rao, K.K.; Samal, S.K.; Mishra, J.S. and Kumar, A. (2016). Rice Breeding for Drought Tolerance Under the Changing Climate Scenario. *In:* Bisht, J.K. et al. (eds.). *Conservation Agriculture: An Approach to Combat Climate Change in Indian Himalaya*. Published by Springer Science + Business Media, Singapore, pp. 545-559. DOI: 10.1007/978-981-10-2558-7_17.

Kumawat, N.; Yadav, R.S.; Kumar, Rakesh and Panwar, P.K. (2016). Contingency crop planning for sustainable Agriculture. *In:* Rawat, S.K. and Narayan, Sarju et al. (eds.). Agriculture Technology for Sustaining Rural Growth. Published by Biotech Books ISBN 978-81-7622-381-2, pp: 57-68.

Kumawat, N.; Yadav, R.S.; Kumar, Rakesh, and Jakhar, R.K. (2016). Pulses production: Scenario and strategies for improving productivity. *In:* Rawat, S.K. and Narayan, Sarju et al. (eds.). Agriculture Technology for Sustaining Rural Growth. Published by Biotech Books. ISBN 978-81-7622-381-2, pp: 337-353.

Mali, S.S. (2016). Basic Concepts of Water Productivity. *In:* Singh, A.K. et al. (eds.): *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 1-13.

Mali, S.S., Singh, A.K. and Kumar, A. (2016). Water Harvesting and Management. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp: 33-53

Mali, S.S.; Jha, B.K. and Naik, S.K. (2016). Effect of planting geometry and fertigation pattern on growth, yield and water productivity of Tomato. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 53-60.

Mishra, J.S. (2016). Weed problems in millets and its management. *In:* Das, I.K. and Padmaja, P.G. (eds.). *Biotic Stress Resistance in Millets*. Published by Elsevier Academic Press, pp. 205-220. DOI: http://dx.doi.org/10.1016/B978-0-12-804549-7.00007-X. ISBN: 978-0-12-804549-7.

Mishra, J.S.; Rao, A.N.; Singh, V.P. and Kumar, R. (2016). Weed management in major crops. *In:* Yaduraju, N.T. et al. (eds.). *Weed Science and Management* . Published by Indian Society of Weed Science & Indian Society of Agronomy, pp. 169-190. ISBN: 13:976-61-931978-9-9.

Mishra, J.S. (2016). Management of aquatic weeds. In Training Manual on Recent Advances in Livestock Fish Integrated Farming System. ICAR-RCER, Patna, pp.39-47.

Naik, S.K. (2016). Soil Health Management. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 251-264.

Patel, V.B. and Dhakar, M.K. (2016). Improving profitability through enhanced nutrient use efficiency in horticultural crops. *In*: Chadha, K.L. et al. (eds.). Doubling farmers' income through horticulture. Published by Daya Publishing House, pp. 257-262.

Prabhakar, C.S.; Choudhary, A.; Choudhary, J.S.; Sood, P. and Mehta, P.K. (2017). Role of Insect Viruses in the Management of Insect Pests. *In:* Anwer, Md. Arshad (eds.). *Biopesticides and Bioagents: Novel Tools for Pest Management*. ©2017 by Apple Academic Press, Inc. CRC, Press, ISBN: 9781771885195 - CAT# N11825, pp. 365.

Prakash, Ved.; Kumar, S.; Dwivedi, S.K.; Rao, K.K.; and Mishra, J.S. (2016). Impact, Adaptation Strategies and Vulnerability of Indian Agriculture towards the Climate Change. *In:* Bisht, J.K. et al. (eds.). *Conservation Agriculture: An Approach to Combat Climate Change in Indian Himalaya*. Published by Springer Science + Business Media, Singapore, pp: 437-457. ISBN: 978-981-10-2557-0(Print) 978-981-10-25587(Online)

Raghav, D.K. and Sinfh, R.K. (2016). Pre-harvested loss due to the oresence of burrow in field in rainfed area of rice agro-eco system of Chota Nagpur region of Jharkhand. *In:* Souvenir of Andman Science Association- International conference on Climate change adoption and biodiversity: Ecological sustanability and resource management for livelihood security (ASA:ICCB-2016) at ICAR-CIARI, Port blair, Andaman and Nicobar Islands, India.

Singh, A.K.; Bhavana, P. and Das, B. (2016). Vegetable based production systems. *In:* Singh, A.K. et al. (eds.). *Approaches to Improve Water Productivity.* Published by Satish Serial Publishing House, New Delhi, ISBN 978-93-85055-80-5, pp. 111-122.

Singh, R.K. and Raghav, D.K. (2016). Assessment of weed management in direct seeded rice for increasing yield and productivity. *In:* Souvenir of Andman Science Association- International conference on Climate change adoption and biodiversity: Ecological sustanability and resource management for livelihood security (ASA:ICCB-2016) at ICAR-CIARI, Port blair, Andaman and Nicobar Islands, India.

Sultana, Rafat; Singh, Ravi S.; Ratnakumar, P.; Verma, Nidhi; Chaturvedi, S.K. Choudhary, A.K.; Sameer, C.V. and Siddiqui, Mohammed Wasim (2016). Pulse Secondary Metabolites: A Perspective on Human and Animal Health. *In*: Siddiqui, Mohammed Wasim and Prasad, Kamlesh (eds.). *Plant Secondary Metabolites: Biological and Therapeutic Significance*(Vol-I). Published by AAP-CRC Press, USA. ISBN: 9781771883528).

Technical Bulletins

Choudhary, J.S.; Kumari, A.; Mukherjee, D.; Maurya, S.; Das, B.; Mali, S.S.; Moanaro and Singh, A.K. (2016). *Badalti Jalvayu mai Aam ke Mukhya Keet evam Vyadhiyo ka Prakop evam Prabhandhan*. Technical Bulletin No.: R-60/Ranchi-26. ICAR Research Complex for Eastern Region, Research Centre, Ranchi. pp. 36.

Das, Bikash; Naik, S.K.; Sarkar, Pradip Kumar; Singhal, Vibha; Arunachalam, A.; Acharyya, Gobinda; Borah, Debojit; Kumar, Jai; Shukla, Gopal and Bhatt, **B.P. (2017). Agroforestry for Livelihood Security in Eastern India. Technical Bulletin No**. ICAR Research Complex for Eastern Region, Patna, pp. 89.

Gupta, J.J.; Dey, A. and Bhatt, B.P. (2017). Fodder production and feeding technology for livestock in eastern India. Technical Bulletin No.: R-61/Patna-35. ICAR Research Complex for Eastern Region, Patna, pp. 27.

Naik, S.K.; Shinde, R.; Mali, S.S.; Jha, B.K.; Das, B. and Singh, A.K. (2016). Diagnosis of nutrient deficiency and its management in horticultural crops. Technical Bulletin No.: R-59/Ranchi-27. ICAR Research Complex for Eastern Region, Research Centre, Ranchi, pp.

Extension Bulletins

Jha, B.K.; Mali, S.S.; Naik, S.K.; Kumar, A. and Singh, A.K. (2016). *Tapak sinchai ke antargat sabjiyon ki ropan jayamiti awam ghulansheel urvarak prayog padhyati*. Extension Bulletin No.: E-154/Ranchi-70. ICAR Research Complex for Eastern Region, Research Centre, Ranchi, pp.

Mali, S.S.; Jha, B.K.; Naik, S.K.; Kumar, A. and Singh, A.K. (2016). Planting geometry and fertigation patterns for drip irrigated vegetables. Extension Bulletin No.: E-151/Ranchi-69**.**

Singh, S.K.; Kumar, Ajay; Sarkar, Bikash; Kumar, Shivshankar; Kumar, Amrendar and Vikash (2016). Shri vidhi dhan ki kheti me kharpatvar niyantran. Parsar Pustika Number : E-155/Patna/81. Tata Trusts, Mumbai.

Singh, S.K.; Kumar, Ajay; Sarkar, Bikash; Kumari, Roma; Kumar, Shivshankar; Kumar, Amarendra and Vikash (2017). Improved Cultural Practices of SRI. Extension Bulletin. Tata Trusts, Mumbai.

Mohanty, S.; Dey, A.; Sarma, Kamal; Kumar, Tarkeshwar; Kumar, Ravi; Ahirwal, S.K.; Narayan, Deva; Kumar, Amrendra and Bari, Fauzia (2017). Fish Disease Surveillance System in Bihar State.

Singh, M.; Deokaran; Govind, H.; Kumar, U.; Parvez, A. and Sultan, A. (2017). Krishak Prashishk Pustika released in Rabi Krishi Mela cum Krishan Goshthi on 25-26, March, 2017.

Training Manuals

Kumar, P.; Pandian, S.J.; Kumar, Gopal and Kumar Pradeep (2017). Training Manual on कुक्कुट पालन एवं बीमारियों की रोक–थामः तकनीकी जानकारियाँ. ICAR Research Complex for Eastern Region, Patna, pp. 37.

Kumar, P.; Pandian, S.J.; Kumar, Gopal.; Kumar, Pradeep and Dayal, S. (2017). Training Manual on आधुनिक तकनीक से ग्रामीण परिवेश में मुर्गी पालन. ICAR Research Complex for Eastern Region, Patna, pp. 30.

Popular Articles

Choudhary, A.K. (2016). IPA 203 – A promising variety of long duration pigeonpea. *Indian Farming*, **66**(2): 7-9.

Choudhary, J.S. (2016). Fal Faslaon me Fal Makhi ka Samekit Keet Prabandhan. *Lakshay*: 30-31.

Dayal, Shanker (2016). Buffaloes: Promising livestock for rural livelihood improvement. *Indian Farming*, **66**(9).

Dayal, Shanker and Dey, Amitava (2016). Selection and breeding for reproduction through scientific techniques. *Akshay Kheti* **3**(1): 88-90.

Dwivedi, S.K; Kumar, S; Bhakta, N; Ved Prakash. and Mishra J.S. (2016). Badh avorodhi dhan ki prajatia. *Kheti*, April, pp. 3-6.

Gupta, J.J., and Dey, A. (2016). Balanced feeding of livestock for health and production. *Akshay Kheti,* June Issue, **2**(2): 67-68.

Kumar, Sanjeev; Shivani and Bhatt, B.P. (2016). Management of complex weed flora under direct seeded rice for optimum yield. *Indian Farming*, **66**(7): 23-28.

Kumar, Ujjwal (2016). E-krishi dwara krishi vikas. *Akshay Kheti*, **2**(2): 68:69.

Mali, S.S. (2016). Wheat irrigation in Gangetic plains of Bihar – It's time for a change. *In:* Improving water use for dry season agriculture by marginal and tenant farmers in the Eastern Gangetic Plains. http://dsi4mtf.usq.edu.au/dsi4mtf/2016/03/.

Mali, S.S.; Jha, B.K.; Naik, S.K. and Singh, A.K. (2016) ड्रिप सिंचित सब्जी फसलों के लिये श्रेष्ठ रोपण ज्यामिति व उर्वरक प्रयोग पद्धति. *Krishisewa*. http://krishisewa.com/.

Naik, S.K. (2016). pH and EC measurement of floricultural crops using the pour-thru extraction method. *Krishisewa*, November, 2016.

Prakash, Ved; Kumar, Santosh; Dwivedi, S.K. and Mishra, J.S. (2017). Impact of climate change on rice and wheat: Adaptation strategies and resource conservation measures. *Indian Farming*, **67**(03): 02-05.

Sarma, K.; Chandran, P.C. Mohanty, Snatashree; Dey, A.; Kumar, Ujjwal and Sarkar, Bikash (2016). Recent advances in livestock fish integrated farming system. ICAR Research Complex for Eastern Region, Patna. 224 p.

Sharma, Rajvir; Singh, Indu Shekhar; Kumar, Lokendra and Bhatt, B.P. (2016). Makhana ki Unnat Kheti. *Kheti*, **69**(2): 42-44.

Singh, Indu Shekhar; Thakur, Abhay Kumar and Kumar, Ashok (2016). Makhana ki Laabhkari Kheti. *Aadhunik Kissan*, **45**(4): 18-21.

Singh, S.K.; Kumar, Ajay and Kumari, Roma (2016). Bihar me rabi faslon ka utpadan evam jal utpadkta badhane ke liye smuchit prvandhan. *Akshay Kheti*, **3**(2).

Singh, S.K.; Kumar, Ajay and Sarkar, Bikash (2016). Shri vidhi dwara dhan ki unnat kheti. *Akshay Kheti*, **3**(1).

Singh, A.K. (2016). Understanding Weed biology to manage wheat field efficiently. *Indian Farming*, **66**(6):17-21.

Singh, A.K. and Prakash, Ved. (2017). Khadya evam poshan suraksha ke liye bakala ki kheti. *Kheti*, February, pp. 25-28.

Policy Papers

Bhatt, B.P. and Mishra, J.S. (2016). Production and technological gaps in middle Indo-Gangetic Plains. Policy Paper. ICAR Research Complex for Eastern Region, Patna, pp. 15.

Bhatt, B.P. and Mishra, J.S. (2016). Second Green Revolution in Eastern India: Issues and Initiatives. Policy Paper. ICAR Research Complex for Eastern Region, Patna, pp. 40.

e-Publications

Desingu, P.A.; Ray, P.K.; John, J.K.; Das, T.; Dubal, Z.B.; Rajak, K.K.; Singh, R.K. and Saikumar, G. (2017). First complete genome sequence of genotype III Japanese encephalitis virus isolated from a stillborn piglet in India. *Genome Announcement,* **5**(3):e01503-16. *https://doi.org/10.1128/genomeA.01503-16.*

Kumar, Pankaj; Pandian, S.J.; Sinha, B.S.; Kumari, R.R. and Kumar, M. (2016). Calf Diarrhoea: Devastating disease of bovine during first three months after birth. *http://www.krishisewa.com/articles/livestock/705-calf-diarrhoea.html.*

Ray, P.K.; Desingu, P.A.; Kumari, S.; John, J.K.; Sethi, M.; Sharma, G.K.; Pattnaik, B.; Singh, R.K. and Saikumar, G. (2017). Porcine sapelovirus among diarrhoeic piglets in India. *Transboundry and Emerging Disease. https://doi.org/10.1111/tbed.12628*

26. Personnel

Division of Land and Water Management

Scientists

Dr. S. K. Singh, Pr. Scientist (Agron.) & I/c Head
Dr. A. Upadhyaya Pr. Scientist
Dr. A. Rahman, Pr. Scientist (Phy.)
Dr. A. K. Singh, Pr Scientist (Agron.)
Dr. Bikash Sarkar, Sr. Scientist (FMPE)
Dr. Ajay Kumar, Sr. Scientist (SWCE)
Dr. Manibhushan, Scientist(SS) (Comp. App.)
Er. P.K. Sundaram, Scientist (FMPE) *(Study leave)*
Mr. Surjit Mondal, Scientist (Soil Science) *(Study leave)*

Division of Crop Research

Scientists

Dr. J.S. Mishra, Pr. Scientist (Agronomy) & Head
Dr. A.K. Choudhary, Pr. Scientist (Plant Breeding)
Dr. Sanjeev Kumar, Pr. Scientist (Agronomy)
Dr. Shivani, Pr. Scientist (Agronomy)
Dr. Md. Monobrullah, Pr. Scientist (Entomology)
Dr. Narayan Bhakta, Sr. Scientist (Gen. & Plant Breeding)
Dr. Santosh Kumar, Scientist (Plant Breeding)
Dr. S.K. Dwivedi, Scientist (Plant Physiology)
Dr. Rakesh Kumar, Scientist (Agronomy)
Mr. Ved Prakash, Scientist (Agril. Meteorology)
Dr. Tshering Lhamu Bhutia, Scientist (Veg. Science)
Mr. Karnena Koteswara Rao, Scientist (Soil Science)
Dr. Kirti Saurabh, Scientist (Soil Science)

Division of Livestock and Fishery Management

Scientists

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

Technical Officers

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

Division of Socio-Economics and Extension

Scientists

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

Technical Officers

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

Performance Monitoring & Evaluation Cell

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

Technical Officer

Mr. Sarfaraj Ahmad, Technical Officer (Computer)

ARIS Cell

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

Technical Officer

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

Farm Section

Mr. A.K. Khan, Farm Manager (T-9)
Mr. Hari Shankar, Technical Officer (T-7-8)
Mr. R.K. Tiwari, Technical Officer (T-5)
Mr. P.K. Singh, Technical Officer (T-5)
Mr. A.S. Mahapatra, Technical Officer (T-5)

Workshop and Estate Section

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

ICAR RCER, Research Centre, Ranchi

Scientists

Dr. A.K. Singh, Pr. Scientist (Horticulture) & Head
Dr. R.S. Pan, Pr. Scientist (Horticulture)
Dr. B.K. Jha,Sr. Scientist (Horticulture)
Dr. Bikash Das, Sr. Scientist (Horticulture)
Dr. P.R. Kumar, Sr. Scientist (Seed Technology)
Dr. S. K. Naik, Sr. Scientist (Soil Sci.-Soil Chemistry/ Fertility/Microbiology)
Dr. Sudarshan Maurya, Sr. Scientist (Plant Pathology)
Dr. Sridhar Gutam, Sr. Scientist (Plant Physiology)
Dr. Asit Chakrabarti, Sr. Scientist (LPM)
Dr. S.S. Mali, Scientist (CWC)
Dr. (Mrs.) P. Bhavana, Scientist (Plant Breeding)
Dr. Jaipal Singh Choudhary, Scientist (Entomology)
Ms. Reshma Shinde, Scientist
Dr. P.K. Sarkar, Scientist (Agroforestry)
Dr. M.K. Dhakar, Scientist
Dr. Anuradha Srivastava Scientist (Food Technology)

Technical Officers

Dr. G. P. Singh, Chief Technical Officer
Shri Y. N. Pathak, Assistant Chief Technical Officer
Sh. Paul Sanjay Sircar, Assistant Chief Technical Officer (Computer)
Shri Om Prakash, Senior Technical Officer (Civil)
Shri Suresh Kumar, Senior Technical Officer (Farm)
Shri Ganga Ram, Senior Technical Officer (Lab.)
Shri Chandrakant, Senior Technical Officer (Lab.)
Shri Chandra Shekher Prasad, Senior Technical Officer (Lab.)
Shri B. P. Mishra, Senior Technical Officer (Farm)
Shri Dhananjay Kumar, Technical Officer (Farm)
Shri Arun Kumar, Technical Officer (Electrical)
Shri Kushal Kesariar, Technical Officer (Farm)
Shri Pradip Kumar Singh, Technical Officer (Laboratory)
Smt. Anima Prabha, Technical Officer (Press & Editorial)
Shri Vijay Kumar Singh, Technical Officer (Lab.)

ICAR RCER, Research Centre for Makhana, Darbhanga

Dr. Rajvir Sharma, Pr. Scientist & Head
Dr. Md. Idris, Pr. Scientist (Entomology)
Dr. I.S. Singh, Scientist (Soil Science)
Dr. B.R. Jana, Scientist (Horticulture)

ICAR RCER, Krishi Vigyan Kendra, Buxar

Subject Matter Specialist

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

Technical

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

ICAR RCER, Krishi Vigyan Kendra, Ramgarh

Subject Matter Specialist

Dr. V. Dwivedi, Sr. Scientist & PC
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

Scientific

Dr. Kriti Sourabh, Scientist w.e.f. 14.10.2016
Dr. Surendra Kr. Ahirwal, Scientist w.e.f. 11.04.2016
Dr. Md. Monobrullah, Pr. Scientist, w.e.f. 22.11.2016
Dr. Virendra Kr Yadav, Pr. Scientist w.e.f. 31.01.2017
Dr. Manoj Kr Tripathi, Scientist w.e.f. 21.03.2017
Dr. Tania Seth, Scientist w.e.f. 31.01.2017
Dr. Tanmay Kr Koley, Scientist w.e.f. 31.03.2017

Administrative

Smt. Ritu Rani, (LDC) w.e.f. 04.04.2016.

Promotion

Scientific

Dr. S.J. Pandian, promoted to Scientist (SS) RGP 7000/- w.e.f. 08.01.2012
Dr. P. C. Chandran, promoted to Scientist (SS) RGP 7000 w.e.f. 08.01.2012
Dr. S.S. Mali, promoted to Scientist (SS) RGP 7000 w.e.f. 12.06.2012
Dr. Pradeep Kumar Ray, promoted to Scientist (SS) RGP 7000 w.e.f. 07.01.2013
Dr. U. R. Sangle , promoted to Sr. Scientist (RGP 9000) w.e.f. 31.12.2013
Dr. Rajni Kumari , promoted to Scientist (SS) RGP 7000 w.e.f. 23.06.2014
Dr. I. S. Singh, promoted to Sr. Scientist (RGP 9000) w.e.f. 09.08.2014
Dr. Pankaj Kumar, promoted to Sr. Scientist (RGP 8000) w.e.f. 8.01.2016

Administrative

Sh. Anil Kr, promoted to UDC, w. e. f. 07.05.2016
Sh. Chandra Kant Mahto, promoted to UDC, w.e.f. 28.05.2016
Sh. R. S. Paswan, promoted to AAO, w. e. f. 10. 05. 2017
Sh. Lakshmi Prasad, promoted to UDC, w. e. f. 25.05.2017

Technical

Sh. Ramesh Kumar, Technical Assistant to Sr. Technical Assistant w.e.f. 28.08.2013
Dr. Deo Karan, SMS (T-6) to SMS (T-7-8) w.e.f. 10.10.2013
Dr. Rama Krishna Roy, SMS (T-6) to SMS (T-7-8) w.e.f. 21.10.2013
Sh. Chandra Shekhar Prasad , Technical Officer to Sr. Technical Officer w.e.f. 01.01.2015
Sh. Dev Charan Kujur, Sr. Technical Assistant to Technical Officer w.e.f. 01.01.2015
Sh. Gopal Baraik Technical Officer to Sr. Technical Officer w.e.f. 01.01.2015
Sh. Kalyan Kumar, Technician to Sr. Technician w.e.f. 08.06.2015
Sh. Dhiraj Prakash, Technician to Sr. Technician w.e.f. 12.07.2015
Sh. Paul Sanjay Sircar, Sr. Technical Officer to ACTO w.e.f. 10.09.2015
Sh. A. S. Mahapatra, Sr. Technical Assistant to Technical Officer w.e.f. 29.12.2015
Sh. Bipin Kumar Mishra, Technician to Sr. Technician w.e.f. 31.12.15
Sh. Amrendra Kumar, Technical Assistant to Sr. Technical Assistant w.e.f. 13.01.2016
Sh. B.P. Mishra, Technical Officer to Sr. Technical Officer w.e.f. 12.02.2016
Dr. Moanaro, Technical Assistant to Sr. Technical Assistant w.e.f. 30.03.2016
Sh. H. P. Kashi , Technical Assistant to Sr. Technical Assistant w.e.f. 26.06.2016
Sh. Sanjay Lal Srivastava, Technician to Sr. Technician w.e.f. 03.10.2016
Sh. Shashi Kumar Azad, Technical Assistant to Sr. Technical Assistant w.e.f. 16.12.2016

MACP

Sh. S. R. Rajak, AAO, 3rd MACP w. e. f. 01.01.2013
Sh. Firoz Akhtar, Assistant, 3rd MACP w. e. f. 30.07.2016
Smt. Sangeeta Chakrabarty, 3rd MACP w. e. f. 23.09.2016

Transfer

Dr. Rajesh Kumar Singh, Head DLWN transferred to CIPHET, Ludhiana w.e.f. 12.08.2016
Dr. A. K. Thakur, Pr. Scientist, RCM Darbhanga transferred to ICAR-NIRJAFT, Kolkata w.e.f. 21.03.2017
Dr Sridhar Gutam, Senior Scientist (Plant Pathology) transferred to ICAR-IIHR, Bengaluru w.e.f. 10.03.2017

Retirement

Sh. V. K. Tiwari, Technical Officer w.e.f. 30.06.2016
Sh. Shakil Ahmad, personal secretary w.e.f. 30.09.2016
Sh. Umesh Singh, AAO, w.e.f. 30.04.2016
Sh. D.K. Sah , STO, w.e.f. 31.08.2016
Sh. Chandra Deo Rai, T-4 w.e.f. 31.08.2016
Sh. Madi Lakra, T-3 w.e.f. 30.11.2016
Sh. A. K. Khan, Chief Technical Officer w.e.f. 31.01.2017
Sh. Chandrakant Mahto, UDC w.e.f. 31.01.2017
Sh. Birendra Prasad , T-5 w.e.f. 31.01.2017
Sh. Gokul Baraik , ACTO w.e.f. 28.02.2017
Sh. R.C. Varma, SMS w.e.f. 28.02.2017
Sh. Hari Shankar, Assistant CTO w.e.f. 31.03.2017

27. On-going Research Projects

Theme-wise Ongoing and New Institute Research Projects

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
Theme 1. Farming system research including climate resilient agriculture						
1. Integrated Farming System and Cropping system for Eastern Region						
1.1	ICAR-RCER/ AICRP/ IFS/ EF/ 2010/ **25(i)**	Development of location specific Integrated Farming System models for small and marginal farmers of Bihar	Sanjeev Kr A. Dey U. Kumar N. Chandra R.K. Kamal S.Mohanty S.K.Samal	June 2010	Mar. 2018	PDFSR, AICRP (External-ly funded)
1.2	ICAR-RCER/ RCM/ 2011/ **25(ii)**	Development of makhana based Integrated Farming System models for low land eco-system	I.S. Singh	July 2011	June 2016	ICAR RCER
1.3	ICAR-RCER/ RC Ranchi/ 2011/ **25(iii)**	Development of location specific Integrated Farming System models for rainfed eco-system of Eastern Plateau Hill region	Pradip K.Sarkar Reshma Shinde M K Dhakar	June 2011	May 2016 Extd. 2018	ICAR RCER
1.4	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	July 2014	June 2017	ICAR RCER
1.5	ICAR-RCER/ DLFM/ 2014/ 155	Optimization of production efficiency in livestock- fish integrated farming system	Kamal Sarma A. Dey S. Mondal S. J. Pandian S.K. Gupta S. Mohanty Tarkeshwar Kr	Aug. 2014	July 2017	ICAR RCER
1.6	ICAR-RCER/ DLFM/ 2014/ 143	Multiplication and production profiling of improved poultry germplasm under Backyard farming system	Reena K.Kamal P.C.Chandran S.J.Pandian	July 2014	June 2019	ICAR RCER
1.7	ICAR-RCER/ DSEE/ 2012/ **134**	Tribal farming system in Eastern India	Ujjwal Kumar B.P. Bhatt R.S. Pan Bikash Das Bikash Sarkar A. Dey Kamal Sarma	Jan. 2013	Dec. 2016	ICAR RCER
1.8	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 Reshma Shinde	Sept. 2014	Sept. 2019	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
1.9		Integrated farming system for improvement of nutrition and livelihood of farm women	T. L. Bhutia Reena K.Kamal S. Mohanty	2015	2017	Externally funded
1.10	New	Integrated Farming System for improving livelihood security of resource poor farmers.	T.L. Bhutia Reena K.Kamal S.Mohanty R.C.Bharati	July 2016	June 2019	ICAR RCER
1.11	New	Eco-energetic analysis of different cropping system in Eastern India.	Bikash Sarkar Ajay kumar S.S.Mali Rakesh Kumar	July 2016	June 2019	ICAR RCER
1.12	New	Evaluation and optimization of IFS	Mani Bhushan Sanjeev Kr A.Upadhyaya R.C.Bharati	2016	2019	ICAR RCER
2. Resource Conservation Technology						
2.1	ICAR-RCER/ DLWM/2012/ **130**	Evaluation of vegetable varieties under different irrigation methods	Shivani A.K. Singh M. Idris T.L. Bhutia	Sept. 2013/ Initiated in 2014	Aug. 2017	ICAR RCER
2.2		Sustainable Resilient Farming System in intensification (SRFSI) in the Eastern Gangetic Plane	Ujjwal Kumar Rajvir Sharma S.K. Singh Bikash Sarkar R. C. Bharati Ved Prakash K. K. Rao	Oct. 2014	June 2018	CIMMYT
2.3		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	2015	2017	Consortium Research Platform on CA
2.4	ICAR-RCER/ DCR/ 2011/ **104**	Evaluation of different production system for Carbon sequestration potential	S.K. Naik S. Maurya Shivani K.K.Rao	July 2011	June 2017	ICAR RCER
2.5	ICAR-RCER/ RCR/2015/**168**	Evaluation of vegetable cropping sequences under drip irrigation with mulching in EPHR	B.K. Jha S.S. Mali S.K.Naik	Aug. 2015	July 2018	ICAR RCER
3. Climate resilient agriculture						
3.1	ICAR-RCER/ RC Ranchi/ 2011/**29**	Understanding the changes in host-pest interactions and dynamics in mango under climate change scenario (NICRA)	Bikash Das J.S. Choudhary S. Maurya S. Gutam, S.S.Mali	Jan. 2011	Mar. 2017	NICRA (Externally funded)
3.2	ICAR-RCER/ DCR/ 2014/ **144**	Impact of elevated CO_2 and temperature on growth and yield of rice-wheat cropping system under predicted climate change scenario.	S.K. Dwivedi Santosh Kumar Ved Prakash	July 2014	June 2017	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
3.3		Management of high intensity rain events in flood prone region of middle IGP for kharif crops and low temperature in Boro rice in eastern IGP (NICRA)	J.S. Mishra Kamal Sarma U.Kumar Bikas Sarkar N.Bhakta Ved Prakash	July 2014		NICRA (Externally funded)
3.4	New	Diversification of rice-wheat system through climate resilient cropping in Eastern India.	Rakesh Kumar J.S. Mishra N.Chandra S.K.Samal R.S.Pan R. Shinde	2016		ICAR RCER
3.5	New	Developing and defining climate smart agriculture practices portfolios in South Asia (CCAFS)	J.S. Mishra K.K. Rao Rakesh Kumar Ved Prakash S.K. Samal	2015	2019	CIMMYT
3.6	New	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 Mani Bhushan	2015	2019	ACIAR
3.7	New	Creal System Initiative for South Asia (CSISA) Phase-III	J.S. Mishra Rakesh Kumar S.K. Dwivedi Md. Monobrullah S.K. Samal	2016	2020	CIMMYT
3.8	New	Creation of seed hubs for increasing indigenous production of pulses in India	A.K. Chaudhary (Nodal Officer) P.R. Kumar (Co- Nodal Officer- RC, Ranchi) I.S. Singh (Co- Nodal Officer- RC, Darbhanga) Hari Govind (Co- Nodal Officer- KVK, Buxar)	2016	2019	DAC&FW, Ministry of Agriculture & Farmers' Welfare, Govt. of India
3.9	New	Development of climate resilient farming system models for livelihood improvement	Md. Monobrullah	2016	2019	DAC&FW, Ministry of Agriculture & Farmers' Welfare, Govt. of India

Theme- 2. Genetic Resource Management and Improvement of Field, Horticultural and Aquatic crops

4. Varietal Development

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
4.1	ICAR RCER/ FF /2011/ **30**	Evaluation and development of drought tolerant rice for Eastern region (STRASA Phase-III)	Santosh Kr M. Idris N. Bhakta S. K. Dwivedi K.K.Rao	April 2014	Feb. 2019	IRRI (External-ly funded)
4.2	ICAR-RCER / RC Ranchi/ 2012/ **128**	Genetic enhancement of Tomato for nematode and bacterial wilt resistance through Molecular markers	P. Bhavana A.K. Singh J.S. Choudhary	Jan. 2013	Dec. 2016	ICAR RCER
4.3	ICAR-RCER / HARP/ 2001/ **03**	Plant genetic resource and improve-ment of fruit and ornamental crops	M.K.Dhakar Bikash Das S. Gutam	2001	Long term	ICAR RCER
4.5	ICAR-RCER/ RCRanchi/ 2012/ **132**	Collection, characterization and evaluation of potentials wild edibles including tuber crops	R.S. Pan Reshma Shinde A. Srivastava	Apr. 2013	Mar. 2018	ICAR RCER
4.7	ICAR-RCER/ DCR/ 2014/**142**	Evaluation and identification of rice genotypes for tolerance to drought stress at different growth stages.	Santosh Kumar N. Bhakta S. K. Dwivedi	July 2014	June 2018	ICAR RCER
4.8	ICAR-RCER/ DCR/ 2014/**160**	Breeding for submergence tolerance in rice	N. Bhakta Santosh Kumar S. K. Dwivedi	July 2014	June 2018	ICAR RCER
4.9	ICAR-RCER/ RC Ranchi/ 2015/171	Improvement of seed quality of solanaceous and cucurbitaceous vegetables	P. R. Kumar S Maurya	Aug 2015	Aug 2020	ICAR RCER
4.10	ICAR-RCER/ RC Ranchi/ 2015/**172**	Genetic improvement for yield and biotic stress resistance in pigeonpea under eastern plateau and hill region	P. Bhavana A.K.Choudhary R.S. Rathi S. Maurya J.S. Chaudhary	July 2015	June 2019	ICAR RCER
4.11	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
4.12		Evaluation of different genotypes of water chestnut	Rajvir Sharma B.R.Jana	2015	2020	ICAR RCER
Theme-3. Improved Production and Protection Technologies for Agri-Horti Crops						
5 . Production Technologies						
5.1	ICAR RCER/ RCM Darb-hanga / 2014/ **158**	Sustainable crop intensification through the development of suitable plant type in cool season pulses un-der rice-fallow and makhana-fallow cropping stystem in Eastern India	A.K.Choudhary I.S. Singh	July 2014	June 2017	ICAR RCER
5.2	ICAR RCER/ RCM Darb-hanga/ 2014/ **159**	Development of value-added product of makhana.	A.K. Thakur I.S. Singh	July 2014	June 2017	ICAR RCER
5.3	ICAR RCER/ RCM Darbhan-ga /2014/ **156**	Response of integrated nutrient management on the production potential of makhana crop growing under field condition in northern Bihar.	I.S. Singh Rajvir Sharma	July 2014	June 2017	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
5.4	ICAR-RCER/ RC Ranchi/ 2014/**151**	Standardization of basin enrichment in high density orchards of bael, sapota and guava under eastern plateau and hill region	Bikash Das S.K. Naik S. Maurya P. Sarkar	Aug. 2014	July 2017	ICAR RCER
5.5	ICAR-RCER/ RC Ranchi/ 2014/**154**	Studies on decomposition rate of different organic substrate and their nutrient release pattern	Reshma Shinde S. Maurya	July 2014	June 2017	ICAR RCER
5.6	ICAR-RCER/ RC Ranchi/ 2014/**152**	Nutritional characterization and value addition of potential underutilized leafy vegetables of Jharkhand	A. Srivastava R. S. Pan	Sept. 2014	Sept. 2017	ICAR RCER
5.7	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/ RC Ranchi/ 2015/**169**	(iii) Phyto-sociology of weeds associated with important agricultural crops under eastern plateau and hill region of India	P. K. Sarkar	2015	2018	ICAR RCER
5.8	New	Ergonomic study of farmers' friendly farm implements in Eastern region.	Bikash Sarkar Rakesh Kumar	2016	2019	ICAR RCER
6. 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 Ram Kewal	July 2015	June 2018	ICAR RCER
6.2	ICAR-RCER/ RC Ranchi/ 2015/**167**	Development and evaluation of disease suppressive potting mixtures in vegetable crops.	S. Maurya	July 2015	June 2018	ICAR RCER
6.3	ICAR-RCER/ RC Ranchi/ 2014/**162**	Phenological monitoring of selected horticultural fruit tree species	S. Gutam	Sep 2015	Aug 2018	ICAR-RCER
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	July 2014	June 2022	ICAR RCER
7.2	ICAR-RCER/ RC Ranchi/ 2014/**149**	Participatory management of rice-fallow in eastern plateau and hill region	A. K. Singh S.K. Singh B.K. Jha, R S Pan Bikash Das Ajay Kumar S.K. Naik Reshma Shinde P. Bhavana S.S.Mali	July 2014	June 2017	ICAR RCER
7.3	ICAR-RCER / DLWM /2014/	Application of optimization techniques in planning and management of land, water and other resources	A. Upadhyaya Manibhushan A. Rahman	July 2014	June 2017	ICAR RCER

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
7.4	ICAR-RCER / DLWM/ 2015/**177**	Optimization of water productivity of aerobic rice based cropping system	S.K. Singh Ajay Kumar	July 2014	June 2017	ICAR RCER
7.5	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 AjayKumar B. Sarkar	Aug. 2014	July, 2017	ICAR RCER
7.6	ICAR-RCER / RC Ranchi/ 2014/**148**	Evaluation of hydrological response of micro water sheds in eastern plateau and hill region	Santosh Mali S.K. Naik P.K.Sarkar	Jan. 2015	June 2018	ICAR RCER
7.7	ICAR-RCER / RC Ranchi/ 2014/**150**	Rehabilitation of coal mine affected areas through agroforestry interventions	P.K. Sarkar S. S. Mali M. K. Dhakar	Sept 2014	Aug 2019	ICAR RCER
7.8	ICAR-RCER/ RC Ranchi/ 2014/**145**	Farmers Participatory Evaluation of Basic slag in Acidic soils of Jharkhand under different cropping systems	S.K. Naik Reshma Shinde A.K. Singh	July 2014	June 2017	Tata Steel
7.9	New	Systemic approach to research and adoption of SRI	S.K. Singh Ajay Kumar	July 2015	June 2018	TATA Trust
7.10	New	Improving rice-lentil-moong bean system productivity through water management.	A.K.Singh Ajay Kumar S.K. Samal	2016	2019	ICAR RCER
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	July 2015 Extd-June 2018	ICAR RCER
8.2	ICAR-RCER / DLFM/EF/ 2011/ **31**	Buffalo improvement	P.C. Chandran A. Dey Pankaj Kumar	June 2012	Dec. 2016 Extd Dec. 2020	ICAR RCER
8.3	ICARRCER/ DLFM/ 2013/ **135**	Characterization of lesser known breeds of farm animals in Eastern India	P.C. Chandran Shanker Dayal Reena K.Kamal	July 2013	June 2017	ICAR RCER
8.4	ICAR-RCER/ DLFM/ 2014/**141**	Management of heat stress in buffalo	S. Dayal	Jan. 2015	Jan. 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 A. Chatterjee	April 2015	Mar. 2019	Network project (linkage NDRI Regional Station, Kalyani)

Sl. No.	Project code	Project Title	Name of PI & CO-PI	Start year	Comp Year	Funding agency
8.6	ICAR-RCER/ DLFM/ 2014/**146**	Development of herb-based calf care mix for production of disease free calf.	S.J. Pandian Pankaj Kumar P.C. Chandran Arun K. Das	Oct. 2014	Sept. 2017	ICAR RCER (linkage IVRI-ERS, Kolkata)
8.7	ICAR-RCER/ DLFM/ 2015/**165**	Meso level animal health interventions and evaluating economic losses from animal diseases	Pankaj Kumar P.K.Ray	Aug 2015	Aug 2018	ICAR RCER
8.8	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
8.9	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
8.10	ICAR-RCER/ DLFM/ 2015/**174**	Identification, documentation and quantification of non conventional feed resources in traditional swine husbandry practices	Asit Chakrabarty	July 2015	July 2018	ICAR RCER
8.11	New	Epidemiological study of Respiratory viral diseases in calves.	P.K.Ray Pankaj Kumar	2016	2019	ICAR RCER
9.0 Fisheries Management						
9.1		National Surveillance Programme for Aquatic Animal Disease (NSPAAD)	S. Mohanty Kamal Sarma T. Kumar	Nov. 2015	Mar. 2018	NFDB
9.2	New	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	New	Assessment of Ichthyofaunal biodiversity 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	July 2017	ICAR RCER
10.2	ICAR-RCER/ DSEE/ 2014/	Growth and instability in production of principal crops in Bihar	Abhay Kumar N. Chandra R. C. Bharati	July 2014	June 2017	ICAR RCER
10.3	New	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
10.4	New	Rural youth as WaSH motivators & caseworkers for watershed linked ECO-WaSH based practices in Jharkhand & Odisha	Asit Chakrabarti	June 2016	July 2017	DST

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

Agrisearch with a human touch