

वार्षिक प्रतिवेदन Annual Report 2010-11



पूर्वी क्षेत्र के लिए भा.कृ.अनु.प. का अनुसंधान परिसर
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ICAR Research Complex for Eastern Region
ICAR Parisar, P.O. Bihar Veterinary College
Patna-800 014 (Bihar)

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Preface

It gives me immense pleasure to bring out the tenth Annual Report of ICAR Research Complex for Eastern Region, Patna. The institute undertakes multi-commodity and multi-disciplinary research so as to enhance productivity of agricultural production system.

In crop science sector, experiments are being conducted on abiotic stress management in rice and wheat. For achieving the goal of food security, emphasis is being given on conservation agriculture and cropping patterns.

To promote vegetable crops cultivation, Swarna Dipti variety of tomato, Swarna Suruchi of pointed gourd, Swarna Mukut of cowpea (bush type) and S. Rituvar of photoinensitive Lablab bean have been released by Institute Variety Release Committee (IVRC). Seven bacterial wilt resistance lines of brinjal have been identified and propagated for plateau region. Five hybrid tomato lines have also been developed which are gaining popularity among the farmers. In order to ensure the supply of quality planting material in horticulture, a total of 3.94 tonnes of breeder seed was produced for different vegetable crops.

In fruit crops, out of 109 genotypes of mango conserved in the field gene bank, Himsagar and ICAR-RCER-R3P2 have been found most promising cultivars. Out of 29 genotypes of litchi being screened, the cv. Trikolia and late Bedana have been found most suitable for the region. Likewise, out of 10 genotypes of Sapota cv. Murabba have been found most promising for plateau region of Jharkhand. The ultra high density orchard of guava (Allahabad Safeda) is gaining popularity among different stakeholders.

In fishery and livestock sector, Jayanti Rohu could be successfully reared in composite culture. Technology has also been standardized for prawn culture in fresh water. Quality fish seed production has been given due importance and the fish fingerlings are being produced in participatory mode. Since, Eastern region of India has 31.0% goat population, genetic improvement in goat (Black Bengal) is being carried out at the Complex.

The Eastern Region of India has about 70% marginal farmers having land operational holdings less than one ha. Hence, the viable integrated farming system models have been developed and replicated in farmers' field for food and nutritional security. Different cropping system have also been evaluated and rice-tomato-bottle gourd, followed by rice-cabbage-cowpea cropping system has been found most suitable for irrigated agro-eco system. Technology has been generated for makhana cultivation in rice fields. Further, makhana-fish-water chestnut system has been developed for farming particularly in Darbhanga, Madhubani, Supaul, Katihar, Purnea, Ararea etc. districts of Bihar. Efforts have been made to increase the water productivity from 0.37 to 0.60 kg/m³, besides conducting 15 training programmes on scaling up of water productivity.

Since, Second Green Revolution is only possible from Eastern India, we are fully aware to re-orient the research priorities particularly during XIIth Five Year Plan period.

I acknowledge the consistent support, keen interest and guidance received from Dr. S. Ayyappan, Secy. DARE and Director General, ICAR in order to implement various research and extension activities. The encouragement, valuable guidance and support rendered by Dr. A.K. Singh, DDG (NRM) during the period under report is duly acknowledged. I am equally thankful to Dr. J.C. Dagar, ADG (Agronomy) and Dr. P.S. Minhas, ADG (Soil and Water Management) ICAR for their support and co-operation from time to time. All Heads of the Divisions/Research Centres deserve appreciation for submitting their research findings in time. The efforts of Dr. R.D. Singh, Head, RCMS, Dr. (Mrs.) Shivani, Sr. Scientist (Agron.), and secretarial assistance by Mr. Kishan Singh and Mr. Sarfaraj Ahmad in bringing out the report is also appreciated.

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

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Characterization of different land uses in old alluvium of agro-ecological region no. 9 of south Bihar was conducted on the basis of different indices of soil quality. Mango orchard was the best land use with high score of relative soil quality index value of 81, followed by rice-wheat-fallow (72), agro-forestry (68) and sugarcane (63). Two lands use namely maize-potato-fallow and red gram with relative soil quality index value of 59 and 53, respectively, were categorized under moderate category of soil quality.

Impact of climate change on major crops of Bihar indicated that by the year 2080 there might be decline in rice and wheat yield. However, rabi maize yield could increase substantial by more than 30%.

Adaptive trial was taken to assess the suitability of molecules for weed control under Zero Till Direct Seeded Rice (ZTDSR) and it was observed that *Bispyriback sodium* was most effective molecule to control the weeds after 25-30 days under ZTDSR.

One hundred and twenty advance breeding lines of rice have been evaluated for drought and sub-mergence tolerance. Ten lines (IR 55419-04, APO, IR 77298-14-1-2-10, IR82870-11, IR 83387-B-B-40-1, IR 83895-B-127-CRA-22-1-1, IR83895-B-127-CRA-4-1-1, IR 83895-B-127-CRA 4-1-1, Abhishek & Lalat) exhibited better tolerance to drought. In case of sub-mergence stress, Swarna Sub-1 performed better compared to other varieties.

The experiment conducted in open top chamber exhibited that with the enhanced conc. of CO₂ and following resource conservation technology, there was increase in the rice yield. However, the increase in the temperature by 1°C reduced the rice productivity even after following the conservation methods.

In case of wheat, Raj 4201 and Raj 4205 exhibited promising characteristics for heat tolerance compared to Ko 807 and Ko 808.

The experiment conducted to find out the effect of transplanted maize on growth and yield

parameters indicated that five week old seedlings were most suitable for transplantation and yield performance (5.3 t/ha).

Growth and yield attributes of 71 accessions of Faba bean (*Vicia faba*) were evaluated and 2 genotypes (BP-14 and BP-23) have been found most promising.

In case of pigeon pea, 38 entries were evaluated. Based on the grain yield, BSMR-736 (3.72 t/ha), followed by ICPL-87 (3.65 t/ha) and Manak (3.62 t/ha) have been found most suitable for cultivation in irrigated ecosystem.

There was paradigm shift in case of insect pest population in rice fields and it was observed that long dry spell, particularly during July and August, checked the leaf hopper population significantly. Accordingly, the termite damage was recorded to be 6.77% and 8.67%, respectively, in hills of BPT-5204 and aerobic varietal trials.

Continues drought like situation for last two years resulted into the growth of new insect pest in rice crop viz. *Haplochrus fasciatus* and *Pyrilla perpeusilla*. The drought like situation enhanced the rodent population in rice-wheat fields to a great extent. Among the various rodent species, *Bandicota bengalensis* (Bandicoot rat) was the most pre-dominant species as its occurrence was recorded to be 67.5% compared to other species.

Promising strains of Makhana were identified, which showed the seed yield of 2.84 t/ha compared to local check (1.56 t/ha).

Out of 109 genotypes of mango being maintained in the experimental farm at Ranchi, Himsagar and ICAR-RCER-R 3P2 have been found most suitable keeping in view the fruit qualities. Late Bedana variety of litchi has also been found the promising cultivar based on the fruit quality. Likewise, in case of Sapota, Murabba cultivar has been found most suitable so far in fruit quality and yield was concerned.

Technology has been standardized establishment of ultra high density guava orchards. Pruning

up to 50% of shoot length thrice in a year could enhance the yield in cv. Allahabad Safeda by 28.04%.

Among the different vegetable crops, tomato, chili, capsicum, pointed gourd, cucumber, bottle gourd, pumpkin, ridge gourd, sponge gourd, french bean, cowpea, drumstick, vegetable soybean, sword bean, jack bean, winged bean, lima bean, velvet bean, yam bean, cluster bean, ivy gourd, spine gourd have been maintained.

Seven promising bacterial wilt resistance lines of brinjal have been identified and propagated to ensure the supply of planting materials.

Technology has been standardized for protected cultivation and poly tunnel cultivation of different vegetable crops.

In case of vegetables, 3.94 tonnes of breeder seed was produced in order to ensure the supply of quality seed material of different vegetables. Apart from that, hybrid tomato (Swarna Sampada) has been developed. Seed production of hybrid tomato has been taken in participatory mode.

Technology has been standardized for round the year production of Oyster mushroom (*Pleurotus florida*, *P. sajor caju* and *Hypsizygus ulmarius*) and five strains of *Volvariella volvacea*.

Integrated farming system models have been developed by involving agriculture, horticulture, live-stock and fishery. These models have been adopted by State Government for replication in different districts of Bihar.

Among the various cropping system, mentha-okra-potato, rice-tomato-bottle gourd and rice-cabbage-cowpea have been found most promising so far in net monetary returns are concerned.

Rice-fish-makhana, makhana-fish-barseem and makhana-fish-water chestnut farming systems have been developed for waterlogged areas. The technology has also been standardized for makhana cultivation in rice fields.

In case of makhana, instant makhana *kbeer* mix product has been prepared in collaboration of CIPHET, Ludhiana. Licensing for manufacturing instant makhana *kbeer* mix has been assigned to M/s Vijay Raj & Co., Darbhanga, Bihar. Likewise, dried instant mushroom *soup* mix has been developed, which is gaining popularity among stakeholders keeping in view its keeping quality and flavour.

Water productivity of different crop sequences under irrigation from secondary reservoir as well as well tube well showed that rice-cabbage-cowpea sequence recorded maximum water productivity values (Rs. 17.8/m³), followed by rice-potato-onion

(Rs. 17.3/m³). Rice-wheat-green gram cropping sequence, however, resulted into lowest water productivity, i.e., Rs. 12.1/m³.

Irrigation nozzle has been developed which works satisfactorily over the operating pressure range of 0.6 to 1.0 kg/cm² with throw diameter range of 9.2-11.2 m, discharge rate of 1.8-2.6 m³/h, and application rate of 2.6 to 2.7 cm/h, respectively.

The performance of kids born from selective breeding of Black Bengal breed of goats was evaluated in terms of height at withers, body length, girth and body weight. The body weight at the age of 3 months in the base and selected populations were 5.6 ± 0.28 and 6.4 ± 0.32 kg, respectively.

Leptospirosis detected in the bovine population at 9.1% level implies that this re-emerging disease can have impact on public health. *Leptospira hardjo* is the main cause of human leptospirosis and it needs to be addressed to avoid public health consequences.

Initial investigation using ELISA revealed a prevalence of 29% Blue Tongue antibodies in goat population. The over-all prevalence rate of PPR was 36.65% in Bihar indicating that there is emerging need for vaccination in small ruminant population.

In case of fisheries, technology has been standardized for integration of Jayanti rohu in composite culture. Fish seed is being produced in participatory mode. Technology has also been standardized for fresh water prawn culture.

Under NAIP, integrated farming system models have been replicated in Chakramdas and Pidapur village covering 250 households. Improved varieties of rice, wheat, mustard and potato have been introduced, which resulted into increase in cropping intensity from 200% to 300%.

During the period under report, about 50 training programmes have been conducted on various aspects of Natural Resource Management, Horticulture, Crop Science, Water productivity, Livestock and Fishery etc. besides 10 OFT, 19 FLDs and 05 Capacity Building Programmes organized by KVK.

Patent application has been drafted for Low Energy Water Application (LEWA) device. Likewise, Decision Support Tool is in prior art search so as to file the patent.

कार्यकारी सारांश

मृदा के विभिन्न गुणों के आधार पर कृषि-परिस्थितिकी-9 में दक्षिण बिहार में बाढ़ से आई हुई मिट्टियों को अच्छा और हल्की श्रेणी का पाया गया है। आम के बगीचों की मृदा के प्रयोग का मृदा गुण चिन्ह दर 81, धान-गेहूँ (72), कृषि वानिकी (68) और ईख (63) अच्छी श्रेणी के पाये गये। दो प्रकार के मृदा प्रयोग जिनका नाम निम्न मक्का-आलू और चना में क्रमशः 59 और 53 का हल्के मृदा गुणों में स्पष्ट रूप से पाये गये।

बिहार राज्य की मुख्य फसलों पर मौसम परिवर्तन के प्रभाव के कारण वर्ष 2080 तक धान और गेहूँ के उपज में कमी होने की आशंका है जबकि रबी मक्का की उपज में 30 प्रतिशत तक वृद्धि होने की संभावना है।

अनुकूलन परीक्षण द्वारा यह देखा गया कि जीरो टिलेज सीधी धान (जेड टी डी एस आर) में बाईइसपारीबैक सोडियम के प्रयोग द्वारा 25-30 दिन के भीतर खरपतवार नियंत्रण किया जा सकता है।

धान के 120 अग्रिम प्रजनन वंशक्रमों का सूखे और मिलावट सह्यता हेतु मूल्यांकन किया गया। 10 वंशक्रम (आईआर55 419-04, एपीओ, आईआर 77298-14-1-2-10, आईआर82870-11, आईआर 83387-बी-बी-40-1, आईआर83895-बी-127-सीआरए-4-1-1, आईआर 83895-बी-127- सीआरए-4-1-1, अभिषेक और ललत) को सूखे के प्रति सह्यता प्रदर्शित की। अन्य किस्मों की तुलना में स्वर्ण सब-1 को सब मारजिन प्रतिबल के आधार पर अच्छा पाया गया।

सघन संरक्षण तकनीक के परीक्षण में ऊपर से खुले हुए चेम्बर में CO₂ के सांद्रीकरण को बढ़ाने पर धान की उपज में वृद्धि पायी गयी। यद्यपि संसाधन विधि में 1⁰ सेंटीग्रेट तापमान को बढ़ाने पर धान की उत्पादकता पर तीव्रता न्यूनतम पायी गयी।

गेहूँ में उष्णीय सह्यता की तुलना में राज 4201, राज 4205 और केओ 807, 808 करने पर राज 4201 और राज 4205 आशाजनक गुणों वाला पाया गया।

मक्के के रोपाई की वृद्धि और उपज के प्राचल के प्रभाव पर परीक्षण किया गया। देखा गया कि पाँच सप्ताह पुरानी पौध को रोपाई हेतु उपयुक्त पाया गया जिससे प्राप्त उपज (5.3 टन/हे.) थी।

फेबा बीन (विकिया फेबा) की 71 किस्मों का मूल्यांकन करने पर 2 जननद्रव्यों (बीपी-14 और बीपी-23) को सबसे

अधिक संभावनाओं वाला पाया गया।

अरहर के 38 जननद्रव्यों का मूल्यांकन किया गया। सिचाई कृषि-प्रणाली में उपज के आधार पर बीएसएमआर-736 (3.72 टन/हे.), आइसीपीएल-87 (3.65 टन/हे.) और मानक (3.62 टन/हे.) में अधिक उपज (3.62-3.72 टन/हे.) पाई गई।

विशेषकर जुलाई-अगस्त के महीने में धान के खेतों में लंबे समय तक सूखा रहने पर कीट पतंगों की संख्या में परिवर्तन पाया गया और लीफ हापर की संख्या में कमी पाई गई। इसी प्रकार बीपीटी-5204 के पिंडलीक और वायुजीवी किस्म जाँच में दीमक के द्वारा क्रमशः 6.77 और 8.67 प्रतिशत नुकसान पाया गया।

लगातार सूखे की स्थिति में जैसा कि पिछले दो वर्ष से देखा जा रहा है धान में नये कीट पतंगों जैसे हापालोचरस फेसिएटस और पाइरिला परपीउसीला की संख्या में वृद्धि देखी गयी। इस तरह की स्थिति में धान-गेहूँ के खेतों में कृतंकनाशी कीट की वृद्धि देखी गई। विभिन्न कृतंकनाशी प्रजातियों बैङ्किोटा बेंगालेसिस (बैंडिकुट रैट) सबसे अधिक प्री-प्रभावी प्रजाति को दूसरे प्रजाति की तुलना में 67.5 प्रतिशत अंकित किया गया।

स्थानीय चेक (1.56 टन/हे.) की तुलना में मखाना की आशाजनक प्रजाति की बीज दर (2.84 टन/हे.) की पहचान की गई।

शोध केन्द्र राँची में आम के 109 जननद्रव्यों को संरक्षित किया गया है, जिसमें फलों की गुणवत्ता के आधार पर हिमसागर और आईसीएआर-आरसीईआर-आर 3पी2 पूर्णतः उपयोगी पाया गया। फल की गुणवत्ता के आधार पर लीची में लेट बेदाना किस्म को अच्छी किस्म जबकि गुणवत्ता और उपज के आधार पर सपोटा में मुरब्बा किस्म को सबसे अधिक उपयोगी पायी गयी।

वर्ष के दौरान 50 प्रतिशत प्ररोहों की तीन बार छँटाई करने पर इलाहाबाद सफेदा किस्म की उपज में 28.04 प्रतिशत की वृद्धि पायी गयी।

विभिन्न प्रकार की सब्जियों जैसे टमाटर, मिर्च, शिमला मिर्च, परवल, खीरा, लौकी, कोहड़ा, नेनुआ, झींगी, फ्रेंचबीन, बोदी, सहजन, सब्जी सोयाबीन, स्वार्ड बीन, विंगड बीन, लैक बीन, लाईमा बीन, वैल्वेबीन, याम बीन, कल्सटर बीन, आईवा गार्ड, स्पाइन गार्ड का रखरखाव किया गया। बैंगन की सात आशाजनक जीवाण्विक म्लानि रोग प्रतिरोधी जननद्रव्य की पहचान की गई जिससे आगे की रोपण सामग्री तैयार की जाएगी।

विभिन्न प्रकार के सब्जी फसलों की सुरक्षित खेती और पॉली टनल की प्रौद्योगिकी का मानकीकरण किया गया।

विभिन्न प्रकार की सब्जियों के 3.94 टन मूल-बीज का उत्पादन किया गया जिससे गुणवत्ता युक्त बीज का उत्पादन किया जायेगा। इसके अतिरिक्त टमाटर का संकर बीज (स्वर्ण सम्पदा) विकसित किया गया। सहभागिता के आधार पर हाईब्रिड बीज का उत्पादन किया गया।

आयस्टर मशरूम की पाँच किस्मों (*प्लूरोटस लोरिडा*, *पी. सजोर काजू* और *हाईपिसिजस अल्मेरियस*) और *वलबेरिला वलवेसिया* से वर्षभर उत्पादन हेतु उत्पादन तकनीक का मानकीकरण किया गया।

कृषि, बागवानी, पशुधन और मत्स्य को सम्मिलित करते हुए समन्वित कृषि प्रणाली को विकसित किया गया। इन सभी प्रणालियों को बिहार सरकार द्वारा विभिन्न जिलों में अपनाया गया।

विभिन्न फसल प्रणालियों में मेंथा-भिंडी-आलू, धान-टमाटर-कद्दू और धान-गोभी-बोदी प्रणाली शुद्ध लाभ हेतु अच्छी पाई गई।

जलभराव वाले खेतों में धान-मछली-मखाना, मखाना-मछली-बरसीम और मखाना-मछली-वाटर चेस्टनेट फसल प्रणाली विकसित की गई। धान के खेत में मखाना की खेती की तकनीक को मानकीकृत किया गया।

सीफेट, लुधियाना के सहयोग से तत्काल मखाना खीर का मिश्रण बनाया गया। तत्काल मखाना खीर का मिश्रण बनाने को मेसर्स विजय राज एण्ड कम्पनी को निर्दिष्ट किया गया। इसी प्रकार तत्काल मशरूम सूप मिक्स को विकसित किया गया।

विभिन्न प्रकार के अनुक्रम फसलों का जल उत्पादकता दूसरे जलाशय जैसे ट्यूबवेल में द्वितीय वर्ष के प्रयोग में यह देखा गया कि सबसे अधिक धान-पत्तागोभी-बोदी अनुक्रम में जल उत्पादकता रु. 17.8/मी³ जबकि धान-आलू-प्याज रु. 17.3/मी³ जबकि इन दोनों से भी अच्छा धान-गेहूँ-चना रु. 12.1/मी³ में पाया गया।

सिंचाई के लिए फव्वारे के अग्रभाग का ईजाद किया गया जिसका परिणाम काफी संतोषजनक रहा है, जिसका दबाव में कार्य करने का दर 0.6 से 1.00 कि.ग्रा./से.मी.² के साथ फेंकने के लिए व्यास दर 9.2-11.2 मी., डिस्चार्ज 1.8-2.6 मी³/हे. और अनुप्रयोग दर 2.6-2.7 सें. मी./हे. हैं।

ब्लैक बंगाल की कुछ खास नस्लों में बकरी के बच्चों का मूल्यांकन वजन, ऊँचाई, गहराई और शरीर की लंबाई के अनुसार किया गया। तीन महीने के वजन के आधार पर यह कुछ बच्चों में क्रमशः 5.6 ± 0.28 और 6.4 ± 0.32 पाया गया।

प्रारंभिक जाँच में प्रणाली में बकरी की जनसंख्या में 29 प्रतिशत ब्लू टंग एंटीबाडी में एलीसा विशिष्ट रूप से कारगर साबित हुआ। कुल मिलाकर बिहार में पीपीआर की 36.65 प्रतिशत सफलता दर पायी गयी जो यह दर्शाती है कि पागुर करने वाले जानवरों की संख्या में यह अधिक है।

मत्सय तकनीक में मिश्रित कल्चर संवर्ध में जयंती रोहू के समाकलन का मानकीकरण किया गया। सहभागिता के आधार पर जीरा (मछली बीज) का उत्पादन किया गया। शुद्ध जल में झींगा पालन की तकनीक का मानकीकरण किया जा चुका है।

एनआईपी के तहत, समन्वित कृषि प्रणाली का नमूना चक्रमदास और पीडापुर गाँव के 250 परिवारों में दोहराया गया। धान, गेहूँ, सरसों और आलू के उन्नत किस्मों को उन परिवारों में अपनाने से फसल सधनता में 200 से 300 प्रतिशत की वृद्धि पायी गयी।

कृषि विज्ञान केन्द्र द्वारा प्राकृतिक सम्पदा संसाधन, बागवानी, फसल विज्ञान, जल उत्पादकता, पशुधन और मछली इत्यादि में 10 ओएफटी, 19 एफएलडी और 5 क्षमता निर्माण योग्यता का आयोजन किया गया।

न्यूनतम उर्जा जल प्रयुक्त उपाय (लेवा) का विशिष्ट अधिकार पत्र का प्रारूप तैयार किया गया तथा डिसिजन सपोर्ट टूल का विशिष्ट अधिकार पत्र दाखिल किया गया।

Historical Perspective

The eastern region comprises of plains of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand and West Bengal, represents 21.85% of the geographical area of the country and supports to 33.64% of country's population. Though the region is endowed with rich natural resources to support higher agricultural production, livestock and fisheries, the production levels have remained low due mainly to lack of location-specific production technologies, dissemination of scientific knowledge to farmers, fragmented land holdings, low seed replacement rate, large population of non-descript type of livestock, poverty, lack of infrastructure facilities, natural calamities e.g. frequent floods, water logging and droughts, and social conflicts. Nevertheless, the region has vast untapped potential to enhance the production. Keeping this fact in view, planning priorities has also been setup to achieve the food self sufficiency at national level from eastern region under Look East Policy of Govt. of India.

ICAR Research Complex for Eastern Region (ICAR-RCER), Patna came into existence on the 22nd February 2001 so as to address diverse issues relating to land and water resources management, crop husbandry, horticulture, agroforestry, aquatic crops, fishery, livestock and poultry, agro-processing and socio-economic aspects in holistic manner for enhancing research capability and providing a backstopping for improvement in agricultural productivity and sustainability. Hence, the mandate of the institute is *"to undertake strategic and adaptive research for efficient integrated management of natural resources so as to enhance productivity of agricultural production systems comprising of field, agricultural and horticultural crops, aquatic crops, agro-forestry, livestock, avian, and fisheries in different agro-ecological zones of the eastern region"*. The modalities to achieve the mandate include:

- To facilitate and promote coordination and dissemination of appropriate agricultural

technologies through network/consortia approach involving ICAR institutes, State Agricultural Universities, and other agencies for generating location-specific agricultural production technologies through sustainable use of natural resources.

- To provide scientific leadership and to act as a center for vocational as well as advanced training to promote agricultural production technologies.
- To act as repository of available information and its dissemination on all aspects of agricultural production systems.
- To collaborate with relevant national and international agencies in liaison with state and central government departments for technology dissemination.
- To provide need based consultancy and advisory support for promoting agriculture, horticulture and livestock in the region.
- Socio-economic evaluation and impact assessment of agricultural technologies.

The complex has four divisions besides two research centres and one KVK. The organizational setup of the complex is given in Fig. 1.

Finance

Summary of allocation and expenditure during the financial year 2010-2011 of the complex is presented below (Table 1).

Table 1. Financial allocation and expenditure during the year 2010-11 (Rupees in Lakhs)

Head of accounts	Budget allocation		Actual expenditure	
	Plan	Non-plan	Plan	Non-plan
Establishment charges	0.00	1059.20	0.00	1059.10
T.A.	15.00	5.00	15.00	5.00
HRD	6.00	0.00	3.94	0.00
Works	250.54	35.00	250.54	34.95
Other charges	311.46	171.80	311.37	171.21
Total	583.00	1271.00	580.85	1270.26

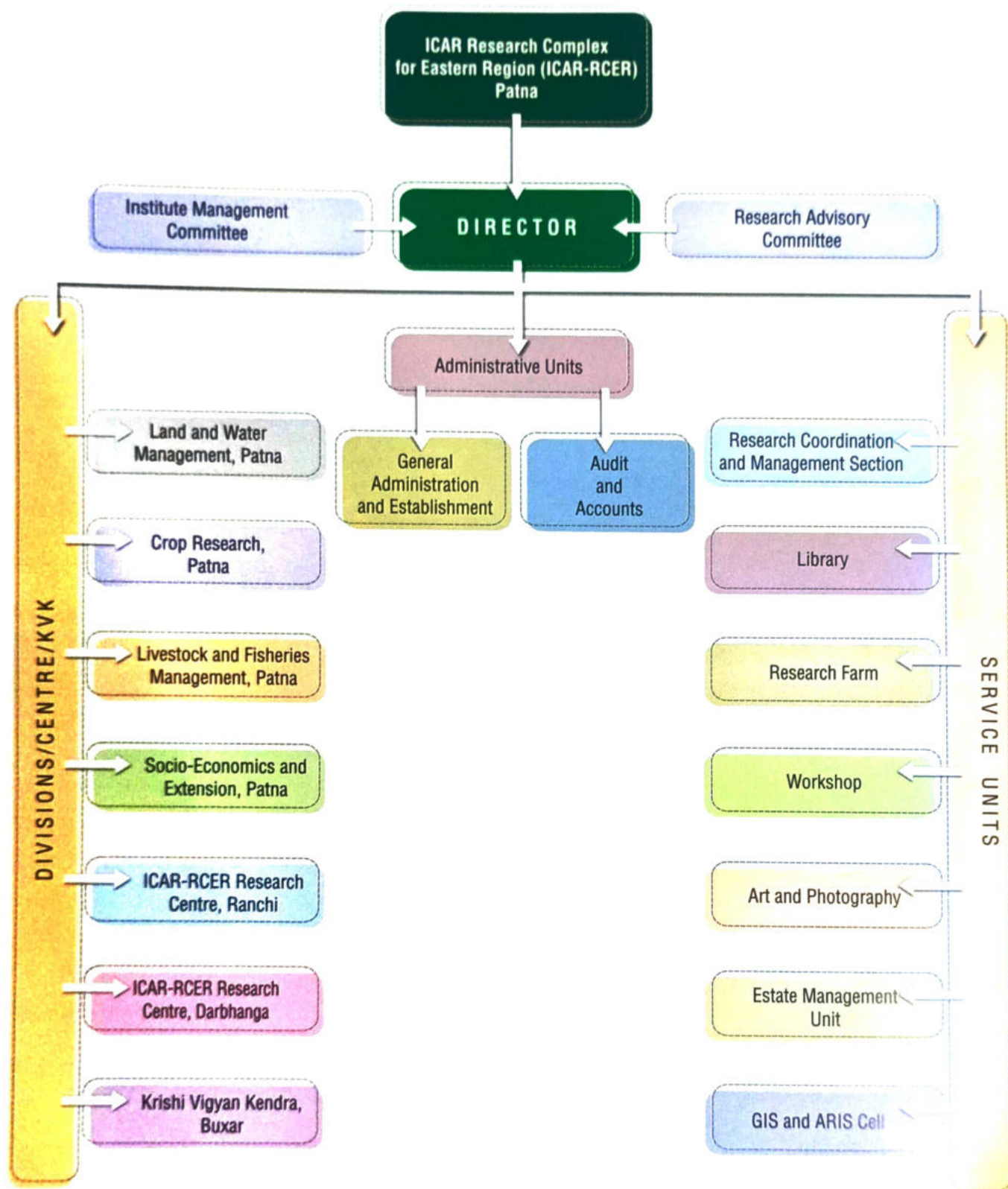


Fig. 1. Organogram of ICAR Research Complex for Eastern Region, Patna

Weather Data ICAR-RCER, Patna

Mean maximum monthly temperature varied from 20.1°C in the month of January to 38.5°C in June and minimum monthly temperature varied from 8.3°C in January to 27.5°C in June. A maximum daily sunshine period of 8.7 hrs was recorded in the month of March and minimum of 5.4 hrs/day in January.

The total annual precipitation was 740.2mm and the patterns of rainfall during monsoon months was erratic. It was maximum in the month of August (266.5mm), followed by July (205.3 mm). More than 50% rainfall was recorded in July and August (Table 2)

Table 2. Monthly meteorological data recorded at ICAR-RCER, Patna

Month	Temperature (°C)		Relative humidity(%)		Sunshine (hrs/day)	Rainfall (mm/day)
	Max	Min	7.00 hrs	14.00 hrs		
January	20.1	8.3	86.6	67.0	5.4	0.0
February	27.4	12.5	76.2	46.0	7.7	4.4
March	35.1	18.8	48.8	28.8	8.7	0.0
April	40.3	24.2	42.1	23.6	8.3	0.0
May	37.6	25.5	58.1	39.6	7.8	64.3(4)
June	38.5	27.5	68.1	51.2	7.9	53.2(7)
July	33.9	27.1	81.9	67.6	6.3	205.3(10)
August	34.0	26.9	83.4	70.5	6.2	266.5(9)
September	32.9	26.2	82.9	70.9	6.0	66.7(7)
October	31.8	22.5	82.9	66.5	6.3	79.3(8)
November	29.5	18.1	79.5	57.4	6.9	0.0
December	24.6	9.9	77.5	57.6	5.7	0.5
Mean/total	32.1	20.6	72.3	53.9	6.9	740.2

Note: Figure in parenthesis indicates the number of rainy days

Weather Data, Research Centre - Ranchi

Mean monthly maximum temperature varied from 21.6°C in the month of January to 39.1°C in the month of April. Mean minimum monthly temperature varied from 8.3°C in the month of January to 25.3°C in the month of June. Mean relative humidity varied from 83% in the month of March to 92% in the month of July, August and September. Total annual precipitation was 835 mm out of which 79.28% was received during monsoon period (Table 3).

Table 3. Monthly meteorological data recorded at Ranchi Centre of the Complex

Month	Average temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)
	Minimum	Maximum		
January	8.3	22.3	88	-
February	12.3	25.3	85	12
March	18.2	32.4	83	-
April	21.8	39.1	84	18
May	24.3	36.0	89	49
June	25.3	35.3	90	101
July	23.6	29.6	92	226
August	24.0	30.1	92	152
September	21.8	28.4	92	183
October	18.8	27.8	91	58
November	15.0	24.7	90	13
December	9.3	21.6	89	23
Total Annual Rainfall, mm			835	

In general, year 2010 witnessed severe decline in total annual rainfall. Rainfall in all months except December was below normal. The distribution of normal rainfall for the year 2010 is given in Fig. 2.

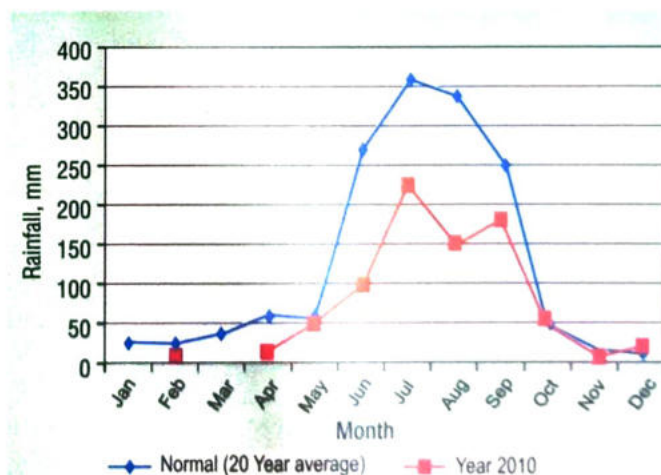


Fig. 2. Distribution of normal rainfall and rainfall for the year 2010

The month of June was severely affected with rainfall deficiency of 63% followed by August (56%). In general, there was 46% deficiency in monsoon rainfall and 45% deficiency in total annual rainfall.

Assessment of Impact, Adaptation and Mitigation of Climate Change on Major Crops of Bihar

Analysis of extreme weather events

Four representative centers namely Pusa (Zone I), Madhepura (Zone II), Sabour (Zone IIIA) and Patna (Zone IIIB) were selected to study the impacts of climate change and adaptation measures to overcome its effects on important cereal and pulse crops grown in Bihar. The historical meteorological data were analyzed to identify the long-term changes in extreme weather events. The weather data of 45 (1961-2005) years for Patna, Pusa and Madhepura and of 34 (1972-2005) years for Sabour were analyzed. Events (number of days) with extreme weather conditions were computed year wise using the following assumptions: (i) average number of days with maximum temperature more than or equal to 40°C; (ii) average number of days with minimum temperature less than or equal to 5°C, and (iii) average number of days with rainfall of more than 90 mm in a day.

The study showed decrease in number of events with maximum temperature more than or equal to 40°C for all zones. A significant ($P=0.10$) decrease in number of days with maximum temperature of 40°C and above is observed for Sabour. Extreme minimum temperature events showed a significant ($P=0.10$) decreasing trend for Pusa and Patna, while an increasing trend for Madhepura ($P=0.10$) and Sabour. Number of rainy days with extreme rainfall showed an increasing trend for all stations except Madhepura. Significant increase ($P=0.10$) in days with extreme rainfall is observed for Sabour (zone IIIB) only.

Impact of climate change on crops

With the current cultivars, cultivation and management practices, the impacts of climate change on rice (short duration Saket-4, medium duration Sita and long duration Radha), wheat, rabi and kharif maize under A2 and B2 scenarios of HADCM3 were explored at Pusa. For 2080's yield of rice declined for both A2

and B2 emission scenarios (for A2 up to 44% and for B2 up to 27%), timely sown wheat yield decreased by 14 % for A2 while for B2 it decreased by 7%. Yield of kharif maize decreased for both A2 (11%) and B2 (12%). Decrease in yield was less for B2 scenario as compared to A2 scenario for wheat and rice. Rabi maize yield however showed increase in 2080 for B2 (15%) as compared to 34% for A2.

Adaptation strategies

Adaptation measures like, shifting of sowing dates, DSR, earlier transplanting, and reducing seed rate and plants per hill for rice crop were carried out using INFOCROP model. Different adaptation measures showed increase in yield of 37% to 2.4% for 2020 and 30% to 3.8% for 2050. But there was decrease in yield in 2080 even after implementing the above said adaptation measures (Fig. 3).

Hydrological Modeling for Assessment of Climate Change Impact in the Bhavani River Basin

For assessing the impact of climate change on streamflow in the Upper Bhavani sub-basin (catchment area of 1494.10 km²), six different GCMs (HadCM3, GFDL, CSIRO, NIES, ECHAM, CGCM2) and two emission scenarios (A2a and B2a) were considered. Mean monthly rainfall (mm/day), minimum and maximum temperature generated using different GCMs for the period 1980, 2020, 2050, and 2080 were extracted from four/six grid points covering the entire Bhavani basin and interpolated using Inverse Distance method. Mean monthly rainfall for 16 rain gauge stations was extracted from the generated rainfall surface and monthly rainfall factor for each station was calculated for input to the hydrological model.

There was a large variation in the simulated stream flow under different GCM scenarios (Table 4). There was increase in annual stream flow under most of the cases except under GFDL and CSIRO scenarios. In case of GFDL, under A2a emission scenario there was decrease in annual stream flow during 2050 (15%)

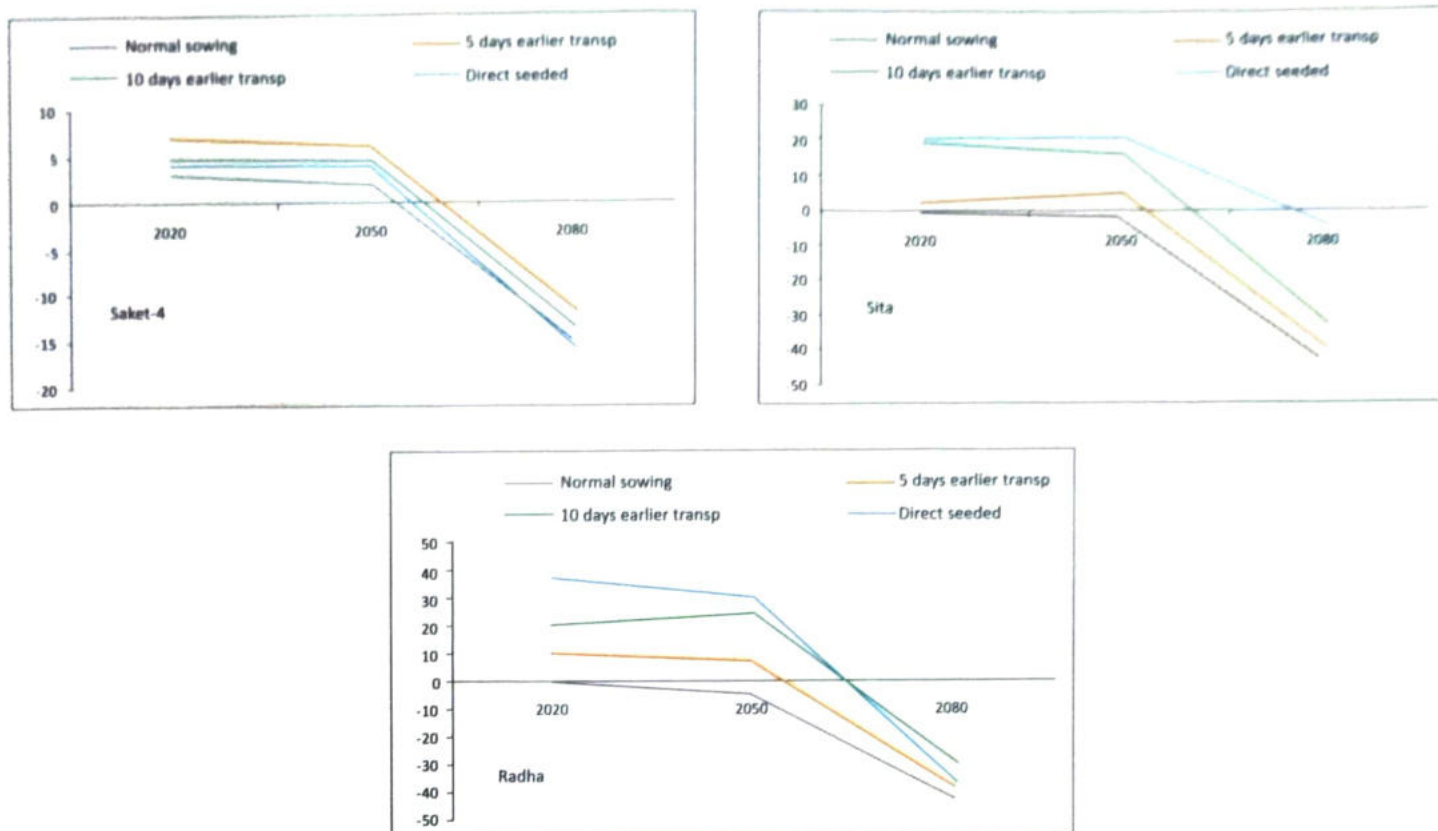


Fig. 3. Per cent change in yield of three varieties of rice at Pusa on implementing adaptation measures for 2020, 2050 and 2080

Table 4. Change in stream flow under different GCM scenarios.

Season	Period	HadCM3*		CGCM2		NIES		GFDL		ECHAM		CSIRO		All GCM	
		A2a	B2a	A2a	B2a	A2a	B2a	A2a	B2a	A2a	B2a	A2a	B2a	A2a	B2a
Annual	2020	15	6	19	12	26	19	11	34	3	32	-17	-9	8	16
	2050	9	23	31	18	67	33	-15	27	24	31	-11	-16	15	13
	2080	26	28	9	2	155	83	-14	41	60	36	16	-8	39	22
Jun-Aug	2020	28	4	24	-9	37	18	-4	8	-2	18	-3	16	8	7
	2050	9	39	65	28	63	67	-18	-18	-1	10	3	-1	20	14
	2080	27	47	-9	4	118	63	-45	-42	26	55	46	20	20	15
Mar-May	2020	37	28	-33	-33	222	152	-27	-49	-34	8	-10	-1	17	21
	2050	50	12	-38	-3	477	526	-29	8	-21	1	-12	-40	83	91
	2080	131	30	-61	-54	921	548	-64	-56	5	4	-10	-36	138	71
Sep-Nov	2020	-1	7	26	35	-12	-2	28	65	13	45	-27	-27	8	23
	2050	7	4	22	16	6	56	-8	63	48	50	-22	-23	2	1
	2080	22	6	35	12	65	15	17	116	93	30	2	-24	39	21
Dec-Feb	2020	2	6	-37	-16	-13	-1	-10	24	-28	69	-21	-34	-19	10
	2050	11	-2	-52	-18	-14	-1	-58	10	29	41	3	-11	-24	-15
	2080	5	3	32	-52	-37	-1	-3	7	38	1	-12	-14	-11	-26

*HadCM3 = Hadley Centre for Climate Prediction & Research; CGCM2 = Centre for Atmospheric Research; CSIRO = Australian Commonwealth Scientific and Industrial Research Organization; GFDL = Geophysical Fluid Dynamics Laboratory; ECHAM = Max Plank Institute for Meteorology.

HadCM3 = Hadley Centre for Climate Prediction & Research; CGCM2 = Centre for Atmospheric Research; CSIRO = Australian Commonwealth Scientific and Industrial Research Organization; GFDL = Geophysical Fluid Dynamics Laboratory; ECHAM = Max Plank Institute for Meteorology.

and 2080 (14%). Similarly, there was decrease in annual stream flow under the CSIRO generated rainfall and temperature scenarios of A2a and B2a emission scenario during 2020 and 2050. During 2080, there was increase (16%) in annual stream flow under A2a emission scenario but decrease (8%) in annual stream flow under B2a emission scenario. The increase in annual stream flow was the maximum under NIES generated scenarios for both the emission conditions

2020, 2050 and 2080. There were 67 and 155% increase in annual stream flow during 2050 and 2080, respectively under A2a emission scenarios. In case of B2a emission scenarios, there were 33 and 83% increase in annual stream flow during 2050 and 2080, respectively. This could be attributed to the variation in rainfall change predicted by different GCMs. The NIES model predicted rainfall change as high as 294.4% and 218.7% under A2a and B2a emission

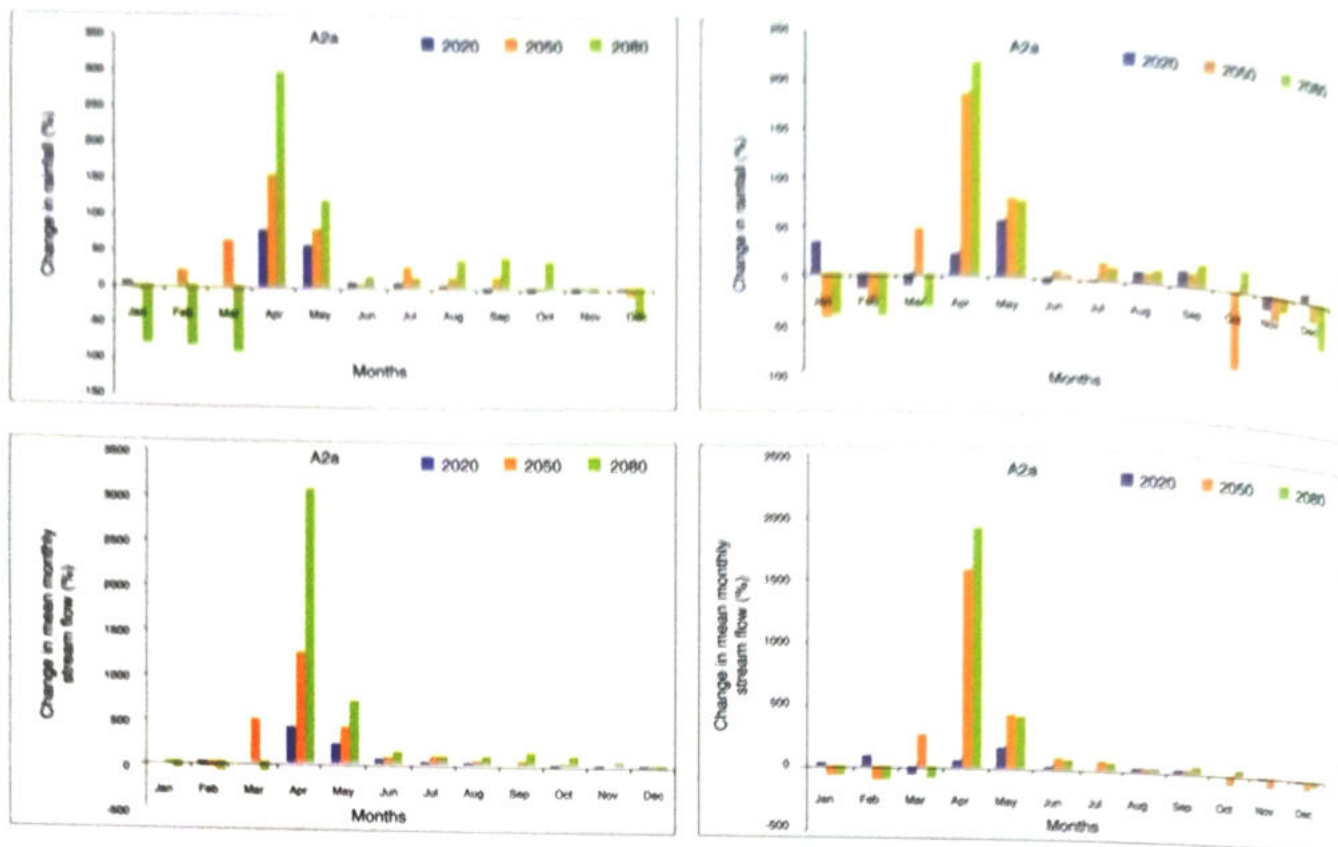


Fig. 4. Change in mean monthly rainfall and streamflow under NIES GCM generated climate change scenarios

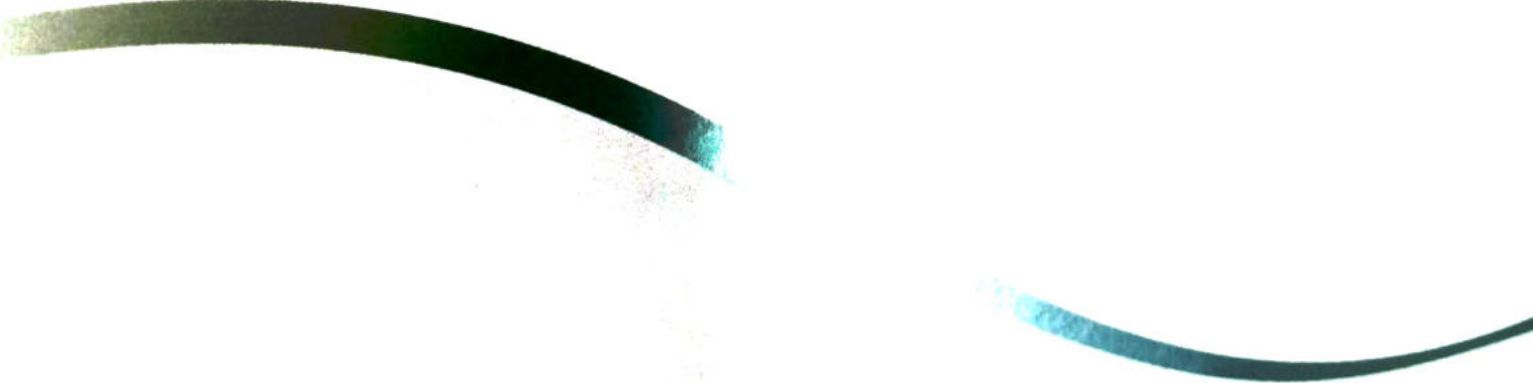
scenario, respectively (Fig. 4). During the same period, the rainfall change predicted by other models varied from 29.5 (HadCM3) to 71.9% (ECHAM) under A2a emission scenario, and from 27.3 (CGCM2) to 85.9% (GFDL) under B2a emission scenarios. During 2050, NIES model predicted 154.6 and 186.4% rainfall change under A2a and B2a emission scenarios, respectively. Whereas the rainfall change predicted by other GCMs during 2050 varied from 23.8 (GFDL) to 63.7% (HadCM3) and from 34.4 (CGCM2) to 55.7% (CSIRO) under A2a and B2a emission scenarios, respectively. When all the GCMs considered together (ensemble average), there were 8, 15 and 39% increase in annual stream flow during 2020, 2050 and 2080, respectively under A2a emission scenarios. Simulation results showed 16, 13 and 22% increase in annual stream flow under B2a emission scenario during 2020,

2050 and 2080, respectively. During monsoon season (Jun-Aug) also there was increase in simulated stream flow in most of the cases except in case of GFDL. On an average, there was increase in monsoon season stream flow of 8, 20 and 20% under A2a emission scenario and 7, 14, 15% under B2a emission scenario during 2020, 2050 and 2080, respectively. During Dec-Feb, there was decrease in stream flow in 2020 (19%), 2050 (24%) and 2080 (11%) under A2a emission scenario, whereas under B2a emission scenario there was decrease during 2050 (15%) and 2080 (26%), and increased during 2020 (10%). Thus, the temporal variability in the rainfall and water resources availability in the basin under the influence of climate change indicated the need for development of different adaptation strategies through land, water, crop and agronomic management interventions.

Feb 1



Research Achievements



RICE

Effect of Drought on Vegetative and Reproductive Stages of Advance Breeding Lines and High Yielding Varieties

In rainfed lowland areas, one of the major abiotic constraints depressing rice production is water stress, including deficit (drought) or excess water (flood). Drought stress is a serious threat to rice production and yield stability in rainfed rice areas. In this context, a field drought- screening was done during kharif season in 2010. One hundred and twenty five entries received from IRRI and CRRI, Cuttack alongwith some local varieties were evaluated with six checks under two treatments, i.e., rainfed and irrigated. Stress was imposed at vegetative and reproductive stages for 13 and 17 days, respectively, by withholding irrigation. Thereafter, crop was re-irrigated for study of recovery rate. Soil moisture status of experimental field during stress period was also recorded and it varied from 7.6-10.3%. Ten entries showed better drought tolerance under field stress as compared to check varieties. Grain yield varied from 2.5-11.2 t/ha and 0.7-6.4 t/ha under non stress (Irrigated) and stress (Rainfed) condition, respectively. The relative water content (RWC), chlorophyll content, leaf area index and photosynthesis rate during stress period was also recorded. The RWC values of advance breeding lines varied from 36-84%. Ten lines out of 125 performed better and showed tolerance under water stress condition. IR55419-04, APO, IR77298-14-1-2-10,

IR82870-11, IR 83387-B-B-40-1, IR83895-B-127-CRA-22-1-1, IR83895-B-127-CRA-4-1-1, IR83895-B-127-CRA-4-1-1, Abhishek and Lalat showed better tolerance to drought under vegetative and reproductive stages (Fig. 5). These lines may be further investigated for their stress tolerance capability.

Physiological management for improved abiotic stress tolerance

Drought stress

High yielding rice varieties of short duration nature were reared in two blocks and one of them was subjected to water stress by withholding irrigation at panicle initiation and flowering stages. The effect of drought stress on gas exchange and chlorophyll fluorescence parameters were measured. Photosynthesis rate declined in plants subjected to stress under both the stages. Varieties Dhanalakshmi, Prabhat and Richaria recorded maximum photosynthetic rate than Saket 4. Stomatal conductance was also observed to be declining in all four varieties with stress. However, Saket 4 showed lesser decline in conductance with stress than Prabhat and Dhanalakshmi. Chlorophyll fluorescence parameters viz. maximum quantum yield of PSII, electron transport rate, photochemical quenching and non-photochemical quenching were recorded in all four varieties. All the parameters except non photochemical quenching declined with stress at panicle initiation and flowering stage. The decline in yield of PSII, electron transfer rate and photochemical quenching was more in Saket 4 than other three varieties. Non-photochemical quenching was higher when stress was imposed among varieties and maximum quenching was observed in Saket 4. Higher photosynthesis rate coupled with lesser decline in yield of PSII, electron transfer rate and photochemical quenching might have increased the tolerance of varieties Prabhat,



Fig. 5. Promising rice genotypes for drought situations

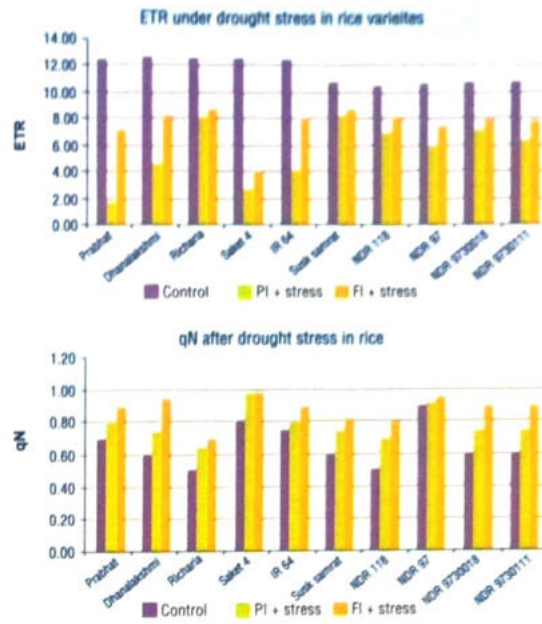
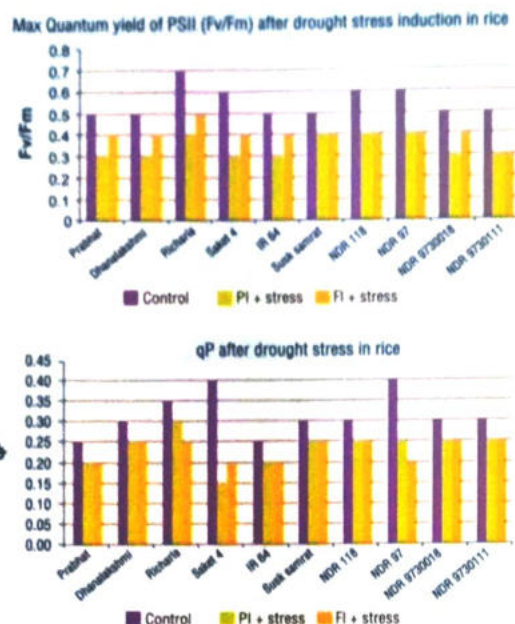


Fig. 6. Performance of rice varieties under drought conditions

Dhanalakshmi and Richaria towards drought stress. NDR series of varieties exhibited greater proline content, less reduction in leaf area, grain weight and chlorophyll content with drought stress (Fig. 6).

Submergence stress

Three promising rice varieties viz. Sita, IR64, Bharani and submergence tolerant cultivar FR-13A were subjected to submergence stress at seedling and active tillering stages. The effect of anti-GA application on gas exchange, chlorophyll fluorescence and grain yield parameters were measured. Photosynthesis rate, stomatal conductance and transpiration rate declined in plants subjected to submergence stress during seedling and tillering stages. However Anti-GA application had enabled all the varieties to maintain their photosynthesis, conductance and transpiration rate at both the stages. The transpiration efficiency (A/T) and carboxylation efficiency were relatively higher in tolerant check variety FR13A. The internal CO₂ concentration (Ci) in mesophyll cells of plants declined with stress imposition in all varieties. However, anti GA application had resulted in enhanced Ci in all varieties. This might have contributed to maintenance of higher photosynthetic rate and accumulation of carbohydrates, which would have been useful in recovery process in plants. Chlorophyll fluorescence parameters viz. maximum quantum yield of PSII, electron transport rate (ETR), photochemical quenching declined with stress at panicle initiation and flowering stage. The decline in yield of PSII, ETR and photochemical quenching was less in FR 13A followed by Bharani and IR 64. Panicle weight and grain weight were found to be decreased in all varieties with submergence stress, however decline was less when the plants were treated with anti-GA. Higher photosynthesis rate coupled with lesser decline in yield of PSII, electron

transfer rate and photochemical quenching with application of anti-GA might have increased the tolerance towards submergence stress and maintenance of yield in rice.

Evaluation of IPM Practices for Hopper Insect Pests

To study the environmentally safer, economically viable and effective technique to manage the hopper pests in rice crop, seven treatments viz., T₁ (control), T₂ (spray of neem oil at the time of transplanting), T₃ (soil application of neem cake at transplantation), T₄ (use of *Braconveria bassiana*), T₅ (use of confidor-Imidacloprid 17.8% SL), T₆ (Neem oil + Neem cake) and T₇ (Neem cake + Bb) were evaluated (Fig. 7). Like previous year, this year also long dry spell was experienced in July and August resulted in high temperature and low humidity. The incidence of green leafhopper (*Nephotettix virescens*) was recorded at milk stage of the crop 0.2-0.4 hopper/ hill and 2-3, hopper sweep in sweep net. The average density of green leafhopper recorded in three years is given in Table 1.



Fig. 7. IPM experimental plots

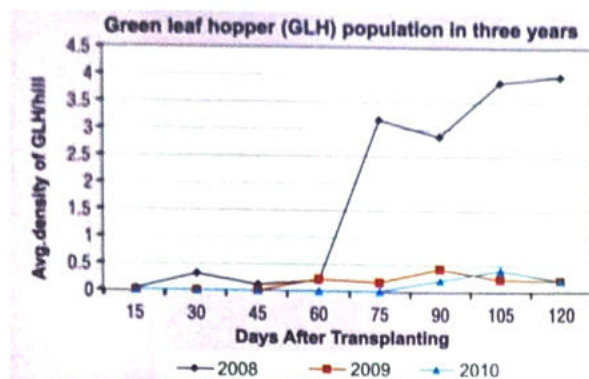


Fig. 8. The average density of green leafhopper recorded in three years

WHEAT

Evaluation of Different Promising Lines for Heat Tolerance

Twenty four wheat entries under Advance Variety Trial (AVT-TS, Irrigated) of All India Coordinated Wheat Improvement Project were evaluated during rabi season in 2009-10. Data on various attributes like germination pattern, date of initiation of flowering, 50% flowering, no. of effective tillers per meter square, panicle length, plant height and some other traits were recorded for compilation and statistical analysis. Through preliminary observation, few lines such as Raj 4201, Raj 4205, Ko 807 and Ko 808 were found ideal for cultivation in Eastern region. Raj 4205 and Raj 4201 showed some promising traits like terminal heat escape, which is being further investigated (Fig.9).

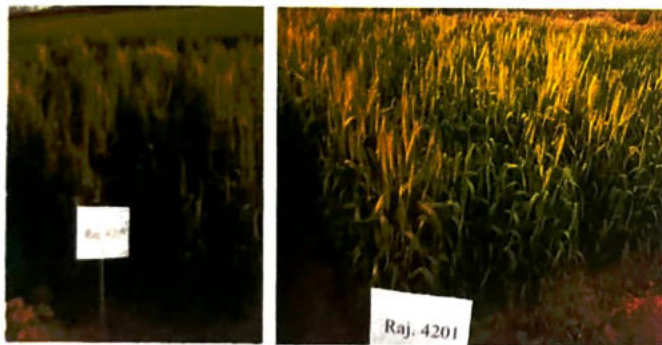


Fig. 9. Promising wheat genotypes for heat tolerance

MAIZE

Performance of Transplanted Maize Under Varying Age of Seedlings and Method of Nursery Raising

Transplanting of maize seedling grown on raised bed, flat bed, sand culture and plastic culture was the main plot treatment, whereas four ages of seedling, i.e., 4, 5, 6 and 7 weeks old were taken as sub-plot treatments (Fig. 10).

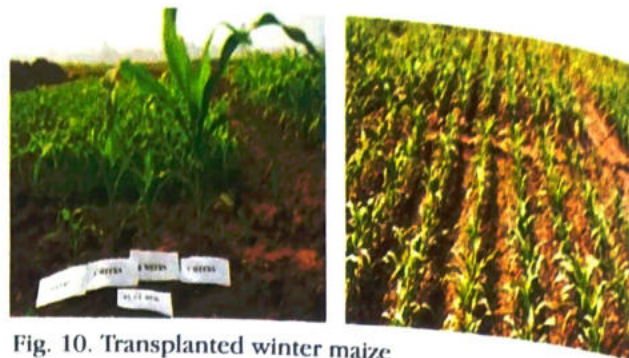


Fig. 10. Transplanted winter maize

Low plant mortality, higher plant height, maximum leaf length, and dry matter were recorded in raised bed sown seedlings which were at par with sand culture. Five weeks old maize seedlings performed better than other aged seedlings (Table 5). Highest yield (5.3 t/ha) was recorded with sand cultured seedlings, followed by raised bed grown seedlings (5.2 t/ha). Five week old seedlings showed high B:C ratio of 1.95 and 1.94, with sand cultured and raised bed grown seedling, respectively. Maximum B:C ratio (2.22) was observed on combination of 5 week old maize seedlings with sand culture/ bed sown. Water use efficiency (WUE) was highest with raised bed grown seedling (220.0 kg/ha/cm) over all other methods of growing seedling while, 5 weeks old seedling had shown highest WUE (238.3 kg/ha/cm).

At the end of 2nd year, it was observed that maize could be easily transplanted by raising its seedlings. However, nursery soil should be mixed with sand (2:1), to minimize the damage to roots during uprooting. Transplanting 5 week old seedlings resulted in maximum grain yield with 20-28 days early maturity over direct sown maize with same yield level and fits well in the rice-maize cropping system.

Table 5. Growth and yield of transplanted maize under different seedling raising method and age

Treatments	Mortality (%)	Plant height (cm) at 90 DAT	Leaf length (cm) at 90 DAT	Dry matter/plant(g) at maturity	Days to 50% flowering	Maturity days	Grain yield (t/ha)
Seedling raised method							
Flat bed	7.3	119	55.6	367.7	56.0	4122	4.7
Raised bed	6.9	121	55.6	405.8	58.1	125	5.2
Sand culture	5.7	121	55.6	412.9	57.8	132	5.3
Plastic culture	8.7	105	55.6	315.9	68.6	135	3.2
C.D.±0.05	1.65	7.3	5.30	16.02	1.34	16.6	0.49
S.E.m.	0.48	2	1.82	4.63	0.39	4.81	0.14
Seedling age							
4 week	7.4	105	55.6	382.2	78.3	141	4.7
5 week	5.3	131	55.6	464.5	60.6	131	5.7
6 week	7.4	115	55.6	369.8	58.5	128	4.5
7 week	8.6	124.9	55.6	286.1	43.1	114	3.4
C.D.±0.05	2.43	8.9	5.30	27.1	1.80	45.5	0.70
S.E.m.	0.83	3.08	1.82	9.29	0.62	5.32	0.24

FABA BEAN

Evaluation of Faba Bean (*Vicia faba* L.) - An Underutilized Crop

Faba bean (*Vicia faba* L.), an annual legume widely adapted to diverse agroclimatic condition, is main *rabi* pulses/legume of Bihar especially in Northern part (Fig. 11). Faba bean is taken as sole crop and as intercrop/mixed crops with variety of combination. To initiate the faba crop improvement programme, an exploratory trial was conducted in pots (2008-09) and in field 2009-10) for multiplication of seeds and preliminary characterization and evaluation of 71 accessions collected from Samastipur, Muzaffarpur, Vaishali and Sitamadhhi districts of North Bihar (Fig. 12).

Perusal of data (Table 6) confirms that altogether maximum and minimum time taken to complete 50% germination was 12.5 and 9.6 days, respectively with overall mean of 11.1 days. Variability was observed in 50% germination stage. Data on this trait showed considerable diversity ranging minimum (10.4) to maximum (88.4) with mean value of 67.9.



Fig. 11. Faba bean collection sites in Bihar



Fig. 12. Evaluation of faba bean accessions at experimental farm

Plant height ranged between 63.4 cm to 94.3 cm with mean of 78.4. Days taken to first flowering (anthesis) was recorded for faba bean. Perusal of data revealed that the minimum number of days taken to come in to flowering was 39.8 whereas maximum was 70.3 days with mean 54.9.

Table 6. Extent of diversity in agromorphological parameters among genotypes of faba bean.

Parameters	Min	Max	Mean	SD (%)	CD (%)
Days to 50% germination	9.6	12.50	11.11	0.75	6.74
Germination (%)	88.4	58.38	67.93	12.37	18.21
Plant height (cm)	63.4	94.28	78.41	6.10	7.78
Branch/ plant	12.70	12.70	10.1	1.1	10.5
Days to anthesis	39.8	70.30	54.9	4.7	8.0
Days to maturity	113.80	113.80	102.50	4.45	4.34
Pod/ plant	65.96	65.96	43.18	7.57	17.53
Pod length (cm)	5.91	5.91	4.12	0.40	9.61
Seed/pod	3.95	3.95	3.02	0.25	8.15
100 seed weight(g)	15.20	35.74	21.42	3.21	14.99
Root dry wt/plant(g)	1.81	4.42	2.98	0.63	21.19
Nodules dry wt/plant (g)	0.57	1.48	0.96	0.21	21.86
Biomass (g/plant)	96.80	259.65	167.64	36.49	21.77
Seed yield (g/plant)	21.89	73.09	45.12	10.97	24.31

In one of the accession (BP-14), four pods were found which was a unique character (Fig. 13). In general, one to two pods are found in faba bean. Likewise, pod formation took place near the collar region in BP-23 (Fig. 14) whereas, pod formation in rest of the material was observed at 5-10 cm above the ground level.

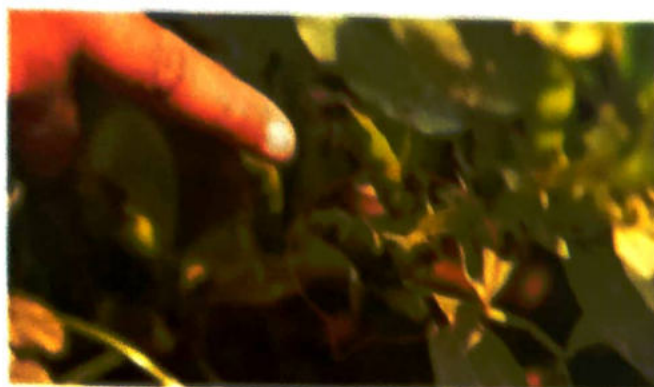


Fig. 13. Four podded germplasm BP-14



Fig. 14. Podding at collar region in BP-23 accession

Evaluation of Different Promising Lines of Pigeon Pea for Their Yield and its Attributing Characters in Indo-Gangetic Plains of Bihar

Thirty eight short, mid and long duration promising lines of pigeon pea were evaluated for their yield and other attributes in Indo-Gangetic plains of Bihar and the data has been depicted in Table 7. On average, ICPL-87 (short duration), BSMR-736 (medium duration) and MAL-13 (long duration) were found best so far yield was concerned.

Table 7. Performance of promising lines of pigeon pea for yield attributes at middle gangetic plains of Bihar

Name of Entries	Duration	Days of 50% flowering	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (H.I)
ICPL-87	Short	72	3.65	2.80	0.43
Manak	Short	52	3.62	2.75	0.43
UPAS-120	Short	103	2.70	1.90	0.41
BSMR-736	Medium	94	3.72	2.25	0.38
BSMR-835	Medium	96	3.02	2.20	0.42
GC-11-39	Medium	53	2.98	1.95	0.40
WRP-1	Medium	99	3.17	1.90	0.36
MAL-13	Long	107	3.15	2.15	0.60
Birsa Bahar	Long	94	2.32	1.85	0.58

Genetic Resource Management and Improvement of Fruit and Ornamental Crops

MANGO

A total of 109 genotypes conserved at the field gene bank were evaluated for different fruit characters. Based on overall fruit quality (average fruit weight > 200g, pulp content > 65%, TSS > 19 °B, TSS/acidity > 150), the genotypes Langra, Anfas, CHM-3 and CHM-5 were found promising. Six promising seedling selections (made from seedling population raised at experimental farm) were evaluated for different fruit characters. The genotype ICAR-RCER-R3P2 was found most promising (Fig. 15). The fruits were oblong to oval in shape, surface colour green, depressed stalk end with shallow cavity, dorsal shoulder narrow, ventral shoulder broad, back of fruits curved, sinus absent, beak prominent, tip of fruit acute, pulp orange coloured, fibreless with pleasant flavour, average fruit weight 222.5g, pulp content 61.5%, TSS 18.7°B, TSS acidity ratio 190.8, total sugar content 10.4%. One genotype of mango was also collected from Khatanga village of Purulia district of West Bengal which is maintained in the experimental farm.



Fig. 15. Close view of mango genotype ICAR-RCER-R3P2

Under the trial on 'performance evaluation of commercial mango cultivars', 20 mango cultivars, grown commercially in different parts of the country, were evaluated. Based on overall fruit quality, the cultivars Langra and Himsagar were found promising (Fig. 16). Under the trial on evaluation of released mango hybrids, 25 hybrids released from different parts of the country were evaluated. The hybrid Jawahar was found most promising based on overall fruit quality (average fruit weight > 200g, pulp content > 65%, TSS > 19°B, TSS/Acidity > 150).



Fig. 16. Close view of Himsagar, grown at experimental farm

LITCHI

To test the performance of litchi genotypes under the eastern plateau and hill conditions, 29 litchi genotypes were evaluated for fruit quality and yield. The fruit weight ranged from 10.8g (Yogada selection 1) to 23.1g whereas, the average fruit diameter ranged between 26mm (Yogada selection 1) to 34mm (Late Bedana). The maximum pulp content was recorded in Late Bedana (77%) whereas, the TSS was maximum in case of Deshi (21.9°B). Based on overall fruit quality, the cultivars Trikolia, Deshi and Late Bedana (Fig. 17) were found promising (fruit weight > 20g, fruit diameter > 32mm, TSS > 20°B and pulp content > 70%).



Fig. 17. Late Bedana-promising fruit cultivar

SAPOTA

To identify suitable sapota genotype for eastern plateau and hill region, ten sapota genotypes were evaluated for fruit quality and yield. The maximum fruit weight (128 g) and fruit volume (124 cc) was recorded in case of cv. DHS-1. The pulp content ranged between 69.8% (Bhuripatti) to 91.0% (Mahayothi) produced one seeded fruits. The maximum TSS (34.2 °B) and yield (12.16 kg/plant) was recorded in case of Bhuripatti. However, based on fruit quality and yield (fruit wt > 100g, pulp content > 80%, TSS > 30°B, yield > 10 kg/plant), the cultivar Murabba was found to be most promising for Eastern Plateau (Fig. 18).



Fig. 18. Fruit yield in Murabba cultivar of Sapota

GUAVA

Development of Ultra-high Density Orcharding in Guava Under Jharkhand Conditions

The project was undertaken to standardize time and level of pruning, irrigation and nutrient requirement for ultra-high density orcharding in guava (Sardar and Allahabad Safeda) under Jharkhand conditions planted during 2007.

During fourth year of orchard establishment, significant effects of different treatments was recorded on yield of summer, rainy and winter season crop, total yield and gross income per hectare in both the cultivars. The maximum total yield (39.74 t/ha) and gross income (Rs. 6.02 lakh/ha) was obtained in case of 80% pruning of canopy in May (Fig. 19) with irrigation at 40% CPE and application of 60% of recommended dose of fertilizers (Fig. 20).

In cultivar Allahabad Safeda, none of the treatments resulted in significant increase in yield of summer season crop over that of control. However, pruning to 50% of shoot length thrice a year viz, March,



Fig. 19. Heavy bearing in guava plants pruned in May

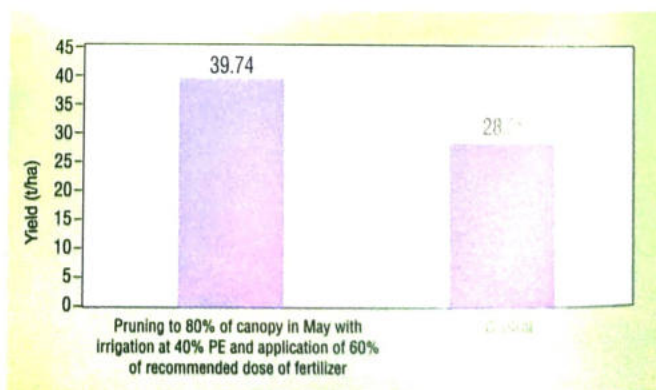


Fig. 20. Yield of guava cv. Sardar under ultra high density orchard

May and October resulted in significant increase in the yield of rainy season and winter season crop over control (Fig. 21). The same treatment resulted in maximum total yield (28.71 t/ha) and gross income (Rs. 4.38 lakh/ha).

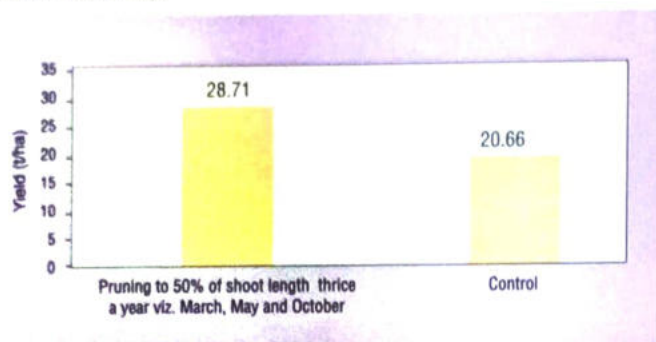


Fig. 21. Yield of guava cv. Allahabad Safeda under ultra high density orchard

BAEL

Studies on Bael (*Aegle marmelos* Correa.) with Special Reference to its Medicinal Value

Bael pulp of cultivar Pant Sujata can be stored upto 2 months at 4°C with good quality condition (Fig. 22). Treatments were highly significant in the characters such as T.S.S., acidity, reducing sugar and



Fig. 22. Storage of bael pulp

total sugar (Table 8 and 9). Storage conditions and treatments interaction were insignificant in all characters except acidity. The minimum acidity (0.56%) was recorded under cold storage condition and 800 ppm benzoic acid treatment. The maximum T.S.S. of 21.87°B was found in sample treated with 800 ppm benzoic acid and kept for two months at 4°C temperature. This treatment also resulted in maximum reducing sugar (8.09%) and total sugar content (9.52%) at same storage condition than other treatments. Storage temperature played an important role for bael pulp storage. Reducing sugar and total sugar were affected by the storage temperature. Under 4°C temperature, reducing sugar per cent and total sugar per cent were higher than that of ambient temperature.

Table 8. Bio-chemical changes of bael pulp during two months of storage during 2010

Treatments (ppm Benzoic Acid)	Initial T.S.S. (°B)	2 months storage at room temp.	2 months storage at 4°C	Initial acidity (%)	2 months storage at room temp.	2 months storage at 4°C	Initial Ascorbic Acid (mg/100g pulp)	2 months storage at room temp.	2 months storage at 4°C
0 ppm	33.50	18.34	20.41	0.44	0.95	0.88	18.92	14.22	15.62
200 ppm		19.54	20.56		0.92	0.73		15.15	17.22
400 ppm		19.96	20.62		0.77	0.75		15.62	18.11
600 ppm		21.55	21.78		0.68	0.72		15.77	18.34
800 ppm		21.27	21.87		0.67	0.56		16.42	18.55
1000 ppm		19.33	19.25		1.10	0.59		16.33	16.75
CD at 5% for A (Tem.) NS				NS			NS		
B (Treatment)		0.82			0.02			NS	
A x B		NS			0.01			NS	

Table 9. Bio-chemical changes of bael pulp during two months of storage during 2010

Treatments (ppm Benzoic acid)	Initial reducing sugar (%)	2 months storage at room temp.	2 months storage at 4°C	Initial total sugar (%)	2 months storage at room temp.	2 months storage at 4°C
0 ppm	9.29	4.14	6.34	13.82	4.75	7.65
200 ppm		4.25	6.52		4.95	8.12
400 ppm		4.99	6.95		5.13	8.40
600 ppm		5.62	7.15		6.44	8.69
800 ppm		5.51	8.09		6.82	9.52
1000 ppm		5.07	7.98		5.11	8.32
CD at 5% for A (Temp.)		0.075			0.284	
B (Treatment)		0.520			0.461	
A x B		NS			NS	

Evaluation of Advance Breeding Lines and Maintenance Breeding in Solanaceous and Cucurbitaceous Vegetable Crops

BOTTLE GOURD

Maintenance of germplasm: In bottle gourd, twenty one germplasm lines were maintained and self seed was produced.

Advancement of segregating generation: Sixteen segregating populations of bottle gourd were evaluated in F_3 generation. On the basis of yield, quality, earliness and resistance to fusarium wilt under natural field condition, only five progeny viz. HABOG-16xHABOG-13-1-1, HABOG-16xHABOG-13-2-1, HABOG-9xHABOG-13-2-1, HABOG-17xHABOG-10-6-5 and HABOG-10xHABOG-26-3-2 were found promising.

AICRP Trials

In hybrid IET, BOGhyb-1 performed better (14.9 t/ha) than the best check variety of bottle gourd, i.e., Pusa Naveen (10.4 t/ha). In varietal AVT-I, BOGvar-4 (19.9 t/ha) followed by BOGvar-3 (17.1 t/ha) performed better compared to the best check variety, i.e., Pusa Naveen (10.4 t/ha).

BITTER GOURD

Evaluation of developed advance breeding lines: Twelve developed advance breeding lines of bitter gourd were evaluated in randomized block

design. Out of these, highest yield was recorded in HABG-30 (16.0 t/ha, av. fruit weight 88.33g, fruit length 16.60 cm and dark green fruits) followed by HABG-31 (Table 10 and Fig. 23).

Table 10. Evaluation of developed advance breeding lines

Acc. No.	Fruit colour	Fruit surface	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield (t/ha)
HABG-23	Dark green	Deep tubercle	14.60	2.91	72.50	9.3
HABG-24	Dark green	Deep tubercle	17.18	2.76	70.50	12.0
HABG-25	Light green	Deep tubercle	14.11	2.53	55.16	10.6
HABG-26	Light green	Deep tubercle	15.08	3.38	81.33	10.5
HABG-27	White	Light tubercle	13.55	2.40	56.83	9.20
HABG-28	Green	Light tubercle	13.30	2.85	61.83	11.94
HABG-29	Green	Light tubercle	15.21	2.73	54.16	11.2
HABG-30	Dark green	Deep tubercle	16.60	3.18	88.33	16.0
HABG-31	Dark green	Deep tubercle	17.16	3.31	96.66	13.6
HABG-32	Light green	Light tubercle	13.81	2.21	36.50	08.7
HABG-33	Dark green	Deep tubercle	14.21	2.78	55.50	13.5
HABG-34	Green	Deep tubercle	15.11	2.71	69.66	13.3
GM	-	-	14.99	2.81	65.58	11.69
SEM	-	-	0.77	0.13	4.83	1.05
CV %	-	-	8.90	8.36	12.22	15.52
CD AT 5 %	-	-	2.25	0.39	14.10	3.6

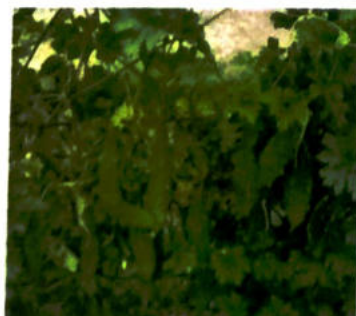
TOMATO

Grafting of tomato on brinjal and tomato

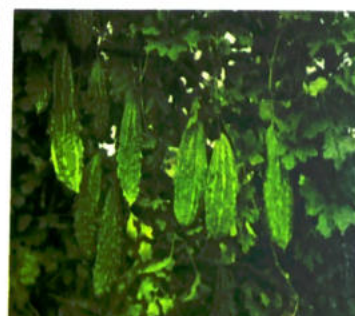
Swarna Baibhav grafted on bacterial wilt resistant rootstock of tomato- Swarna Lalima, recorded maximum yield of 1.97 kg/plant than the other rootstocks Swarna Shyamali, Swarna Pratibha, HAB-900 and HAB-901 (Table 11 and Fig. 24-28). Highest percentage survival of rootstock against bacterial wilt was recorded in Swarna Shyamali and HAB-900 (95%).



HABG-28



HABG-29



HABG-30



HABG-34

Fig. 23. Growth performance of some advance breeding lines of bitter gourd

Table 11. Evaluation of tomato grafts

S No	Name	Survival % of plant at 90 DAT	Plant height (cm)	No. of fruits/plant	Fruit weight (gm)	Yield/plant (kg)
1	RS-S. Pratibha Scion- S. Baibhav	89.44	100.25	23.19	72.10	1.45
2	RS-S. Shyamali Scion-S. Baibhav	95.0	114.50	31.55	112.70	1.92
3	RS-HAB-900 Scion-S. Baibhav	95.0	107.50	29.30	114.10	1.72
4	RS-HAB-901 Scion-S. Baibhav	92.50	110.50	27.59	99.70	1.74
5	RS-S.Lalima Scion-S. Baibhav	87.50	123.25	35.96	101.05	1.97
6	S.-Baibhav (Check)	44.16	115.75	24.99	107.20	1.43
	GM	83.93	111.95	28.76	101.14	1.70
	SEM	6.05	7.47	2.33	11.10	0.14
	CV %	14.43	13.35	16.21	21.95	17.06
	CD AT 5 %	18.20	-	7.00	-	-



Fig. 24. Evaluation of grafted tomato



Fig. 25. Swarna Shyamali + Swarna Baibhav



Fig. 26. Susceptible scion Swarna Baibhav



HAB-900 + Swarna Baibhav



HAB-901 + Swarna Baibhav

Fig. 27. Swarna Baibhav grafted on brinjal root stock



Swarna Lalima + Swarna Baibhav

Fig. 28. Swarna Biabhav grafted on tomato root stock Swarna Lalima

Evaluation of advanced breeding lines

Five progeny were evaluated in F_7 generation for desirable economic traits and reaction to bacterial wilt under natural field condition (Table 12 and Fig. 29). From existing population, fruit yield per plant ranged from 0.87–1.27 kg. Acidity varied from 0.30–2.94%. Highest yield per plant was recorded in HAT-295 (1.27 kg/plant; acidity 2.94%), followed by HAT-296 (1.07 kg/plant; acidity 0.30%) and HAT-297 (0.99 kg/plant; acidity 0.38%).

Table 12. Performance of promising advance breeding lines (F_7) of tomato

Lines	Plant height (cm)	No. of branches	No. of fruits/plant	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield / plant (kg)	Acidity	TSS °Brix	Survival of plant at 90 DAT
HAT - 295	103.77	5.95	22.5	4.47	5.56	109.95	1.27	2.94	3.34	99.50
HAT - 296	98.75	5.85	16.00	5.04	5.40	102.45	1.07	0.30	3.91	99.00
HAT - 297	109.02	5.75	22.50	4.81	5.10	108.20	0.99	0.38	3.41	98.75
HAT - 298	87.62	5.20	16.75	4.84	5.74	78.20	0.93	0.48	3.69	99.25
HAT - 299	87.65	6.15	18.25	4.47	3.52	59.60	0.87	0.49	3.74	99.25
GM	97.36	5.78	19.2	4.72	5.06	91.67	1.03	-	3.61	99.15
SEM	2.64	0.15	1.30	0.13	0.22	8.92	0.08	-	0.19	0.58
CD at 5 %	8.21	0.46	4.00	0.41	0.68	27.42	-	-	-	-
CV %	5.43	5.24	13.57	5.73	8.79	19.47	17.33	-	10.57	1.17



HAT - 295

HAT - 296

Fig. 29. Promising advance breeding lines of tomato

Development of improved variety/hybrid, suitable for protected cultivation

One F_1 hybrid HATH-10 and three OP lines viz. EC-596741, EC-596742 and EC-596743 were identified for protected cultivation (Table 13 and Fig. 30).



EC - 596743



EC - 596742



HATH - 10



EC - 596741



Fig. 30. Promising lines & hybrids of tomato under protected cultivation

Table 13. Yield of different hybrid and open pollinated (OP) lines of tomato

Hybrid/Oplines	Plant height (m)	Fruit weight (g)	Yield (t/ha)
HATH 10	5.50	80.0	180.0
EC 596741	5.25	120.0	130.0
EC 596742	2.60	100.0	150.0
EC 596743	5.10	90.0	160.0

AICRP (VC) Trial on Varietal Resistance

Evaluation of AVT-II lines in bacterial wilt sick plot

Six entries of AVT-II lines of tomato were tested in bacterial wilt sick plot. The data revealed that five entries BT-1, Megha Tomato -2, BT-106, LE626 and LE142 were moderately resistant to bacterial wilt (Table 14).

Table 14. Performance of AVT-II Lines of tomato in bacterial sick plot during 2010-11

Entries	% wilt			Reaction	Yield (t/ha)
	30	60	90		
BT 1	17	20	26	MR	9.9
Megha 2	7	9	29	MR	13.7
BT 106	2	3	29	MR	16.1
LE 626	3	5	30	MR	18.0
LE 142	3	3	29	MR	16.0
Pusa Ruby	16	21	50	S	12.5
CD (P0.05)					NS
CV %					31.99

AICRP (VC) trial on integrated management of soil borne diseases by use of chemicals

Ten treatments of integrated disease management by non chemical were tested for three years (2008-09 to 2010-11) on tomato (cv Pusa Ruby) against soil borne diseases. Pooled mean revealed that maximum yield was obtained with Karanj Cake @1.0 t/ha (12.9 t/ha) followed by Neem cake (10.44 t/ha). Summer ploughing resulted in a yield of 10.23 t/ha. Other better treatments were green manuring with *Sesbania* + Neem cake + Antagonist (*Trichoderma viride*) (10.35 t/ha) and green manure with cowpea (9.86 t/ha, Table 15).

AICRP (VC) trial on integrated disease management of bacterial wilt

Eleven treatments of integrated disease management were tested for 4 years (2008-09 to 2009-10) on tomato (cv Swarna Lalima) against soil borne diseases (Table 16). Pooled mean revealed that maximum yield was obtained with combination of treatments (yield

Table 15. Performance of integrated disease management of soil borne diseases of tomato by use of non-chemicals in different years (2008-09 to 2010-11)

Treatments	Tomato wilt %			Average	Yield (t/ha)			Average
	2008-09	2009-10	2010-11		2008-09	2009-10	2010-11	
Seedling grown in solarized bed	81.7	88.3	41.7	70.6	6.5	1.3	23.0	10.26
Summer ploughing	71.7	86.7	41.7	66.7	4.36	4.38	21.96	10.23
Green Manuring with cowpea	85.0	88.3	23.3	65.6	1.72	3.24	24.62	9.86
Neem cake @ 1.0 t/ha	71.7	80.0	25.0	58.9	3.64	3.8	23.88	10.44
Seed treatment with antagonist (Tv) + soil + seedling dip for 30min.	80.0	80.0	16.7	58.9	0.86	3.72	22.74	9.10
Green Manuring with <i>Sesbania</i> + Antagonist(Tv)	75.0	83.3	30.0	62.8	3.64	4.38	27.88	11.96
Green Manuring with <i>Sesbania</i> + Neem cake @ 1.0 t/ha	86.7	86.7	21.7	65.0	1.3	3.66	24.2	9.72
Green Manuring with <i>Sesbania</i> + Neem Cake + Antagonist(Tv)	88.3	80.0	28.3	65.6	1.52	6.86	22.66	10.35
Karanj Cake @ 1.0 t/ha	76.7	85.0	16.7	59.4	2.6	4.96	29.0	12.19
Control	86.7	86.7	20.0	64.4	2.3	2.86	22.3	9.15
CD (P0.05)					NS	NS	NS	2.21
CV %					145.9	54.96	26.44	12.72

Table 16. Effect of Integrated management of bacterial wilt of tomato in cv Swarna Lalima during 2006-07 to 2009-10

Treatments	<i>Ralstonia solanacearum</i> population (cfux10 ⁴ per g soil) at days				% reduction in <i>R. solanacearum</i> population at 90 days over initial	Yield (t/ha)	% increase in yield over drainage
	0	30	60	90			
FYM@ 3.0 t/ha	106.3	43.9	67.4	41.6	60.9	29.80	39.6
Green Manuring with <i>Sesbania</i>	84.9	53.6	58.6	42.0	50.5	25.81	20.7
PGPR @ 5 kg/ha Soil application	80.1	48.4	56.1	41.4	48.3	20.25	-5.3
PGPR Root dipping@1%	89.8	67.7	63.4	51.4	42.8	22.03	3
PGPR Soil application+ Drenching	82.8	66.9	61.2	53.1	35.9	26.51	51.2
Liming@2.5 t/ha	78.7	42.6	63.5	54.0	31.4	22.15	3.6
Karanj cke @1.0 t/ha	96.4	72.9	68.5	39.3	59.2	23.02	7.6
Spent compost@1.0 t/ha	99.3	88.2	88.7	53.1	46.5	28.08	31.3
Combination of all	79.4	81.1	69.8	52.0	34.5	34.37	60.7
Control	86.5	72.8	64.4	59.5	31.2	23.37	9.3
Drainage	78.5	60.8	67.8	54.1	31.1	21.38	—
Mean	87.5	63.5	66.3	49.2	31.27	25.17	
CD (P0.05)	14.85	15.27	NS	8.6		6.20	
CV %	14.6	20.4	29.4	15.0		14.7	

34.37 t/ha with 60.7% increase in yield over that of drainage alone), followed by soil application of PGPR @ 5kg/ha + drenching with PGPR 1% (yield 26.52 t/ha with 51.2% increase in yield over that of drainage alone).

BRINJAL

Evaluation of Germplasm

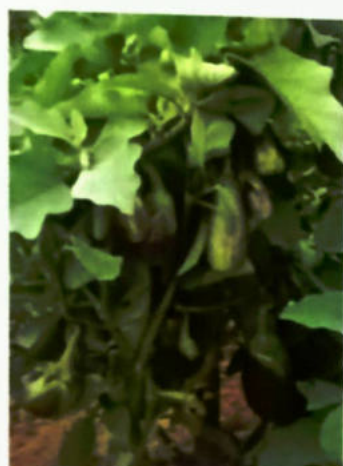
Two hundred germplasm of brinjal received from NBPGR, New Delhi were evaluated with seven checks in augmented block design. Out of these, seven lines

were found resistant to bacterial wilt (Table 17 and Fig. 31). Highest yield was recorded in IC-545934 (2.41 kg/plant; fruit weight 95.0g; fruit length 11cm and long purple), followed by IC-112797 (1.51 kg/plant; fruit weight 92.0 g; fruit length 9.50 cm and oblong purple).

Eight lines of brinjal germplasm that were found resistant to bacterial wilt in 2009-10 under natural field condition were also tested in bacterial wilt sick plot with artificial inoculation (Table 18 and Fig. 32). Out of these only two lines were found resistant at 90 DAT viz. IC-261786 (fruit weight 118.0 g; fruit length 17.3 cm and long green) and IC-261793 (fruit weight 252.0 g; fruit length 7.7 cm and round green striped).

Table 17. Promising bacterial wilt resistant lines of brinjal under natural field condition

Acc. no.	Survival % at 90 DAT	Fruit shape and colour	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	No. of fruits/plant	Yield/plant (kg)
IC-112797	80	Oblong purple	9.5	5.0	92.0	25.5	1.51
IC-545941	90	Oblong green striped	11.0	4.7	110.0	19.0	1.36
IC-305048	80	Round purple	6.2	4.0	56.0	21.3	1.16
IC-112993	80	Round light purple	6.0	4.0	54.0	18.6	1.13
IC-545901	80	Long dark purple	15.0	3.2	75.0	24.6	1.42
IC-545934	80	Long purple	11.2	4.0	95.0	32.0	2.41
IC-545931	80	Oblong green striped	13.2	6.2	212.0	7.6	1.18



IC 305048



IC 305121



IC - 545901



IC - 545931



IC - 545934



IC - 545941

Fig. 31. Growth of bacterial wilt resistant lines of brinjal

Table 18. Promising bacterial wilt resistant lines of brinjal under bacterial wilt sick plot

Acc. no.	Survival % at 90 DAT	Fruit shape and colour	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield upto 90 DAT
EC-329327	71.87	Oblong light purple	8.5	5.0	106.0	4.80
IC-089900	78.12	Oblong green striped with purple tinge	11.7	4.0	94.0	20.60
IC-090146	6.25	Oblong light green purple	10.5	5.0	150.0	2.6
IC-261786	84.37	Long green	17.3	3.9	118.0	12.0
IC-261793	84.37	Round green striped	7.7	9.0	252.0	6.3
IC-285126	71.87	Round green purple tinge	9.7	8.5	176.0	9.8
IC-545948	75.0	Round green striped	4.0	4.8	47.0	10.1
IC-90141	40.0	Oblong purple black	10.3	5.6	152.0	5.4



IC-261793



IC 261786

Fig. 32. Evaluation of bacterial wilt resistant lines of brinjal under bacterial wilt sick plot

Characterization of Bacterial Wilt Resistance Gene(s) in Brinjal using Conventional and Molecular Approaches

Development of F_1 s

In brinjal, thirty six F_1 s have been developed from nine parents viz., Swarna Shree (P_1), Swarna Shobha (P_2), Swarna Mani (P_3), HAB-381 (P_4), HAB-792 (P_5), HAB-900 (P_6), HAB-901 (P_7), Swarna Shyamali (P_8) and Swarna Pratibha (P_9) with distinct response to bacterial wilt disease in half diallele fashion during Jan-June 2010 (Fig. 33).

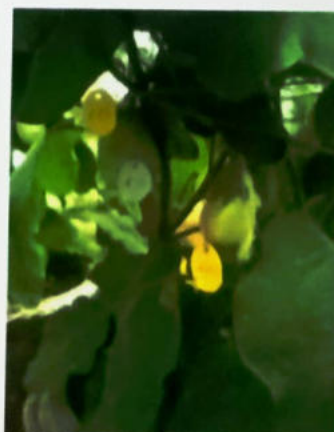


Fig. 33. Development of F_1 crosses

Evaluation of parents and F₂ for bacterial wilt resistance

Nine parents and thirty six F₂ of brinjal were evaluated for wilt resistance in bacterial wilt sick plots during rainy season and upon artificial inoculation with bacterial suspension. Observations on percent plant survival were recorded at 90 days after transplanting. Among the parents, HAB-501 (P₁) and among crosses HAB-501 x HAB-501 (P₂ x P₂), HAB-792 x HAB-501 (P₂ x P₂), HAB-792 x HAB-501 (P₂ x P₂) and HAB-501 x HAB-501 (P₂ x P₂) were recorded resistant to bacterial wilt (Fig. 34-36).

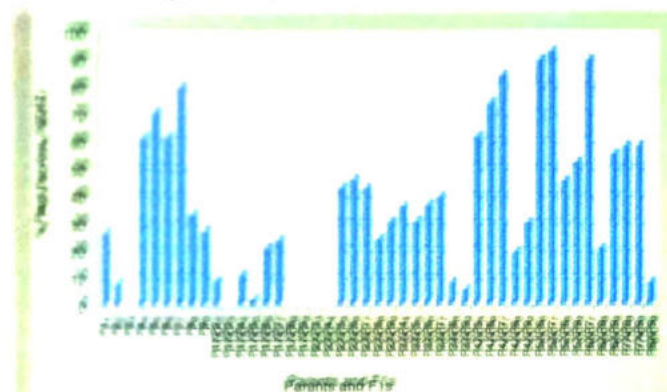


Fig. 34 Survival of plants in parents and F₂ against bacterial wilt in brinjal

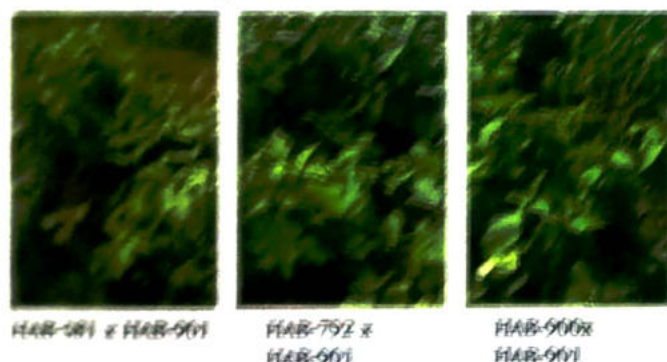


Fig. 35 Resistant parents and crosses in brinjal

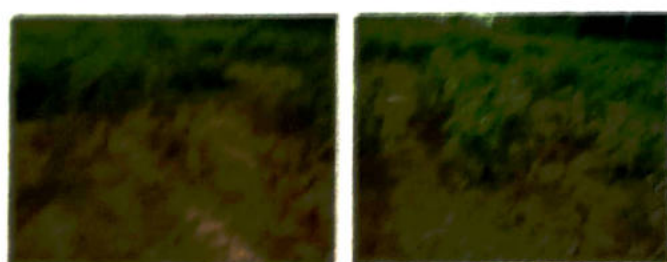


Fig. 36 Susceptible parents and crosses in brinjal

Evaluation of IET lines of brinjal in bacterial wilt sick plot

Nine entries of IET lines of brinjal were tested in bacterial wilt sick plot. The data revealed that four entries, BRBWRES-2, BRBWRES-4, BRBWRES-5 and SM-6-6 were resistant at 90days. Arka Nidhi was moderately resistant to bacterial wilt.

Evaluation of AVT-I lines of brinjal in bacterial wilt sick plot

Nine entries of AVT-I lines of brinjal were tested in bacterial wilt sick plot. The data revealed that five entries, BRBWRES-1, BRBWRES-2, BRBWRES-5, BRBWRES-6 and SM-6-6 were resistant at 90days. BRBWRES-4 and Arka Nidhi showed moderately resistant to bacterial wilt.

Evaluation of AVT-II lines of brinjal in bacterial wilt sick plot

Nine entries of AVT-I lines of brinjal were tested in bacterial wilt sick plot. The data revealed that six entries, Singhnath, BB-54, Bholanath, FIUtkal, FI-VNR218 and SM-6-6 were resistant at 90days. Arka Nidhi showed moderately resistant to bacterial wilt.

CUCUMBER

Evaluation and Maintenance of Gynomonoecious Lines

Five individual plant progeny of cucumber obtained from the cross of Swarna Ageti x EC- 399587 (Gynodioecious line) were evaluated. Out of these, highest yield was recorded in HACGM-2 followed by HACGM-5 (Table 19 and Fig. 37).

Table 19. Performance of cucumber gynomonoecious line

ACC. NO.	Days to 50% flowering	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield (t/ha)	Flesh Thickness (cm)	Placental thickness (cm)
HACGM-1	38.25	16.20	3.75	112.12	21.2	0.52	1.05
HACGM-2	36.50	19.97	4.25	163.25	27.5	0.60	1.35
HACGM-3	39.25	17.42	3.92	153.62	24.5	0.45	1.02
HACGM-4	38.50	16.85	3.97	158.81	24.0	0.55	1.07
HACGM-5	39.50	16.52	3.47	129.62	24.8	0.55	1.02
GM	38.4	16.79	3.87	143.5	24.4	0.53	1.10
SEM	0.78	0.57	0.13	5.16	1.3	0.06	0.05
CV %	4.09	6.87	7.08	7.20	11.0	23.64	10.73
CD AT 5 %	-	-	0.42	15.87	-	-	0.18



Fig. 37 Field performance of gynomonoecious lines of cucumber

Evaluation of promising lines developed through interspecific hybridization (*C. sativus* x *C. bardwickii*)

Five stable lines were identified, on the basis of yield quality, earliness and plant type in F₁₁ generation (Table 20). Highest yield was recorded in HAC-151 (15.9 t/ha, av. fruit weight 142.75 g), followed by HAC-152 (15.7 t/ha, av. fruit weight 135.62g).

Table 20 Evaluation of promising lines developed through interspecific hybridization

ACC. NO.	Days to 50% flowering	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield (t/ha)	Flesh Thickness (cm)	Placental thickness (cm)
HAC-151	41.75	13.92	3.95	142.75	15.9	0.60	1.12
HAC-152	42.50	13.07	3.87	135.62	15.7	0.45	1.17
HAC-153	39.00	13.35	3.82	112.50	13.8	0.46	1.10
HAC-154	42.50	11.65	4.07	142.75	13.6	0.62	1.15
HAC-155	37.50	14.90	4.17	150.25	11.0	0.57	1.12
GM	40.65	13.38	3.98	136.77	14.0	0.54	1.13
SEM	0.71	0.50	0.17	10.42	0.5	0.05	0.06
CV %	3.56	7.62	8.85	15.24	8.3	21.90	10.88
CD AT 5%	2.20	1.56	-	-	1.8	-	-

PERENNIAL CUCURBITS

Ivy gourd

Two germplasm are being maintained in the field gene bank. The spindle shaped (4.91 cm long) striped green fruited line HAIVG-1 (6.7 kg/plant; fruit weight 24.3g) performed better than the long (5.75cm) and green fruited line HAIVG-2 (5.0 kg/plant; fruit weight 16.70g).

Pumpkin

In hybrid AVT-II, VNR-14 (14.4 t/ha) followed by VNRP-16 (13.7 t/ha) PPUH-1 (13.2 t/ha) and PPUH-2 (11.8 t/ha) performed better than the best check variety Pusa Vishwas (8.9 t/ha).

Ridge gourd

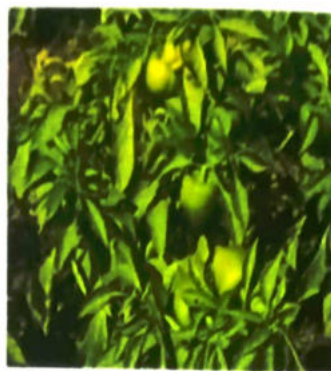
In ridge gourd varietal AVT-II, highest yield was recorded in HARG-109 (4.9 t/ha) followed by HARG-109 (3.8 t/ha) and Utkal Trupti (3.3 t/ha).

CAPSICUM

Two lines of capsicum were identified for multi location testing in AICRP (VC) trials viz. HACAPV-271 and HACAPV-845 for open field cultivation. The yield and morphological features is given in Table 21 and Fig. 38.

Table 21. AICRP (VC) trials for open field cultivation

Name	No. of primary branches	Plant height (cm)	Days to 50% flowering	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Yield (t/ha)
HACAPV-271	3.0	43.0	31.0	6.40	6.60	105.0	30.0
HACAPV-845	4.0	60.0	34.0	6.10	6.60	120.0	35.0



HACAPV-271



HACAPV-845

Fig. 38. Production performance of Capsicum

AICRP Trials in Vegetable Crops

Two lines of bush type French bean (HAFB-5 and HAFB-6 in AVT-I), 2 pole type lines of dolichos bean (HADB-5 and HADB-6 in AVT-II) and 2 powdery mildew resistant mid-season lines of garden pea (HAP-1 and HAPMR-2 in AVT-II) were evaluated (Fig. 39).

To develop powdery mildew resistant early garden pea lines for testing under AICRP 16 individual powdery mildew resistant and early maturing plants were selected from F₃ populations of 3 crosses viz. VRP-16 x IPS-1, VRP-16 x HAPMR-2 and VRP-16 x PC-531 and advanced to exercise selection pressure in the next generation.

In Cowpea (Bush type) AVT-I, the entries 09/COPBVAR-3 (20.6 t/ha) and 09/COPBVAR-4 (18.7 t/ha) performed better than the check variety. i.e., Kashi Kanchan (16.0 t/ha).

In French bean (Bush type) AVT-I, the entries 09/FBBVAR-7 (39.0 t/ha), 09/FBBVAR-2 (36.7 t/ha) and 09/FBBVAR-3 (34.7 t/ha) performed better than the best check Arka Anoop (34.1 t/ha).



Fig. 39. Promising selection of early PMR line in garden pea

Integrated Disease Management of Soil Borne Disease of French bean by Use of Non-chemicals

FRENCH BEAN

Maximum yield of French bean was obtained in control (10.90 t/ha with minimum disease 12.4% collar rot), followed by Karanj Cake @ 1.0 t/ha (10.35 t/ha with minimum disease 11.9% collar rot). In general, green manuring with *Sesbania* treatments resulted in increased incidence of soil borne disease in French bean (Table 22).

Management of Plant Genetic Resources and Improvement of Leafy and Underutilized Vegetable Crops

AMARANTH

In total 49 germplasm of leafy amaranth were maintained through fresh seed multiplication. Out of 12 multi-cut type germplasm lines evaluated alongwith 2 checks viz., Pusa Lal Chaulai and Pusa Kirti, the red leaved line HAMTH-15 (17.3 t/ha) was found promising (Fig. 40) and recorded 28.08% yield increase over Pusa Lal Chaulai (13.5 t/ha). HAMTH-33 (19.4 t/ha) and HAMTH-42 (19.2 t/ha) were the promising green leaved lines and recorded 40.94 and 39.60% yield increase over the green leaved check variety Pusa Kirti (13.8 t/ha).

OTHER LEAFY VEGETABLES

The germplasm of palak (2), methi (2), Malabar nightshade/poi-*Basella* spp. (2), Lai sag-*Brassica rugosa* (1), Chinese cabbage- *Brassica pekinensis* (1),



Fig. 40. Promising line of red leaf amaranth

Bathua- *Chenopodium* spp.(4) and Kang kong- *Ipomoea aquatica* (1) were maintained. The palak line HAPLK-1 (46.2 t/ha) collected from Muzaffarpur, Bihar performed better than the Bikaner collection HAPLK-2 (43.2 t/ha). The Kasuri methi line recorded leaf yield of 24.2 t/ha and performed better than Pusa early bunching (7.6 t/ha). The green leaved line of poi performed better (10.0 t/ha) than the red leaved line of poi (*Basella rubra*) (8.8 t/ha). The Lai sag (*Brassica rugosa*) line HALS-1 recorded leaf yield of 15.8 t/ha. The Kang-kong line recorded yield of 4.2 t/ha. The Chinese cabbage line recorded yield of 15.6 t/ha. (Fig. 41). The locally collected mint line recorded leaf yield of 9.5 t/ha.

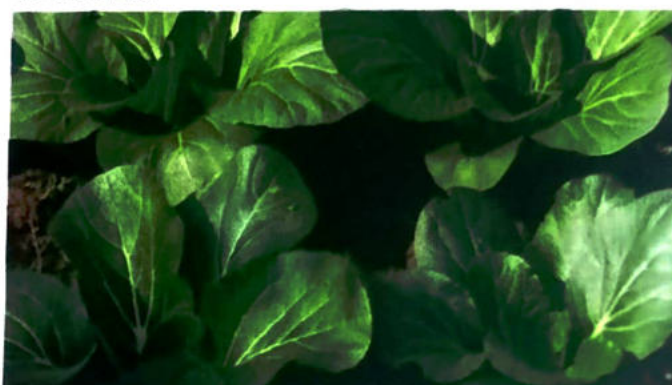


Fig. 41. Promising line of Chinese cabbage

Table 22. Performance of integrated disease management of soil borne disease of French bean by use of non -chemicals in different years (2008-09 to 2010-11)

Treatments	Collar rot %			Average	Yield (t/ha)			Average
	2008-09	2009-10	2010-11		2008-09	2009-10	2010-11	
Seedling grown in solarized bed	7.9	8.7	20.8	12.5	8.52	10.82	9.26	9.53
Summer ploughing	8.1	10.0	11.0	9.7	6.46	10.5	12.84	9.93
Green Manuring with cowpea	6.3	14.7	7.9	9.6	6.90	10.66	10.00	9.19
Neem cake @1.0 t/ha	6.0	7.0	10.4	7.8	8.20	10.90	13.42	10.84
Seed treatment with antagonist								
(Tv) + soil + seedling dip for 30min.	8.9	7.8	13.0	9.9	6.20	11.32	11.86	9.79
Green Manuring with <i>Sesbania</i> +								
Antagonist (Tv)	42.3	10.5	31.7	28.2	4.92	9.36	5.38	6.55
Green Manuring with <i>Sesbania</i> +								
Neem cake @ 0.10 t/ha	28.0	8.9	32.7	23.2	5.92	12.4	6.42	8.25
Green Manuring with <i>Sesbania</i> +								
Neem Cake + Antagonist (Tv)	39.7	14.1	26.2	26.7	3.52	12.7	5.82	7.34
Karanj Cake @ 1.0 t/ha	10.0	11.4	14.2	11.9	8.60	11.80	10.66	10.35
Control	9.2	14.2	13.8	12.4	9.00	10.7	13.0	10.92
CD (P0.05)					0.30.8	NS	NS	0.9
CV%					26.5	55.0	35.8	5.8

UNDERUTILIZED BEAN

Seven new *basmati* vegetable soybean lines were introduced from AVRDC, Taiwan. In all, thirty one germplasm of vegetable soybean including 8 *basmati* lines were maintained through fresh seed multiplication. Out of 7 newly introduced *basmati* vegetable soybean lines evaluated, the lines AGS-456 (273.68 g/plant; 20.2 t/ha) (Fig. 42), AGS-461 (258.20 g/plant; 19.1 t/ha) and AGS-447 (250.68 g/plant; 18.5 t/ha) were 15 days earlier than Swarna Vasundhara (*non-basmati*) and took only 63 days after sowing for 50% harvest of fresh green pods. These lines recorded 53.89, 45.18 and 40.95% yield increase over Swarna Vasundhara (177.84 g/plant; 13.1 t/ha), respectively. These lines also recorded > 50% recovery value of fresh shelled green grains which were having characteristic *basmati* (scented rice) flavour after boiling.



Fig. 42. Promising basmati vegetable soybean line AGS-456 introduced from AVRDC, Taiwan

OTHER BEANS

The germplasm of Faba bean (20) (Fig. 43a), Vegetable pigeon pea (7), winged bean (10), lima bean (2), sword bean (2), velvet bean (2), Jack/Horse bean

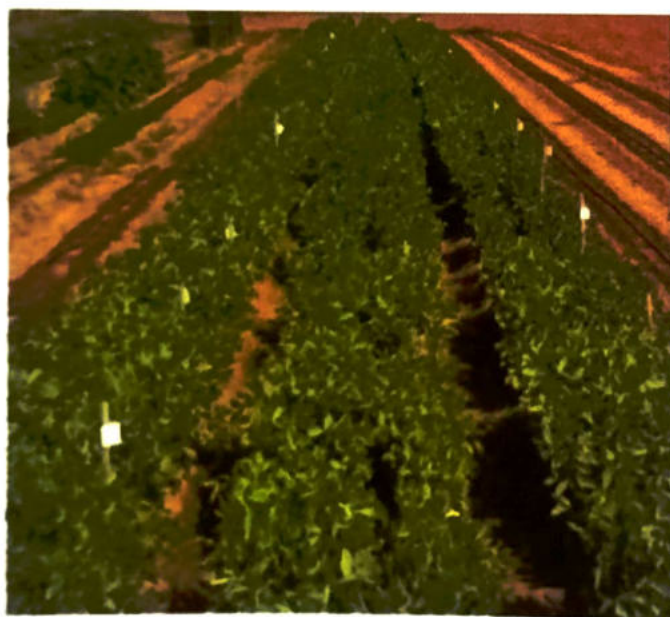


Fig. 43a. Evaluation of promising lines of faba bean

(1), cluster bean (1) and yam bean (2) (Fig. 43b) were evaluated and maintained through fresh seed multiplication. The yam bean line HAYB-1 (tuber weight 233.69 g; tuber yield 51.9 t/ha) performed better than Rajendra Misrikand-1 (tuber weight 222.47 g; tuber yield 49.4 t/ha).



Fig. 43b. Evaluation of promising lines of yam bean (HAYB-1)

Evaluation of Substrates and Assessment of Water Requirement for Commercial Production of Oyster Mushroom

Experiment was conducted in June to November 2010 on oyster mushroom viz. *Pleurotus florida*, *P. sajor caju* and *Hypsizygus ulmarius*. Paddy straw was used as substrate. Water requirement of *P. sajor caju* was recorded to be 2.17 and 2.17 litres for one kg of mushroom production during July-August and Oct-Nov., respectively. Likewise, 2.3 liters water was required in case of *P. florida*. Water requirement was 2.3 and 1.85 litres, respectively, for *P. florida* and *H. ulmarius* (Fig. 44).

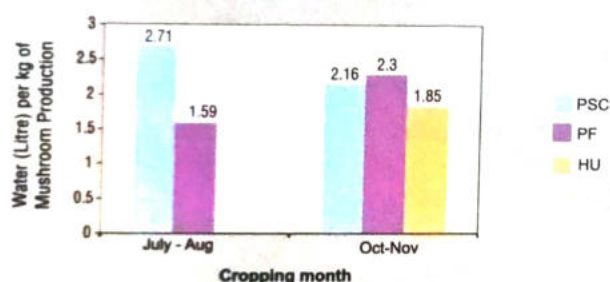


Fig. 44. Water Use Efficiency of Oyster Mushroom Production on Paddy Straw Substrate

Biological efficiency (BE) of *P. sajor caju* was 54.3% and 89.7% in July -Aug. and Sept-Oct. crop, respectively. In *P. florida*, BE in July-Aug crop was less (48.4%) but substantially high (98.7%) in Sept-Oct. In *H. ulmarius*, the BE was highest, i.e., 118.4% (Fig. 45).

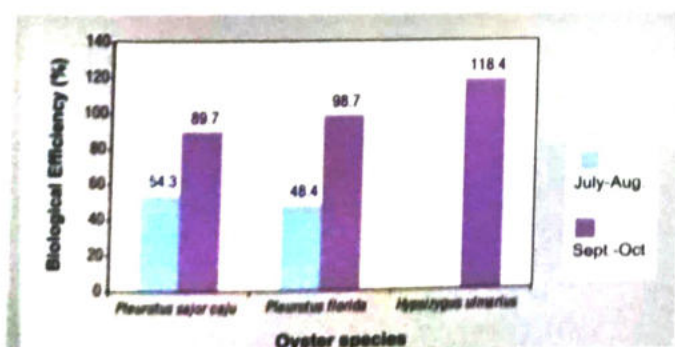


Fig. 45. Biological Efficiency of Oyster mushroom on Paddy Straw substrate in Different Months

AICRP (mushroom) strain evaluation of Oyster mushroom (*Pleurotus sajor caju* and *Pleurotus florida*)

The experiment was conducted with five strains of *Pleurotus sajor caju* in summer season (June, 2010). The strains viz; PSC 1, PSC 3, PSC4 and PSC 5 resulted in biological efficiency of 51.7, 76.5, 85.0 & 66.1%, respectively (Table 23 & Fig. 46).

Table 23. Performance of strains of *Pleurotus sajor caju*

Strains	Yield (g) per bag (3.5kg wet straw)	BE %
PSC 1	449.5	51.7
PSC 2	0.0	00.00
PSC 3	669.0	76.45
PSC 4	743.6	84.98
PSC 5	578.6	66.13

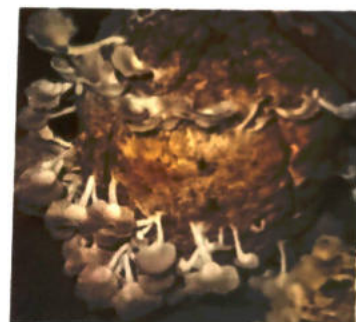


Fig. 46. Fruiting bodies of *Pleurotus sajor caju*

Strain evaluation of paddy straw mushroom (*Volvariella volvacea*)

Five strains of paddy straw mushroom (*Volvariella volvacea*) were tested in September, 2010. Maximum BE was found in *V. volvacea* -13 (10.1%, followed by *V. volvacea* -9 (9.3%) and *V. volvacea* -11 (8.5%) and minimum with *V. volvacea* -12 (3.9%). The detailed data is given in Table 24. The fruiting bodies of *V. volvacea* -13 appeared in 19 days of spawning whereas, other strains took 11-13 days.

Table 24. Performance of strains of paddy straw mushroom during September 2010

Strain	Day of FB initiation	Number of fruiting bodies	Yield (g) per bed (16.5 kg dry straw)	BE (%)
<i>Volvariella volvacea</i> -1	0	0	0	0
<i>V. volvacea</i> -9	11	151.3	1532.7	9.3
<i>V. volvacea</i> -11	13	114.0	1407.3	8.5
<i>V. volvacea</i> -12	12	47.7	643.3	3.9
<i>V. volvacea</i> -13	19	101.3	1667.5	10.1
CD (P 0.05)		41.0	545.1	
CV %		41.2	43.2	

Study on Genetic Diversity in Makhana

To find out the suitable parents for hybridation programme in makhana, a study on genetic diversity was conducted (Fig. 47). A total of 36 germplasm (29 from Manipur and 7 from Bihar) were evaluated. The material was sown on 15th January 2010 at a spacing of 1 x 1m in RBD having a plot size of 30m² for each replicate. The data were recorded on various characteristics and elite plant material was screened for each population.

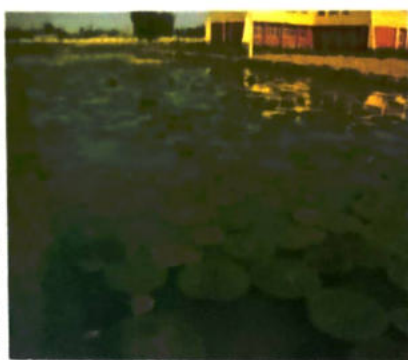


Fig. 47. Genetic diversity of makhana

Development of an elite strain from earlier available germplasm of makhana

Fourteen pure lines of makhana, developed during the year 2008-09, were sown on 15th January 2010 along with a local cultivar (as a check) in RBD with 3 replications for the evaluation of genetic potential of these lines.

The promising strain of makhana (having a seed yield of 2.84 t/ha against the 1.56 t/ha seed yield of a local check) was identified. To know the performance of this strain in farmer's field, 60 kg seed has been distributed among 5 progressive farmers of Darbhanga and Madhubani districts. The productivity shall be given in next annual report since the crop will be harvested in the months of August.

Standardization of Plant-to-Plant and Row-to-Row Spacing in Makhana

To find out an optimum spacing in makhana crop, the seedlings of local cultivar of Makhana were transplanted at different spacings of 1 x 1m, 1.25 x 1.25m, 1.5 x 1.5m, and 1.75 x 1.75m in well prepared low-land fields on 21.04.2010. The size of each experimental field was 500m². The data on various economic traits were recorded from time to time. The crop was harvested on 22nd August 2010. The seed yield was re-

corded to be 57.5kg, 68kg, 62.5kg and 56kg for 1 x 1m, 1.25 x 1.25m, 1.5 x 1.5m and 1.75 x 1.75m spacing, respectively. The data revealed that 1.25 x 1.25m spacing was ideal for makhana cultivation.

Makhana Cultivation at Shallow Water Depth

Traditionally, Makhana is grown in the natural water bodies like ponds, lakes, swamps and ditches (Fig. 48). In these water bodies, the average depth of stagnant water is generally 4-6 feet. Due to high water depth of water bodies, the agronomic management of the crop is very tedious and as a result, the productivity of this crop is very low (0.8-1.0 t/ha). Further, no other extra crops can be taken in these water bodies because of the water depth. Keeping this fact in view, an experiment was conducted to find-out the possibilities of makhana cultivation in low lying fields.

In the year 2009-10, a low land field having the clay soil was chosen for this experiment. A plot was well prepared by two deep ploughings and farmyard manure was added to it @ 3.0 t/ha. After ploughing, a bund of 1.5 feet height and 2 feet width was made along the entire surrounding of each plot. On the 15th January, the pond was filled with water up-to the height of half feet of bund and direct sowing of makhana seeds was done at the spacing of 1.25 x 1.25 m by putting 3 healthy seeds at 4 cm depth. Germination of all the seeds was completed by the end of February. By the mid of April 2010, the flowering was started and continued up to the harvesting of crops. On the 12th August, makhana was harvested with a record seed yield of 2.84 t/ha compared to 1.0 t/ha in traditional systems. Similar results were obtained in the year 2008-09.

Hence, makhana can be grown successfully at shallow water depth and the field may be utilized to take another crop like paddy, chestnut, barseem etc.



Fig. 48. Traditional makhana cultivation

Development of Crop-Livestock Based Farming System under Irrigated Condition

The project undertaken in 2 acres to develop dairy based integrated system model in intensified crop-livestock production system in irrigated areas was continued in third year. The results of four crossbred dairy cows integrated in the system and farmer's practice model simulated with one cattle are presented in Table 25.

Table 25. Crop production in intensified dairy based production system as compared to farmers' practice

Attributes	Farmers' practice (control)	Intensified dairy based production system
Total land	1 Acre	1 Acre
Food crop area %	0.9 Acre	0.6 Acre
Fodder area & animal shelter	0.1 Acre	0.4 Acre
Crop Production		
Wheat yield	0.73 t	0.59 t
Wheat straw yield	0.95 t	0.63 t
Rice yield	1.53 t	1.04 t
Rice straw	1.84 t	1.22 t
Fodder yield		
Kharif Maize	862 Kg	1735 Kg
Berseem	140 Kg (1st cut)	2918 Kg (upto 2nd cut)
Oat (up to 2 cuts)	-	683 Kg
Lactation yield (kg)	939.8	2193.12
Total dung produced (Tones)	5.11	32.12

Under irrigated condition in rice-wheat cropping system (Fig. 49) indicated that an income of Rs. 36,800/- and 125,700/- was obtained in farmer's practice and

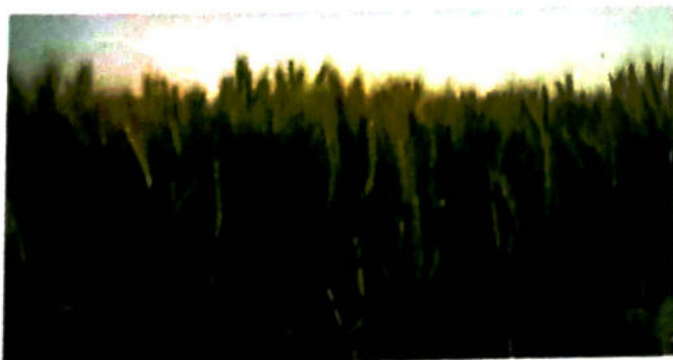


Fig. 49. Wheat cultivation in crop-livestock farming system

intensified system with dairy, respectively. Whereas, employment generation was observed to be 226.25 and 757.25 man days in farmers' practice and intensify system respectively, indicating 3.35 fold increase in employment generation

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

Land holdings in Bihar consist predominately of small and marginal farm size with a high degree of fragmentation. Hence, the livelihood of the farmers itself is at the stake. Keeping this fact in view, integrated farming system models were developed over one acre and two acre area not only for food and nutritional security of the farming family but also for round the year employment opportunities. The area under different components has been allocated as per need and in view of nutrient recycling within the system (Fig. 50).

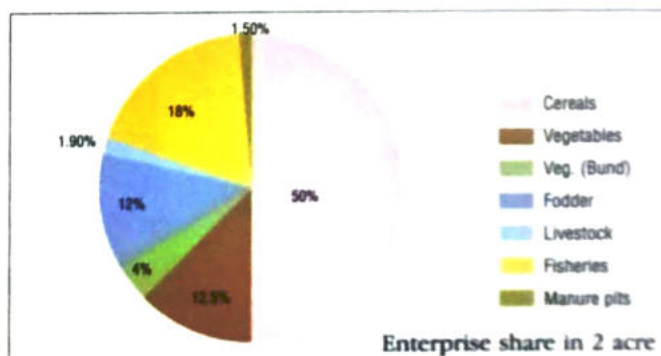
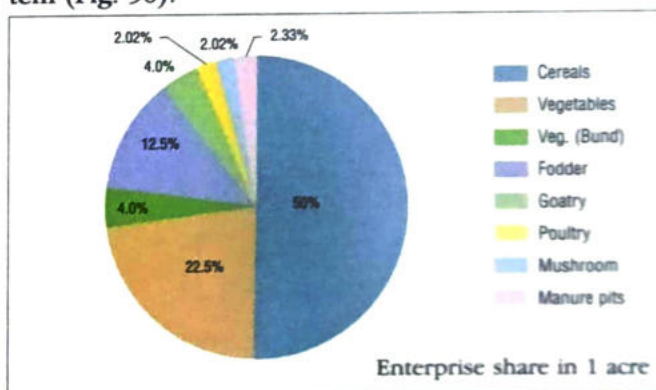


Fig. 50. Per cent contribution of different components under 1 and 2 acre IFS module

In one acre model, goat, poultry, mushroom, and vermicomposting have been integrated with the crop components. Under crop components, rice-wheat, rice maize, rice-lentil and rice- mustard (as cereal based cropping system) and cowpea-cauliflower- tomato, okra-pea-cabbage and cucurbits-cabbage-brinjal (as vegetable based cropping systems) were followed and nutrient recycling from the system was studied. Cow-pea-cauliflower-onion cropping system along with poultry + mushroom + goatry fetched the highest net income of Rs. 99,591 in comparison with other cropping system in a farming system mode which was about four times more than rice-wheat cropping system (Rs. 22,886.0) in isolation. In addition, 1.75 tonnes of vermicompost, 5.6 tonnes of goat manure and 0.8q of poultry manure were also produced by the system

which was equivalent to 230 kg of Urea, 496 kg of SSP and 163 kg of MOP (or chemical fertilizers).

In two acre IFS model (Fig. 51), livestock (3 cows + 3 calves), fisheries, duckery, and vegetables and fruits enterprises were integrated with prevalent rice-wheat, rice-maize, rice-lentil and rice-mustard cropping system. Different enterprises were evaluated with the same cropping system for their economic return and employment within different farming systems. It was found that rice-wheat + vegetables + livestock + fisheries + duckery IFS model gave the maximum return. Rs. 1, 61,277 with additional employment opportunity of 460 man-days. In addition, 2.1 t of vermicompost and 27.8t of cow dung was produced. It was equivalent to 482kg of urea, 967 kg of SSP and 396 kg of MOP.



Fig. 51. Integrated farming systems models for irrigated ecosystem

Again, different combinations were made and analyzed statistically. Among different combinations (Table 26), crop (0.95 ha) + fish (0.15) + poultry (500 no.) + duck (35 no.) resulted in maximum sustainability index (70.6) and was followed by Crop (0.8 ha) + fish (0.15 ha) + poultry (500 no.). It was also revealed from the study that plots in which recycled manures from the system were applied resulted in buildup of organic carbon in the soil (Table 27). The details of expenditure, income, resource recycling and sustainability of different farming systems models has been depicted in Table 28-30.

Table 26. Expenditures and income statement of 1 acre IFS model

Components	Establishment cost (Rs.)	Recurring expenses (Rs.)	Net income at 3rd year (Rs.)
Crop (0.2 ha)	-	10,462	8,398
Horticulture (0.09 ha)	1080	9,225	21,015
Fodder	-	4,206	-
Goat (20 + 1) (0.018 ha)	45,000	10,820	39,180
Mushroom (0.003 ha)	10,000	3,500	6,100
Poultry (100 chicks) (0.0015 ha)	12,000	20,000	32,500
V.C. & Manure pits	8,000	2,660	-
Interest on working capital/ depreciation cost etc.	-	7,608	-7,608
Total	76,080	68,475	99,591

Table 27. Recycling of farm waste and gain/saving of nutrients through 1 acre IFS model at ICAR-RCER, Patna (2009-10)

Farm waste	Quantity produced (q)	Production/ use pattern (q)	Nutrient gain (kg)	Fertilizer saving (kg)
Goat manure	56	39 (GM- 27) 17 (VC-12)	N- 69.7, P- 50.24 K- 79.8	230 kg urea 496.25 kg SSP
Veg. waste	11	6.3 (VC-4.4) 4.5-As fodder	N- 11, P- 9.3 K- 9.8	163 kg MOP
Poultry manure	8	Used in crops	N-25.3, P- 20.0, K- 8.4	
RWM Straw	48.3	1.53-mushroom 1.5-V.C. 45 q-sold		

Table 28. Expenditures and income statement of 2 acre IFS model

Components	Establishment Cost (Rs.)	Recurring expd. (Rs.)	NI at 3 rd year (Rs.)
Crop (0.4 ha)	-	20,325	19,010
Horticulture (0.15 ha)	2,500	17,785	39,647
Fodder (0.01 ha)	-	6,224	Used
Fishery (0.1 ha)	70,000	5,528	14, 172
Duckery (on the pond)	18,000	4,200	10,800
Dairy (3 + 3) (0.016 ha)	70,000	62,500	81,870+
			15,000 used
V.C. & Manure pits	15,000	3,300	
Interest on working capital/ depreciation cost etc.	-	17,750	-17,750
Total	1,75,500	1,26,595	1,61,277

Table 29. Recycling of farm waste and gain/saving of nutrients through 2 acre IFS model at ICAR-RCER, Patna (2009-10)

Farm waste	Quantity produced (t)	Production/ use pattern (t)	Nutrient added in soil (kg)	Fertilizer equivalent (kg)
Cow dung	27.8	21.0 (FYM- 14.7) 2.0 (VC- 1.2) 4.8- Pond treat.	N-207.8 P- 143.0 K-225.4	482 kg urea 967 kg SSP 396.5 kg MOP
Veg. waste	1.1	0.8 (VC- .56) 0.3- As fodder to cattle	N- 14.0 P- 11.8 K- 12.5	
DRD	—	—	—	

Table 30. Productivity (REY) kg/ha and economics of different integrated components

Components	REY (kg/ha)	Cost of production (Rs.)	Gross return (Rs.)	Net return (Rs.)	NI/day (Rs.)	S.I. (%)
Crop alone (cereals)	9351	27906	88834	60928	167	-6.8
Crop (0.5) + veg. (0.5)	19405	83953	184347	100394	275	7.7
Crop (0.5) + Veg. + Fruits (0.25)	31776	92152	301872	209720	629	48.0
Crop (0.8) + fish (0.15) + poultry-500 (0.05)	42847	147853	407046	259193	458	66.3
Crop (0.85) + fish + duckery-35	11841	33443	112489	79046	216	-0.1
Crop (0.8/0.06) + fish (0.12) + goat (0.02)	14953	42848	142053	99205	272	7.2
Crop (0.75/0.1) + fish (0.12) + cattle- 3+3 (0.03)	24425	90348	232037	141689	388	23.0
Crop (0.8) + fish (0.15) + Poultry-500 (0.05) + Duckery (35)	44531	152078	423044	270966	742	70.6
Crop (0.95) + mush. (0.02) + goat- 20 (0.03)	15324	45000	145578	100578	275	7.7
S.D.	12822	46843	124672	79493	195.3	
C.V. (%)	57.0	58.9	55.0	54.1	51.3	

Sustainable Livelihood Improvement through Need Based Farming System Models in Disadvantaged Districts of Bihar (NAIP Comp. 3)

A multi disciplinary project with an aim to improve the livelihood security of the rural people in four disadvantaged districts of Bihar at the 7 selected clusters/sites in a participatory bottom up approach in consortium mode was taken up. It was planned to implement appropriate land and water-centric and location-specific livelihood options through Integrated Farming System models with a potential for up-scal-

ing to mass rural communities in the region. Field implementation at the selected clusters (50-150 ha) was planned for specific activities. At each cluster level, local alliance was established to have a linkage with wider group of constituency and stakeholders beyond the selected site for free flow of ideas, exchange of views, publicity of the work, strengthen linkages and wider dissemination of the work and dialogue process. The major achievements under different activities are as per below:

Introduction of improved varieties and cropping systems to increase cropping intensity, employment and net income

In order to increase production, cropping intensity and employment, 14 new varieties and 8 cropping systems were introduced. In previous years it was observed that the cropping intensity (C.I) increased from 200% to 300% mainly due to introduction of summer/catch crops in the cluster. Wheat and maize yield was recorded to be 3.75 t/ha and 6.24 t/ha, respectively, indicating yield increase by 17.3% and 24.7%. The increase was due mainly to varietal replacement in these crops. The employment generation increased by 15.2% (additional 55 mandays/ha/yr) by adopting different cropping systems. Likewise, increase in net income ranged between 27% (rice-maize-moong) and 153% (rice-potato-moong).

Maximizing the productivity of water bodies through integration of makhana and fish

The technology aimed to enhance multiple uses of water by the introduction of makhana + fish + water chestnut system in the ponds for generating the additional revenue and maximizing the net profit earned per unit area than the conventional method of makhana cultivation (Fig. 52).

The integration exhibited the yield of 1.40, 0.27 and 3.70 t/ha, respectively, to makhana, fish and water chestnut compared to 1.70 t/ha for makhana alone in traditional methods of cultivation. The outcome of the intervention from the 96 beneficiaries tried in an area of 50 ha of Darbhanga Sadar Block, revealed that makhana as a primary crop gave a net profit of Rs 20,614 per hectare with an employment generation of 247 man days/ha/yr. The fish as a secondary crop integrated in makhana ponds showed an additional net income of Rs 11,806/ha/yr with an additional employment generation of 24 man days/ha/year. Likewise, water chestnut taken as tertiary crop generated an additional net income of Rs.13445 per ha with an employment generation of 83 mandays/ha/yr. The technology is suitable for flood prone ecosystem of Darbhanga, Madhubani and Saharsa districts of Bihar.



Fig. 52. Makhana-fish cultivation

Improved production of seed potato and cultivation of processing potatoes & chip making along with capacity building for other income generation activities:

A total of 209 farmers' of Vaishali Cluster were trained in potato seed production, cultivation of processing grade potato and potato chip making about 802.9q of foundation seed of K. Pukharaj and K. Kanchan was produced in 4 ha area involving 43 small & marginal farmers. Likewise, 1399.40q of processing potato was produced from 4 ha area involving 67 small & marginal farmers. Micronutrient deficiencies such as Boron, Iron & copper was detected and reported for the first time on cluster basis from Pusa and Rosera of Samastipur. Accordingly nutrient inputs were distributed one spawn lab was also established at Bahadurpur (Pusa). Three group leaders of women FIG became Master trainer and imparted training in nearby area by establishing three mushroom training centres in three villages.

Fisheries enhancement through fish culture in pens and cages in *Chaur* lands

A total of three nos. of pens (0.35 ha total area) with 20,000 nos. fry were raised. Thirty five nos. of cages were fabricated and installed in Pirapur *chaur* at Jandaha Cluster. Open water fisheries management was done through stoking of about 15,000 advanced finger-ling. In order to make available carp seed, a

portable *eco-hatchery* (capacity 0.5 million) was established at the *cbaur* site (Fig. 53)

Breed improvement in cattle and goat and Preventive health care and feeding management

Total confirmed pregnancy in cattle was 120 out of which calving occurred in 50 (24 M, 26 F) during the year. Altogether 139 kids were born from Black Bengal Buck and 104 animals were treated under health care and feeding management.



Fig 53. Interaction with the farmers' (above) and establishments of eco hatchery (bottom) at NAIP site

Developing sustainable farming system models for prioritized micro watersheds in rainfed areas of Jharkhand

Planting of fruit plants in *Bariland* of each household

To address the nutritional security, 1175 fruit plants including mango (477), guava (294), aonla (165) and papaya (239) were planted in *Bariland* of 229 households of Dumka and Jamtara district in

Jharkhand. Additionally, all the 229 farm families established 3-4 drumstick plants in their backyard gardens.

Demonstration of mushroom cultivation for income generation by women group

Eighty women farmers in Dumka district were regularly and successfully growing oyster mushroom. The harvest/bag was 1.0-1.5 kg. The sale price of mushroom was Rs.80-100/kg. Out of 6 SHGs involved in mushroom cultivation, the Ashra SHG with 21 women of Guhijori village deposited Rs.13,000/- and Gulab Baha SHG with 12 women of Karela village deposited Rs.9796/- in their bank accounts. In Jamtara district, 2 farm women have started growing oyster mushroom.

Floriculture introduced for income generation by farm women

One woman farmer of Palasi village in Jama Block of Dumka district cultivated marigold in 1.25 decimal land and harvested 52 kg flowers which were sold @ Rs. 20/- per kg and a total income of Rs. 1040 was generated.

Modeling the Performance of Few Major Cropping Systems in Eastern India in the Light of Projected Climate Change (NAIP- Comp. 4)

Open top chamber experiment

Four varieties of rice viz., Rajshree, Rajendra Bhagwati, Swarna Sub 1 and MTU 7029 were evaluated under three OTCs, i.e., OTC1- Control, OTC2- 25% increase of CO_2 , OTC3- 25% increase of CO_2 and 1°C increase of temperature over control (Fig. 54). Similarly, promising HYV of eastern region- Swarna Sub 1 was evaluated under different nutrient management practices under OTC4 (25% higher CO_2 and 1°C higher temperature over control).

Swarna sub1 and MTU 7029 took more total duration under control OTC and Rajashree and Rajendra Bhagwati took more duration under 25% increase of CO_2 and 1°C higher temperature conditions. The du-

ration of Swarna Sub 1 under OTC4 was higher compared to open field conditions. All the varieties inside OTCs produced more yield compared to open field conditions. Different varieties performed differently with increase in CO_2 and 1°C higher temperature. Rajashree and Swarna Sub1 produced higher yield in control OTC. However, Rajendra Bhagwati produced higher yield under 25% increase of CO_2 and 1°C higher temperature. MTU 7029 produced higher yield under 25% increase of CO_2 . Least variability of yield, however, have been noticed for Rajendra Bhagwati and MTU 7029 under different OTC treatments and open field conditions (Fig. 55).

Under nutrient management treatments, (25% increase of CO_2 and 1°C higher temperature) the split application of nitrogen fertilizer treatment produced higher yield. There was not any influence of elevated CO_2 and temperature on pH, organic carbon, available nitrogen, and exchangeable K. SMBC increased significantly with additional nutrient either through fertilizer or through organic amendment (Table 31).

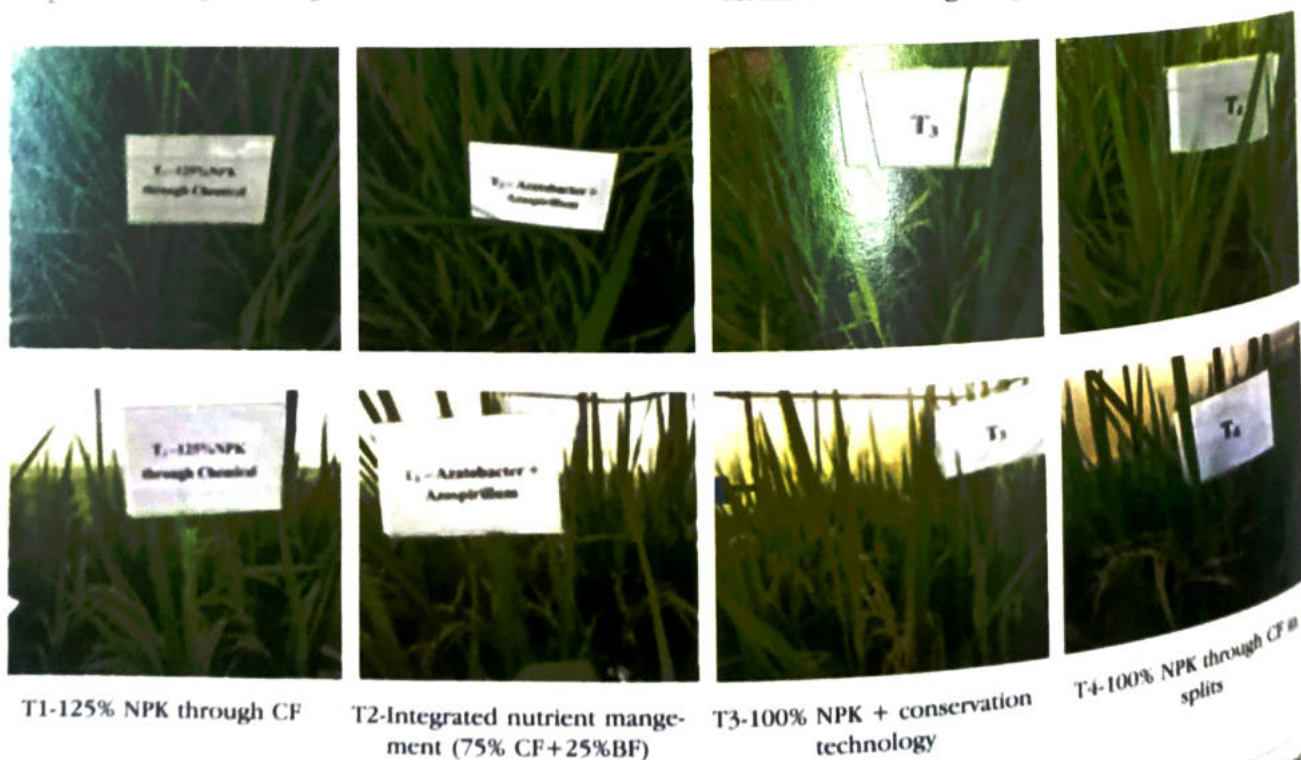


Fig. 54. Performance of Swarna Sub 1 under different management practices in OTC-4

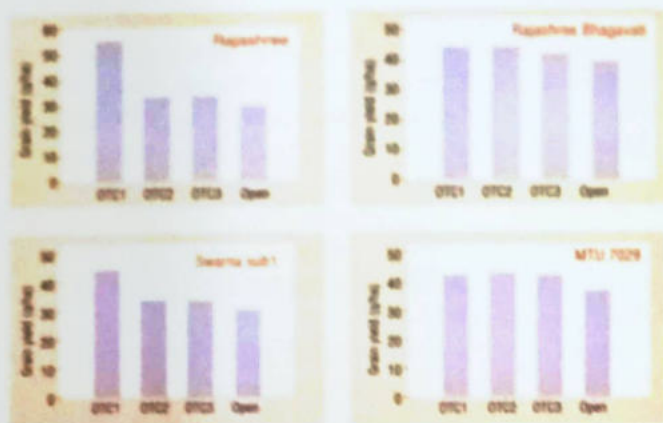


Fig. 55. Performance of different varieties under OTCs and open

Table 31. Soil pH, organic carbon, SMBC, available N, P and K under different OTCs

Treatments	pH	Organic Carbon	SMBC	Available N	Available P	Exchang-able K
OTC1	6.90	0.64	104	187.44	18.21	184.8
OTC2	7.06	0.66	138	232.68	19.62	306.4
OTC3	7.05	0.72	158	187.02	24.20	280.4
T1	7.03	0.76	176	205.48	14.28	298.0
T2	7.10	0.87	168	242.60	12.96	286.4
T3	7.08	0.85	160	201.34	12.60	246.4
T4	7.05	0.70	152	247.64	12.40	210.8
CD(0.05)	NS	NS	36.88	NS		NS

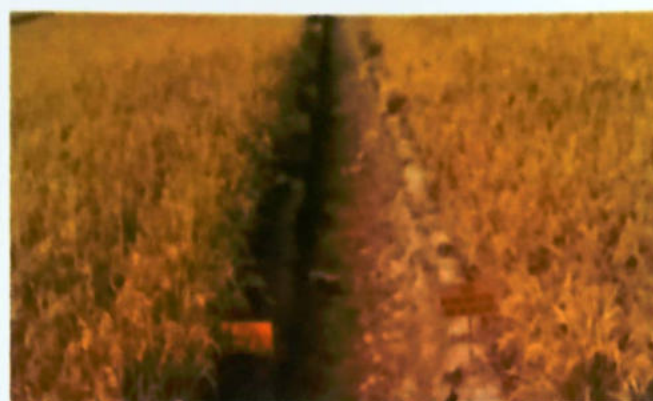


Fig. 56. Rice crop at Physiological maturity stage



Fig. 57. Lentil crop at pre flowering stage

Nutrient Management in Rice - Lentil Cropping System

A field experiment was conducted in randomized block design (RBD) to find out suitable nutrient management system with respect to one secondary nutrient sulphur and one micro nutrient zinc under rice - lentil cropping system. Four levels of sulphur S_1 (0kg), S_2 (20kg), S_3 (30kg), and S_4 (40kg), and zinc Zn_1 (0kg), Zn_2 (4kg), Zn_3 (5kg), and Zn_4 (6kg) respectively, were applied on hectare basis. Both, sulphur and zinc, were applied to rice crop and their direct effects on rice and residual effects on lentil were investigated.

The texture of soil of experimental plot was silty clay loam with mean pH value of 6.8, electrical conductivity 0.16 ds/m in 1:2 soil: water solution, organic carbon 0.68 per cent, with available nitrogen 244.7 kg/ha, available phosphorus 28.6 kg/ha, available potash 185.8 kg/ha, sulphur 8.3 kg/ha and zinc 0.8 kg/ha. This was third crop cycle for rice (Fig. 56) and second for lentil (Fig. 57), hence data presented here are of two cropping seasons, data on lentil belongs to 2009-10 and rice data is of 2010.

The lentil crop was taken just after harvest of rice during Nov 2009 to March 2010. It is observed that the plant height of lentil is significantly influenced by different levels of application of Zn and S (Table 32). Maximum and minimum plant height was recorded as 42.2 cm and 32.8 cm, respectively in case of S_4 and S_1 level of sulphur at harvest. Number of productive

branches per plant have been recorded minimum 13.9 with no application of zinc whereas maximum (16.3) was obtained in case of S_3 . Pod/plant were recorded maximum 63.8 in case of S_4 and minimum value (45.9) with S_1 treatment. Maximum lentil seed yield 1.15 t/ha was recorded with S_4 treatment whereas lowest yield (1.01 t/ha) was noticed with S_1 treatment.

Table 32. Effect of sulphur and zinc on growth, yield attributes and yield of lentil during 2009-10

Treatments	Plant Height (cm)	Branches/plant	Pod / plant (t/ha)	Grain yield wt (g)	1000 grain	Harvest Index
S_1	32.8	14.4	45.9	1.01	24.7	0.40
S_2	38.70	15.9	54.2	1.10	24.7	0.39
S_3	39.8	16.3	58.0	1.15	24.8	0.39
S_4	42.2	16.2	63.8	1.11	25.0	0.38
CD	2.8	1.9	8.6	0.035	NS	NS
Zn_1	34.7	13.9	47.9	1.03	24.7	0.38
Zn_2	38.8	14.7	53.2	1.10	24.7	0.39
Zn_3	40.7	15.4	59.3	1.12	24.9	0.40
Zn_4	39.5	16.1	62.9	1.12	24.9	0.39
CD	2.8	1.9	8.6	0.035	NS	NS

Data presented in Table 33, shows the combined response of both the factors on lentil seed yield. Minimum lentil seed yield of 0.96 t/ha was recorded in control whereas, corresponding maximum lentil seed yield (1.24 t/ha) was recorded with combined application of 30 kg sulphur and 6 kg zinc.

Table 33. Effect of sulphur and zinc on seed yield (t/ha) of lentil during 2009-10

Treatments	S ₁	S ₂	S ₃	S ₄	Mean of Zn
Zn ₁	0.96	1.00	1.07	1.10	1.03
Zn ₂	1.04	1.14	1.12	1.11	1.10
Zn ₃	1.07	1.12	1.15	1.12	1.12
Zn ₄	0.99	1.14	1.24	1.10	1.12
Mean of S	1.01	1.10	1.15	1.11	
CD	Mean effects 0.41		Interaction (NS)		

Effects of sulphur and zinc on rice (Crop season 2009)

The plant height of rice was significantly affected by both the factors (sulphur and zinc). Application of Sulphur @ 20kg/ha (S₂) produced significantly taller plants over control (S₁). Similar type of response was also recorded in case of zinc application (Table 34).

Table 34. Effect of sulphur and zinc on growth, yield attributes and yield of rice during 2010

Treatments	Plant height (cm)	LAI	Panicle/m ²	Grains/panicle	Grain yield (t/ha)	HI (%)	1000 seed wt.(g)
S ₁	121.5	6.35	271.4	191.8	7.25	0.41	15.9
S ₂	124.6	7.12	287.9	199.5	7.45	0.42	16.0
S ₃	126.3	7.51	303.6	204.9	7.44	0.42	15.9
S ₄	128.4	7.84	300.1	205.6	7.43	0.41	16.0
CD	2.1	0.63	15.6	9.08	0.24	NS	NS
Zn ₁	122.7	6.64	274.0	193.1	7.20	0.42	15.9
Zn ₂	126.2	7.25	291.4	202.03	7.35	0.41	16.0
Zn ₃	128.3	7.73	307.9	205.59	7.45	0.42	16.0
Zn ₄	129.4	8.15	311.4	207.7	7.57	0.42	16.1
CD	2.1	0.63	15.6	9.08	0.24	NS	NS

Effect of sulphur and zinc on rice yield is shown in Table 35. Minimum rice yield of 7.09 t/ha was recorded with no application of zinc and sulphur where as corresponding maximum rice yield (7.72 t/ha) was recorded with combined application of 30 kg sulphur and 6 kg zinc. In case of zinc application, Zn₄ produced significantly higher grain yield over Zn₁ but produces at par with other tested levels of zinc.

Table 35. Effect of sulphur and zinc on rice seed yield (kg/ha) during 2010

Treatments	S ₁	S ₂	S ₃	S ₄	Mean of Zn
Zn ₁	7.09	7.17	7.23	7.29	7.20
Zn ₂	7.23	7.37	7.39	7.41	7.35
Zn ₃	7.35	7.56	7.42	7.45	7.45
Zn ₄	7.31	7.68	7.72	7.55	7.57
Mean of S	7.25	7.45	7.44	7.43	
CD	Mean effects 0.24		Interaction (NS)		

Crop and Resource Management Practices for Sustainable Future Cereal-base Systems

Under Cereal Systems Initiative for South Asia (CSISA), Platform Research is being conducted at Sabajpura farm in Patna for strategic experimental research for future cereal systems with focus on rice-

wheat system, its intensification and future diversification for high cereal production with sustainable natural resource management. Broad Technical Programme/Activities are: (i) Participatory adaptation of new crop and resource management technologies for conservation agriculture systems (ii) New generation of resource-efficient, high-yielding cereal systems and (iii) Operation in technology delivery hubs and other selected areas and interactions with breeding programs.

Four scenarios of cropping with different residue crop health and nutrient management practices has been sown in three replications having large plot size (1,900 m² each). Details are given in Table 36.

Among the different scenarios grain yield of wheat 2009 – 10 under conservation agriculture (Scenario 3: zero tillage and keeping one third residue of the previous crop rice) was 40 per cent higher than the conventional practice by farmers (Scenario 1) (Fig 58). The conventional practice was determined by benchmark survey of 30 farmers in the vicinity of the experimental area within 25-30 km. Higher grain yield was also reflected in higher yield attributing characteristics of wheat in scenario 3. Under future cereal system (Scenario 4) potato and maize intercropping was considered for intensification and diversification (Fig. 59). In these plots, 18.2 t/ha of potato and 6.8 t/ha of maize yield was obtained. The cost of different components for wheat production was calculated and it was observed that net incomes were 233 and 444% higher in scenario 3 and 4, respectively, as compared to scenario 1. On average, conservation agriculture (Fig. 60) practice could save 17% irrigation water in comparison to conventional practice in scenario 1.

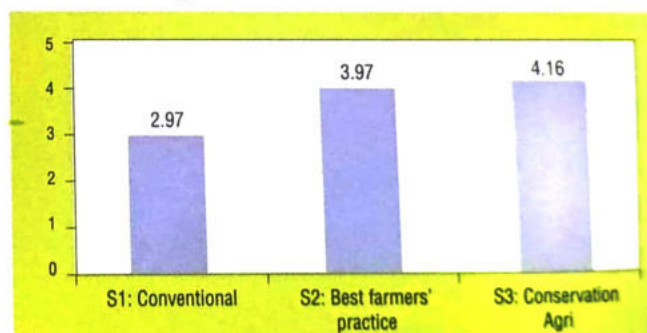


Fig. 58. Wheat grain yield (t/ha) during 2009-10 in different scenarios

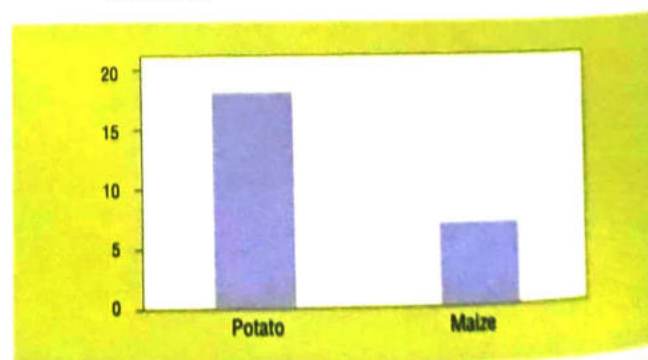


Fig. 59. S4 (Intensification and diversification): Potato and maize yields (t/ha)

Table 36 Crop production scenarios and management practices

Scenarios	Drivers of change	Crop rotations	Crop Management (CM)	Tillage in system	Residue management	Crop health	Nutrient management
1	Business as usual	Rice-wheat (current)	Farmers practice	CT-CT	Removal	As usual	As usual
2	Increasing food demand	Rice-wheat-mungbean	Best Available	CT-ZT-CT	Anchored-removal-incorporation	Best Available	Best Available
3	Increasing food demand, Degrading natural resources, energy and labor crises	Rice-wheat-Mungbean	Conservation Agriculture	ZT-ZT-ZT	Retention anchored retention	Best management	SSNM Based
4	Food and nutritional security, Intensification and Diversification, farm profitability	Rice-Potato+Maize-Mungbean	Best practice	ZT-CT-ZT	Retention-anchored-retention	Best management	SSNM Based

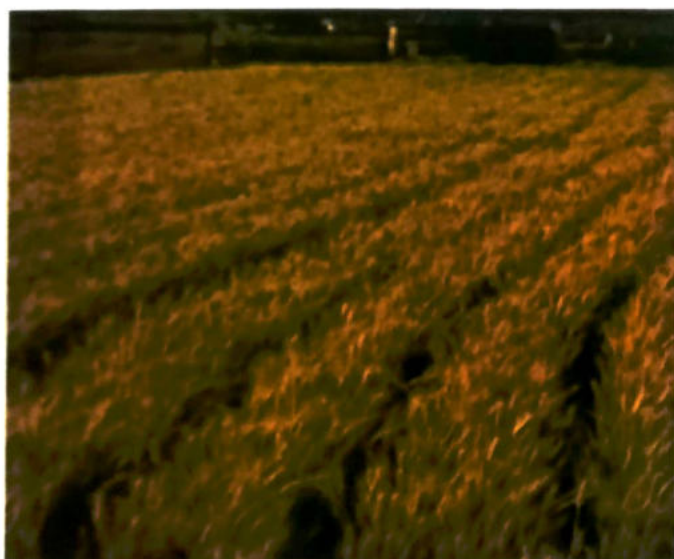


Fig. 60. Zero tillage wheat under conservation agriculture in scenario 3

One third crop residue of wheat was retained for cowpea and entire cowpea residue was recycled in rice in scenario 3 by zero tillage (Table 37).

The total potato shoot after harvesting of potato tuber was incorporated for earthing up of maize and one third maize residue was retained for rice-cowpea cultivation. Again cowpea residue was retained for rice in S4. Mungbean residue was incorporated for rice cultivation in S2. Thus 18.90 t/ha of crop residue was added/recycled in S4 and 8.09 t/ha in S3 as compared to 4.96 t/ha in S2.

Table 37. Amount of crop residue recycled in different scenarios

Scenario	Crop residue (t/ha) added in different scenarios			
	Rice in wheat/potato + maize	Wheat in green gram/cowpea	Green gram/cowpea in rice	Total
S1	Removed	Removed	fallow	-
S2	1.95	1.42	1.59	4.96
S3	2.09	2.80	3.20	8.09
S4	2.32	13.50	3.08	18.90

The zero tillage rice with residue retention of previous crops in S4 and S3 exhibited 30 and 17% higher than the conventional practice in S1 (Fig. 61).

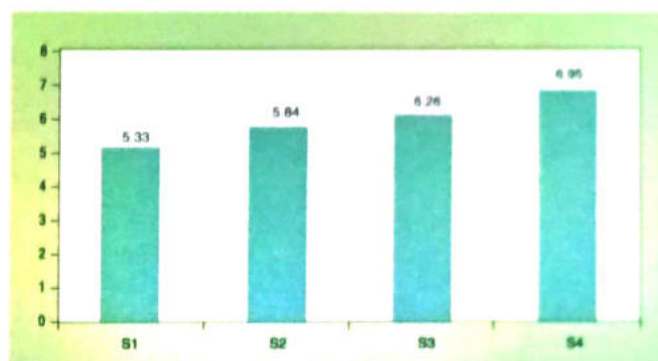


Fig. 61. Rice yield (t/ha) in different scenarios

Survey and Surveillance of Insects Pests of Rice and Wheat Cropping System of Patna District of Bihar

Survey of insect pests was carried out in different cultivars grown at Complex Research farm and Sabjpura in vegetative, flowering, milking and maturity growth stages of the rice crop. Due to consecutive long dry spell in early months of crop establishment, the incidence of termite (*Odontermes* sp) infestation was experienced at vegetative stage in BPT-5204 and varietals trial plots and Sabjpura, respectively. The intensity of damage was recorded to the tune of 6.77% per hill in BPT-5204 and 8.67% in aerobic rice varietals trial. The severity of mealy bug (*Brevinnia rebi*) infestation was 25.9% at vegetative stage in MTU-7029. The incidence of rice seed bug (*Leptocoris oratorius*) was observed above ETL (1-2 bugs/hill) in Satyam (Avg. 1.5 bugs /hill) and BPT -5204 (Avg. 1.2/hill). Maximum average density of adult leaf folder (*Cnaphalocrocis medinalis*) was recorded in BPT-5204 at maturity stage (Avg. 1.0/hill). Though, no damage was noticed in rice crop because larval stage of leaf folder caused damage at vegetative growth stage of the crop. The incidence of green leaf hopper and yellow stem borer ranged 0.2-0.4/hill. The insect density was recorded low as compared to previous years (Fig. 62).

Two new Coleopteran beetles, *Haplochrus fasciatus* Fabricius (family: Melyridae) and

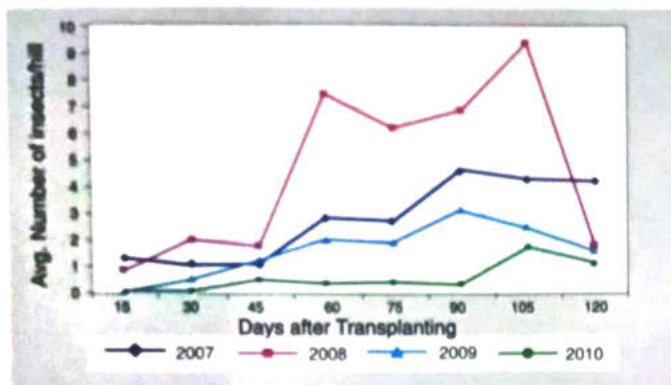


Fig. 62. Average density of insects per hill in four years in MTU 7029 at ICAR Farm



Fig. 63. New insects identified in rice fields

Gonocephalum sp (family: Tenebrionidae) were identified (Fig. 63). *Hapalochrus fasciatus* was not reported earlier in rice crop. Former beetle is known as vegetable beetle, it feeds paddy crop at very early vegetative stage. Another hemipteran pest of sugar cane, *Pyrilla perpusilla* (family: Fulgoridae) was also observed in paddy crop for last two year. The changing of pest complex may be due to erratic rainfall; resultant the insects are adopting themselves on alternate host plant for survival.

Eco-biology and Management of Rodent Fauna of Rice-Wheat Cropping System

In rice crop mainly three rodent species- Lesser bandicoot rat (*Bandicota bengalensis*), field mouse (*Mus booduga*), and soft furred field rat (*Millardia meltada pallidior*) were collected. Bandicoot rat was found predominant (67.5%) rodent species in rice crop followed by *M. booduga* (Fig. 64). Burrow density of *B. bengalensis* was recorded maximum (315.26 ± 36.62 nos/ha) as compared to *M. booduga* and *M. meltada* (Fig. 65).

Damage assessment was carried out at different growth stages of the crop in Satyam, SB₁ and Rajendra Sweta cultivars at ICAR complex farm, however, damage of hill and tiller at booting and flowering stage



Fig. 64. (A) Breeding potential of *Mus booduga* (B) Advance stage embryo

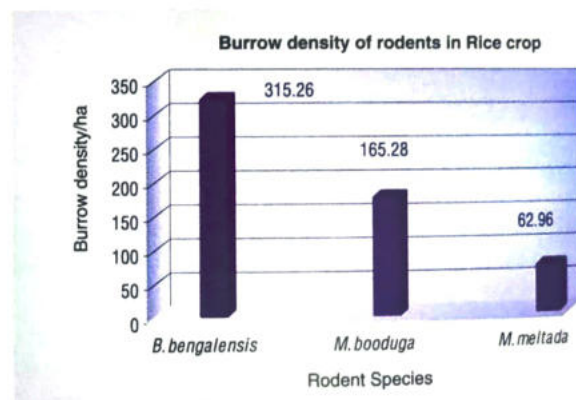


Fig. 65. Average burrow density/ha of rodents in rice crop

were recorded in Satyam and Rajendra Sweta to the tune of 6.58% & 4.26%, and 19.48% & 16.48%, respectively. Maximum tiller damage was recorded at maturity stage in all the three cultivars (Table 38).

The efficacy of three poisons- an acute poison (zinc phosphide- ZNP), a chronic (Bromadiolone-BR 0.005) wax cake and a fumigant, aluminium phosphide (ALP) were tested under field conditions at the ripening of the crop in three cultivars. Treatments were carried out in active burrows, i.e., burrows with rats. An active burrow is identified by the presence of fresh (moist) soil at its openings and closed burrows openings with loose soil. Pre-baiting was carried out in the test of acute poison (zinc phosphide). Poison bait (zinc phosphide) and wax block (Bromadiolone) were wrapped in paper and placed about 20-25cm deep

Table 38. Mean percentage of affected hills and damaged tillers by bandicoot rat based on random sampling of 1m² area in different rice cultivars at various growth stages crop

Cultivar	Growth stage	Percent affected hills	Percent tiller damage	Damage assessment
Satyam	Vegetative	4.18	3.86	Moderate*
	Booting / flowering stage	6.58	4.26	Moderate
	Milking and dough stage	7.66	4.59	Moderate
	Maturity	16.31	14.77	High**
Rajendra sweta	Vegetative	-	-	-
	Booting / flowering stage	7.14	4.69	Moderate
	Milking and dough stage	17.27	15.82	High
	Maturity	16.43	10.82	High
SUB1	Vegetative	-	-	-
	Booting / flowering stage	-	-	-
	Milking and dough stage	12.36	11.16	High
	Maturity	15.11	11.27	high

*Moderate 3-5% damage; ** High 6-22 % Damage

inside the active burrow. Pellets (one per burrow) were also placed 20-25 cm deep inside the active burrow and all openings were plugged. The openings of all active and non active burrows nearby were also plugged. The reopening of plugged burrows or creation of new openings was done at different days after treatment and data were compared with those obtained from the untreated control. Estimated rat mortality was adjusted by the Schneider ovelli's formula. All the treatments were observed up to 20 days. In the 1st test carried in Satyam variety, out of 25 burrows, 20 burrows (80%) in control, 13 (52%) in zinc phosphide and 7 (28%) aluminium phosphide burrows were reopened. The estimated mortality was 35 % in ZNP, 15% in BR and 65% in ALP. In the second test in SB₁ field, 20 burrows were treated. 18 out of 20 (90%) in control, 12 (60%) in ZNP, 15 (75%) in BR and 5 (25%) burrows were opened. Mortality was estimated 33.33% in ZNP, 16.66% in BR and 72.22 % in ALP. In third test, mortality was estimated to be 38.45, 7.09 and 53.84% in ZNP, BR and ALP, respectively. It indicates that aluminium phosphide was much better than zinc phosphide and Bromadiolone wax cake in achieving immediate popu-

lation knockdown. The technique of placing of poison whether it is zinc phosphide, Bromadiolone or fumigant aluminium phosphide in side burrow should have least effect on non target animals and also safe for environment.

Water Harvesting and Better Cropping Systems for the Benefit of Small Farmers in Watersheds of the East India Plateau

To conduct the study, Pogro and Amagara watersheds were selected and data from different sub-watersheds (namely Usri, Hurdag and Nagwan) of Damodar River Basin and Brahmani River Basin located in the eastern India have been collected for calibration and validation of the hydrological model and developing regionalized parameters. The brief description of the three subwatersheds is given in Table 39.

Historical daily rainfall data measured at the outlet of the above three sub-watersheds were collected from the Soil Conservation Department of DVC Hazaribagh. Surface runoff and sediment yield data of all the three subwatersheds for the monsoon period were also collected from the Soil Conservation Department, DVC, Hazaribagh for the calibration and validation of the hydrological model. Other meteorological data, viz, rainfall, minimum and maximum temperature were also collected from a meteorological observatory located at Hazaribagh (85° 22' longitude and 23°59' latitude and 611m altitude). Daily rainfall data was also collected from the District Agriculture Department, Purulia (86° 25' longitude and 23°20' latitude and 255 m altitude). Topographic maps (1:250000 scale) were collected from the Survey of India, Kolkata and Soil and land use map was collected from NBSS and LUP, Kolkata. The data is shown in Fig.66.

Analysis of rainfall and runoff data: Nagwan sub-watershed receives maximum rainfall among the

Table 39. Description of the selected sub watersheds of Damodar River basin

Details	Nagwan	Usri	Hurdag
Name of the catchment & State	Damodar , Jharkhand	Barakar, Jharkhand	Damodar , Jharkhand
Name of the river valley project	Damodar Valley Corporation(DVC)	DVC	DVC
Name of the sub-watershed	Upper Sewani – 7A	Usri Nadi-32	Katery Naia
Name of the gauging station	Nagwan	Giridih	Hurdag- Pt2d
Location of gauging stations (Longitude – Latitude)	85°24' -24°03'	86°20' -24°11'	85°35' 45"-23°48' 40"
Name of the stream	Upper Sewani	Usri -32	Katery Naia
Areal extent of the sub-watershed (Longitude and latitude)	85°18' -85°23' E 23°59' -24°05' N	86°04' 34"-86°24' 12"E 24°10' 50"-24°31' 54"N	85°34' 21"-85°39' 20"E 23°48' 42"-23°52' 05"N
Area (km ²)	92.46	731.02	23.04
Slope	1-5%	1-5%	1-5%
Soil	Red loamy soil, sandy loam	Red loam, alluvial soil	

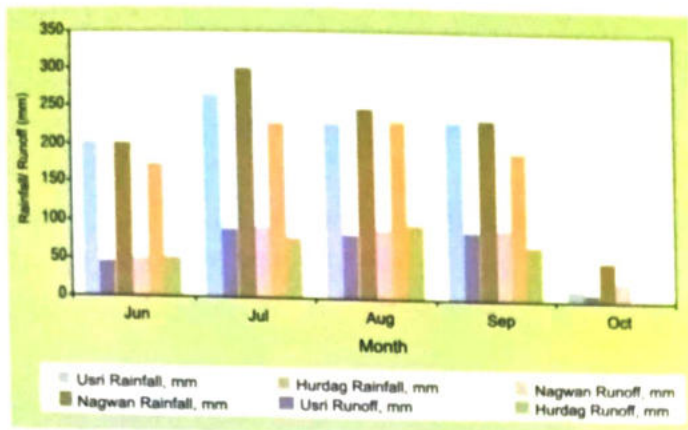


Fig 66. Mean monthly rainfall and runoff in three sub watersheds of the DVC

three subwatersheds. Though there is not much variation in the mean monthly rainfall in the three subwatersheds, analysis of daily data showed significant variation in the rainfall characteristics of the three subwatersheds, thus affecting the runoff yield from each watershed. On an average, 20 -35 % of the rainfall gets converted to runoff.

Digitization and Generation of Hydrological Response Units (HRUs)

Scanned toposheets are georeferenced using TNTMips software with maximum possible ground control points and least RMS errors. The contour lines are then digitized and further converted from "feet" to "metre" unit to generate DEM in meter. DEM layer is developed with 30 m of spatial resolution. DEM layer and mask layer (bit map) of the study area is imported to TNTmips for slicing and sub-watershed generation. Using the GEOFORMULA and WATERSHED ANALYSIS utility of TNTmips, the elevation layer is sliced into different classes. Slope (degree) and aspect map are generated on the basis of DEM. Similarly, soil and land use thematic map (.jpeg file format) are geo-referenced and classified with "Maximum Likelihood" algorithm of "Supervised Classification". Thematic map of soil with different textural classes and land use map with different classes are generated.

Sliced elevation layer, soil layer and landuse layer are overlayed to develop the layer of Hydrological Response Units (HRUs). Each layer is re-projected with same projection (UTM), raster extent and pixel size to make them compatible with each other for overlaying process. In this way, the Usri and Hurdag subwatersheds were divided into 15 and 11 HRUs, respectively. Finally, area, slope (mean, median, and mode), aspect (mean, median, and mode) and elevation (mean, median, and mode) values as well as soil and landuse class extent for each HRUs were then extracted through the HRUs vector layer and individual thematic layer for input to hydrological model (Table 40).

Table 40. HRU wise elevation and slope of Usri and Hurdag sub watersheds

HRU	Usri			HRU	Hurdag		
	Area (km ²)	Elevation (m)	Slope (%)		Area (km ²)	Elevation (m)	Slope (%)
1	0.78	330.65	1.01	1	0.01	1368.13	43.51
2	2.66	335.37	7.17	2	0.02	1377.07	52.10
3	6.44	322.68	2.16	3	0.04	1365.14	16.53
4	9.00	356.03	0.92	4	0.07	2278.86	34.74
5	9.98	306.24	2.29	5	0.11	1988.17	48.77
6	10.13	361.59	0.53	6	1.12	2028.40	38.70
7	10.67	322.23	1.34	7	1.27	2384.76	58.78
8	13.33	333.12	1.07	8	2.34	2131.54	63.74
9	21.31	294.35	1.25	9	4.04	1814.01	88.11
10	68.36	316.74	1.95	10	6.18	1466.97	52.76
11	68.97	341.63	2.35	11	6.27	1240.89	22.48
12	82.47	339.63	1.30				
13	84.82	312.56	1.72				
14	104.15	346.48	1.62				
15	185.41	352.68	1.06				

Water Resource Management

Based on observations and modelled results, guidelines to help with the design of watershed development have been developed to assist the planner with determining what interventions would be suitable in specific areas, and estimating the volume of potentially 'harvestable' water. These guidelines were trialled with a group of PRADAN professionals.

Development of drip irrigation practices in okra-potato-mentha system

A field experiment was conducted during 2010-11 with Mentha (Fig. 67)-Okra (Fig. 68)-Potato (Fig. 69) cropping system during summer, rainy and winter seasons. The soil was silty clay loam with mean soil pH of 7.07, electrical conductivity 0.25 dSm⁻¹ in 1:2.5 soils: water solution, organic carbon 0.81%, available nitrogen 230.62 kg/ha, available phosphorus 48.03 kg/ha and available potash 187.34 kg/ha, respectively. The experiment was carried out following split-plot design with four levels of irrigation [Three drip method 100%, 80% and 60% of PE alongwith their evaluation with surface irrigation (IW/CPE= 0.80) at 6 cm depth] as main plots and 3 levels of fertigation (75,100 and 75% of soluble N & K) as sub-plots with 3 replications.



Fig. 67. Mentha crop (summer season)



Fig. 68. Okra crop (rainy season)



Fig. 69. Potato crop (winter season)

The system productivity of mentha-okra-potato in terms of mentha equivalent yield was highest with the application of drip irrigation at 100% PE than other treatments which was higher by 25 % over the surface irrigation of 6 cm depth. In general, the production of

mentha, okra and potato were higher with application of drip irrigation as compared to surface irrigation of 6cm depth (Table 41).

The maximum water use-efficiency (82.52kg/ha/mm) was observed from drip irrigation at 60% PE, followed by drip irrigation at 80% PE (76.86 kg/ha/mm). However, lowest water-use-efficiency (32.91 kg/ha/mm) was observed in case of surface irrigation of 6cm depth. In drip irrigation method, water tension remained low as compared to surface irrigation of 6 cm depth. This is one of the main reasons for getting higher equivalent yield under drip irrigation method. Maximum weed density and dry weight of weeds was also noticed under surface irrigation of 6 cm depth and it was significantly higher over all the levels of drip irrigation. The less weed density and dry weight of weed might be due partial wetting of the soil under drip irrigation method. Maximum B: C ratio (3.67) was accrued from drip irrigation at 100% PE, followed by drip irrigation at 80% PE (3.60).

The system productivity of mentha-okra-potato in terms of mentha equivalent yield was highest with the application of 125 % recommended dose of soluble N & K fertigation than other treatments. Maximum realization of B: C ratio (3.62) was also observed with 125% recommended dose of soluble N & K, followed by fertigation with 100% recommended dose of soluble N & K (3.60). However, interaction between irrigation levels and levels of recommended N & K fertilizer were statistically insignificant (Table 42).

Table 42. Effect of different levels of recommended N & K fertilizer on yield and economics of mentha-okra-potato cropping system

Recommended levels of N & K Fertilizers	Yield			Net return (Rs./ha)	Cost of cultivation (Rs./ha)	B:C ratio	Mentha equiv-Yield (t/ha)
	Mentha (t/ha)	Okra (t/ha)	Potato (t/ha)				
125%	8.15	4.25	28.74	2,92,425	1,11,439	3.62	74.13
100%	8.05	4.15	26.68	2,81,301	1,08,131	3.60	69.71
75%	7.32	3.45	24.65	2,62,602	1,04,126	3.52	63.52
CD (5%)	0.47	0.21	2.33				

Soil chemicals parameters at the end of the experimentation were slightly improved due to varying levels of recommended N & K fertilizers as compared to initial levels (as indicated in Table 43).

Table 41. Effect of irrigation levels on yield, water-use-efficiency and economics of mentha-okra-potato cropping system.

Treatments	Yield			Net Return (Rs/ha)	Cost of cultivation	B:C ratio	Total water used (mm)	Mentha equiv. yield (t/ha)	Water-use-efficiency (kg/ha/mm)
	Mentha (t/ha)	Okra (t/ha)	Potato (t/ha)						
Irrigation levels									
Drip 100% PE	9.56	4.48	32.97	3,33,175	1,24,689	3.67	1181	84.46	71.51
Drip 80% PE	7.90	4.24	29.63	3,05,231	1,17,329	3.60	984	75.64	76.86
Drip 60% PE	7.63	4.04	25.98	2,79,759	1,10,929	3.52	820	67.67	82.52
W/CPE = 0.80%									
6 cm depth)	6.26	3.05	18.18	1,56,304	1,38,600	2.12	1480	48.72	32.91
CD (5%)	0.66	0.36	3.22	*	*	*	*	*	*

Table 43. Soil chemical parameters as influenced by different levels of recommended N & K fertilizers at the end of the cycle of mentha-okra-potato cropping system

Recommended levels of N & K fertilizers	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
125%	0.86	245.44	48.07	201.34
100%	0.85	242.55	48.06	197.38
75%	0.83	236.31	48.05	191.84
Initial	0.81	230.62	48.03	187.34

Results indicate that drip irrigations saves 25- 45 % water in comparison to surface irrigation and farmers may apply 125% of the recommended soluble N & K under mentha-okra-potato system.

Studies on Irrigation and Nutrient Requirement of Diversified Cropping System in Irrigated Eco-System of Central Bihar

A field experiment was conducted in split-split plot design replicated thrice allotting cropping systems in main plot, levels of irrigations in sub plot and levels of nutrients in sub-sub plot at main campus farm during kharif 2009, so as to find out the irrigation and nutrient requirement of different crops under diversified cropping systems. Five cropping systems viz. C_1 (Rice-tomato-bottle guard) (Fig. 70), C_2 (Rice-potato-onion), C_3 (Rice-mustard-tomato), C_4 (Rice-coriander-Lady's Finger) and C_5 (Rice-Cabbage-Cowpea) (Fig. 71) were tested. These cropping systems were tested at two levels of irrigations viz. I_1 -Optimum level, I_2 - Sub-optimum level and two levels of nutrients viz. F_1 -Recommended level and F_2 -50% of recommended level, respectively. Soil samples were collected from the experimental plots and analyzed for physical and chemical

properties (Table 44). The texture of the soil was silt clay loam with mean value of pH 6.97, electrical conductivity 0.12 ds/m in 1:2 soils: water solution, organic carbon 6.64 g/kg, available nitrogen 262.68 kg/ha, available phosphorus 26.4 kg/ha and available potash 181 kg/ha, respectively.

Two crop cycles for all diversified cropping systems has been completed and the yield of different crops was converted in terms of paddy (Table 45). Results of paddy yield equivalence revealed that during second year of experimentation, there were significant variations among cropping systems, levels of irrigation and nutrients and its interaction. Among the cropping systems, maximum yield equivalence was recorded in paddy-tomato-bottle gourd (48.98 t/ha), followed by rice-cabbage-cowpea (34.43 t/ha) and rice-potato- onion (28.36 t/ha), respectively. Among levels of irrigation, maximum yield equivalence was recorded at optimum level (31.61 t/ha) followed by sub-optimum level (29.37 t/ha) and the increase was to the tune of 8.16%, respectively. Among levels of nutrient, maximum yield equivalence was recorded at recommended level (31.18 t/ha) followed by 50 % of recommended level of fertilizer and the increase was to the tune of 4.96%, respectively. Maximum net profit (Table 46) was recorded in rice-tomato-bottle gourd (Rs. 2, 43,825/ha) followed by rice – cabbage – cowpea (Rs. 1, 66,323/ha) and rice-potato-onion (Rs. 92, 592/ha) respectively. Similar trend was observed in benefit cost ratio (3.46, 3.22 and 1.87), respectively. Among levels of irrigation, maximum net profit was recorded at optimum level of irrigation (Rs. 1, 20,009 / ha) as compared to sub-optimum level (Rs. 1,09,117/ha). Among levels of nutrient, maximum net profit was recorded at recommended level (Rs. 1, 16,999/ha) followed by 50% of recommended level (Rs. 1, 14,049 /ha), respectively.



Fig. 70. $C_1 I_1 F_1$ (Rice-tomato-bottle gourd)



Fig. 71. $C_5 I_1 F_2$ (Rice-cabbage-cowpea)

Table 44. Effect of levels of irrigation and nutrient on chemical status of soil after second crop cycle in diversified cropping system (2009-10)

Treatments	pH	EC	Org. carbon (g/kg)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potash (kg/ha)
Initial status of nutrients	6.50	0.11	10.5	281.00	23.56	193.20
Average nutrient status after first crop cycle (2008-09)	7.08	0.10	8.52	247.62	24.17	151.01
Average nutrient status after second crop cycle (2009-10)	6.97	0.12	6.64	262.68	26.40	181.02
Rice-tomato-bottle gourd (C1)	7.13	0.12	0.78	280.01	29.57	177.22
Rice-potato-onion (C2)	6.94	0.14	0.64	253.75	28.59	188.41
Rice-mustard-tomato (C3)	6.87	0.10	0.60	259.30	25.27	186.92
Rice-coriander-L. Finger (C4)	6.97	0.10	0.66	251.04	25.85	170.85
Rice-carrot-cowpea(C5)	6.94	0.12	0.64	269.31	22.72	181.69
SE m ($\pm$)	0.09	0.005	0.009	4.27	0.68	3.75
CD at 5%	NS	0.016	0.03	13.92	2.22	12.23
Level of Irrigation (I)						
I ₁	7.02	0.115	0.69	277.61	28.01	185.89
I ₂	6.92	0.117	0.63	247.75	24.79	176.14
SE m ($\pm$)	0.03	0.003	0.005	2.30	0.40	1.16
CD at 5%	0.095	NS	0.02	7.25	1.26	3.65
Level of Nutrient (N)						
F ₁	7.02	0.12	0.70	277.29	27.17	185.09
F ₂	6.92	0.11	0.68	248.08	25.63	176.95
SE m ($\pm$)	0.02	0.003	0.004	1.72	0.44	0.95
CD at 5%	0.06	0.009	0.01	5.07	1.30	2.80
C.V%	1.87	12.52	3.62	3.58	9.17	2.89

Soil studies indicated that there was significant variation in EC, organic carbon, available nitrogen, phosphorus and potash except pH after second crop cycle. It has been observed that in all the systems there

Table 45. Effect of levels of irrigation and nutrient on yield equivalence (t/ha) in terms of paddy (2009-10)

Cropping Systems	Irrigation		Mean	Fertilizer		Mean
	I ₁	I ₂		F ₁	F ₂	
C1 - Rice-tomato-bottle gourd	51.38	46.57	48.98	50.28	47.68	48.98
C2 - Rice-potato-onion	30.43	26.29	28.36	28.86	27.85	28.36
C3 - Rice-mustard-tomato	13.64	12.57	13.11	13.61	12.60	13.11
C4 - Rice-coriander-L. finger	18.21	16.94	17.57	18.03	17.12	17.57
C5 - Rice-cabbage-cowpea	34.37	34.49	34.43	35.11	33.76	34.43
Mean	29.61	27.37	-	29.18	27.80	-
Factors	C	I	F	C x I	C x F	I x F
SE(m) $\pm$	1.47	0.35	0.27	0.78	0.61	0.38
C.D. at 5%	4.79	1.10	0.80	2.46	1.80	1.12

Cost of rice: Rs. 7000/ton taken for converting yield of different crops to the paddy yield equivalence.

was increase in pH, EC and phosphorus, but reduction in organic carbon, available nitrogen and potash from initial status of the nutrient. This may be attributed to exhaustive cropping. There was decreasing trend in organic carbon, available nitrogen and potassium in all the systems from initial status of the soil but variations among cropping systems, levels of irrigation and nutrient was found significant. This may be because of vegetable dominated crops in the system, whose nitrogen and the potassium requirement is quite higher than other crops in the system (Table 47).

During third year of experimentation, only rice crop was taken. Growth and yield parameters were

Table 46. Yield equivalence in terms of rice, net-return, cost of production and benefit cost ratio in different cropping systems (2009-10)

Cropping systems	Yield equivalence of different crops (t/ha)			Paddy yield equivalence (t/ha)	Gross return (Rs. /ha)	Cost of cultivation (Rs. /ha)	Net return (Rs. /ha)	Benefit cost ratio
	Kharif 2009	Rabi 2009-10	Summer 2010					
Rice-tomato-bottle gourd (C1)	4.72	20.05	24.22	48.98	3,42,860	99,035	2,43,825	3.46
Rice-potato-onion (C2)	4.80	14.31	9.18	28.36	1,98,520	1,05,928	92,592	1.87
Rice-mustard-tomato (C3)	4.84	8.22	0.03	13.11	91,770	70,378	21,392	1.30
Rice-coriander-L.finger (C4)	4.90	6.18	6.50	17.57	1,22,990	74,288	48,702	1.65
Rice-cabbage-cowpea(C5)	4.68	21.97	7.79	34.43	2,41,010	74,687	1,66,323	3.22
SE m ($\pm$)	0.04	1.19	1.33	1.47	-	-	-	-
CD at 5%	0.13	3.88	4.34	4.79	-	-	-	-
Level of Irrigation (I)								
I ₁	5.10	14.30	10.18	29.61	2,07,270	87,261	1,20,009	2.36
I ₂	4.47	14.00	8.91	27.37	1,91,590	82,473	1,09,117	2.32
SE m ($\pm$)	0.03	0.29	0.12	0.35	-	-	-	-
CD at 5%	0.09	NS	0.38	1.10	-	-	-	-
Level of Nutrient (N)								
F ₁	4.90	14.27	10.01	29.18	2,04,260	87,261	1,16,999	2.34
F ₂	4.67	14.03	9.08	27.80	1,94,600	80,551	1,14,049	2.42
SE m ($\pm$)	0.02	1.96	0.09	0.27	-	-	-	-
CD at 5%	0.06	N.S	0.27	0.80	-	-	-	-

Table 47. Effect of levels of irrigation and nutrient on different growth and developmental characters of rice in different cropping systems (2010)

Treatment	Plant height (cm)	No. of tiller	Length of Panicle (cm)	Leaves/plant	Root length (cm)	No. of grain/panicle
Cropping System						
Rice-tomato-bottle gourd (C1)	65.86	12.83	25.30	5.0	11.08	136.47
Rice-potato-onion (C2)	68.41	13.58	26.02	5.0	10.75	139.38
Rice-mustard-tomato (C3)	67.86	14.25	25.94	5.0	11.58	141.52
Rice-coriander-L.finger (C4)	67.28	14.50	25.30	5.0	11.42	134.75
Rice-carrot-cowpea(C5)	65.33	13.33	24.97	5.0	10.17	127.61
SE m ($\pm$)	1.08	1.10	0.43	0.18	0.46	6.28
CD at 5%	NS	NS	NS	NS	NS	NS
Level of Irrigation (I)						
I ₁	66.53	13.23	25.50	5.0	11.50	137.57
I ₂	67.26	14.17	25.52	5.0	10.50	134.32
SE m ($\pm$)	1.19	0.53	0.24	0.15	0.25	3.98
CD at 5%	NS	NS	NS	NS	0.80	NS
Level of Nutrient (N)						
F ₁	68.74	13.90	25.58	5.0	11.10	140.12
F ₂	65.15	13.50	25.43	5.0	10.90	131.77
SE m ($\pm$)	0.95	0.64	0.21	0.12	0.25	3.46
CD at 5%	2.80	NS	NS	NS	NS	NS

recorded and analyzed. Results revealed that none of the growth and development characters reached to the level of significance in all the cropping system, levels of irrigation and nutrients (Table 48).

Table 48. Effect of levels of irrigation and nutrient on 1000 grain wt, grain and straw yield of rice in different cropping systems (2010)

Treatment	Chaffy grain/panicle	1000 grain wt (gm)	Grain yield (t/ha)	Straw yield (t/ha)
Cropping System				
C ₁	28.07	20.09	3.72	7.63
C ₂	29.88	20.04	3.83	7.75
C ₃	31.47	19.64	3.90	7.80
C ₄	27.19	19.61	4.07	7.86
C ₅	27.94	19.95	3.87	7.82
SEm $\pm$	2.46	0.32	0.17	0.14
CD at (P=0.05)	NS	NS	NS	NS
Irrigation				
I ₁	30.19	19.77	4.04	7.50
I ₂	27.63	19.96	3.71	8.04
SEm $\pm$	1.68	0.15	0.12	0.15
CD at (P=0.05)	NS	NS	NS	0.47
Fertilizer				
F ₁	31.43	20.08	4.19	8.03
F ₂	26.39	19.65	3.56	7.51
SEm $\pm$	1.46	0.18	0.07	0.09
CD at (P=0.05)	4.31	0.53	0.20	0.26

Makhana-Rice Cropping System

In makhana based cropping system, to identify the suitable varieties of Basmati rice, an experiment was conducted during the Kharif season of 2010 (Fig. 72). After harvesting the makhana crop, two varieties of Basmati rice (Pusa Basmati-1 and Pusa Rice Hybrid-10) were transplanted on 20th August 2010 in a makhana based low land field. The experiment was conducted in a randomized block design with 3 replication. The plot size of each genotype in each replication was 42m². The seed yield was recorded to be 4.06 and 4.42 t/ha, respectively, to Pusa Basmati-1 and Pusa Rice Hybrid-10.



Fig. 72. Makhana followed by rice cultivation

Makhana-Barseem Cropping System

In this experiment, makhana was cultivated only at 0.3m water depth. Makhana was transplanted on 20th April, 2010 and harvested on 18th August, 2010. Seed yield was recorded to be 2.16 t/ha. In the same field, barseem was sown on 1st November 2010 following the standard package of practices (Fig. 73). The first cutting of the fodder was made after 52 days and crop was continued up-to the mid of April. During this period a total four cuttings of green fodder were made from this field. From this plot the total fodder yield of 48.0 t/ha was obtained.



Fig. 73. Barseem cultivation in Makhana field

Makhana-Chestnut Cropping System

In this experiment, makhana was transplanted on 15th April, 2010 in a low land field having a water depth of 0.30m. makhana was harvested on 18th August, 2010 with a seed yield of 2.3 t/ha. After harvesting of makhana, chestnut was transplanted in the same field on 20th August 2010 (Fig. 74). By the end of December 2010, the crop was harvested and the yield was recorded to be 10.4 t/ha. From this experiment it may be concluded that water chestnut can be taken successfully in makhana grown water bodies.



Fig. 74. Makhana based Chestnut cropping system

Development of Vegetable based Integrated Farming System for Marginal Farmers of Irrigated Upland

A field experiment on integrated farming system was undertaken at main campus farm in one acre land to develop a vegetable based integrated farming system model for marginal farmers of irrigated upland area. Food crop was integrated with seasonal vegetables, fodder crop, goatry and vermicompost. Area under different components was allocated as per Fig. 75. Six cropping systems like Rice-wheat-green gram (C_1), Rice-potato-green gram (C_2), Lady's finger-potato-onion (C_3), Bitter gourd-tomato-bottle gourd (C_4), Lady's finger-coriander-sponge gourd (C_5) and Brinjal-carrot-cowpea (C_6) with two levels of fertilizer i.e. (i) 100% recommended dose of fertilizer (F_1) (ii) 50% recommended dose of fertilizer + goat manure & vermicompost (F_2) were tested in randomized block design. Soil samples were collected from the experimental plots and analyzed for physical and chemical properties. The texture of the soil was silt clay loam with pH of 6.6, electrical conductivity 0.14 ds/m, organic carbon 1.20%, available nitrogen 313kg/ha, available phosphorus 38.5 kg/ha and available potassium 259 kg/ha.

Yield of all crops were converted into lady's finger yield equivalence and on this basis promising crop-

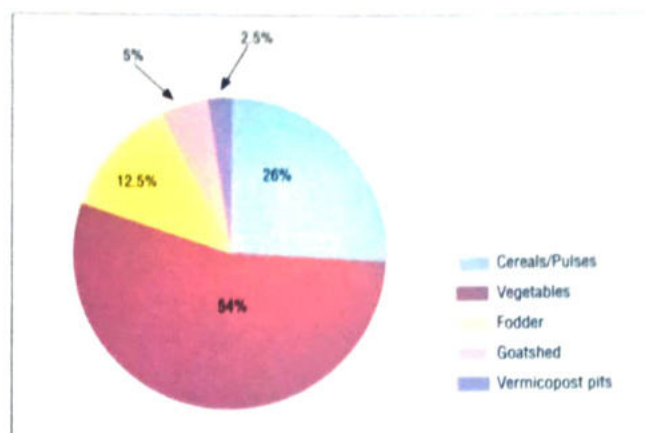


Fig.75. Land allocation of different components

ping systems were evaluated (Table 49). Results revealed that there were significant variations among cropping systems. In case of rice based cropping system; lady's finger yield equivalence of rice-potato-green gram (18.86 t/acre) was found significantly superior than that of rice-wheat-green gram (9.02 t/acre). Among vegetable based cropping systems maximum yield equivalence was recorded in bitter gourd-tomato-bottle gourd (23.42 t/acre) followed by lady's finger-potato-onion (22.76 t/acre). Maximum net return (Table 50) was recorded in bitter gourd-tomato-bottle gourd (Rs. 82411/acre) followed by lady's finger-potato-onion (Rs. 76363/acre). Similar trend was observed in benefit: cost ratio (3.38 and 3.04, respectively).

Cultivation of rice-potato-green grams as food crop and bitter gourd-tomato-bottle gourd as vegetable crop in integrated manner with goatry and recycling of vermicompost in the allotted area gave a net return of Rs.75,520 per acre along with 2.9 tonnes of goat manure and 0.7 tonnes vermicompost (Table 51).

Table 49. Evaluation of promising cropping system on the basis of Lady's finger yield equivalence (2009-10)

Cropping system	Lady's finger yield equivalence (t/acre)			System wise LFYE (t/acre)
	Kharif	Rabi	Summer	
Rice-wheat-green gram (C_1)	2.96	3.73	2.33	9.02
Rice-potato-green gram (C_2)	3.09	13.05	2.73	18.86
Lady's finger-potato-onion (C_3)	3.17	1.35	6.34	22.76
Bitter gourd-tomato-bottle gourd (C_4)	6.67	9.05	7.70	23.42
Lady's finger-coriander-sponge gourd (C_5)	3.10	3.67	2.68	9.44
Brinjal-carrot-cowpea (C_6)	5.12	3.12	2.89	11.14
SEm	0.31	0.37	0.25	0.52
CD(P=0.05)	0.98	1.17	0.78	1.64
Fertilizer level				
100% RDF (F_1)	4.11	7.73	4.22	16.11
50% RDF + goat manure & vermicompost (F_2)	3.93	7.56	4.00	15.56
SEm	0.06	0.08	0.08	0.13
CD(P=0.05)	0.18	0.23	0.25	0.41

Table 50. Economics of different cropping system (2009-10)

Cropping system	Total LFYE	Gross income	Cost of cultivation	Net return	B: C ratio
Rice-wheat-green gram (C ₁)	9.02	45115	24897	20218	1.81
Rice-potato-green gram (C ₂)	18.86	94310	31144	63166	3.03
Lady's finger-potato-onion (C ₃)	22.76	113825	37462	76363	3.04
Bitter gourd-tomato-bottle gourd (C ₄)	23.42	117100	35289	82411	3.31
Lady's finger-coriander-sponge gourd (C ₅)	9.44	47185	24052	23133	1.96
Brinjal-carrot-cowpea (C ₆)	11.14	55695	25303	30392	2.20
SEm	0.52				
CD(P=0.05)	1.64				
Fertilizer level					
100% RDF (F ₁)	16.11	80570	30765	49805	2.62
50% RDF + goat manure & vermicompost (F ₂)	15.56	77785	27058	50727	2.88
SEm	0.13				
CD(P=0.05)	0.41				

Table 51. Contribution of components in Vegetable based IFS

Enterprises	Area (m ²)	LFYE (t)	Gross return (Rs)	Production cost (Rs)	Net Return (Rs)	B:C ratio
Bitter gourd-tomato - bottle gourd	1040	4.90	24520	8002	16518	3.36
Rice-potato-green gram	2160	12.65	63234	18032	45202	
Goat (10+1) Kids-20	200	3.96	19800	6000	13800	
Total		21.51	107554	32034	75,520	

Assessment of Soil Quality in Different Agro-ecosystems of South Bihar

Soil quality in different land uses of old alluvium soils of Agro ecological region no. 9 (hot sub-humid with alluvium derived soils (South Bihar plain)) with growing period of 150-180 days was assessed. The major land uses observed in the study area were rice-wheat-fallow, maize-potato-fallow, red gram, sugarcane, agro-forestry, orchards (mango) and soil sampling (0-60 cm) was done for each of the land use system. Soil physical, chemical and biological quality parameters were estimated using standard procedures. Soil quality index were prepared with four categories viz., class I to class IV. Soil quality of all the indicators in class I was in optimum and above optimum values whereas, in class IV the values of all the soil qualities indicators were below optimum level. There were two levels in the middle categories(class II and III). Ranking was done for each land uses based on the soil quality index and summation of scores for each land uses were done.

Relative soil quality index of four categories such as best, good, moderate and poor were established (Table 52). The scoring was also assigned from 0 to 100 for four classes, for best class from 80-100, good from 60-80, moderate from 40-60 and poor for <40. Accordingly, mango orchard adjudged as the best land use with the highest score of 81, which maintained best soil quality followed by rice-wheat-fallow (72), agro-forestry (68) and sugarcane (63), in good category. Maize-potato-fallow (59) and red gram (53) fall under moderate category of soil quality.

Table 52. Relative soil quality index of different land uses

Classes	RSQI Value	Agricultural land use system
I	80-100	Mango orchards
II	60-80	Rice-Wheat system, Agro-forestry and Sugarcane
III	40-60	Maize-Potato system and Red gram
IV	<40	-

Effect of organic amendments on Soil Microbial Biomass Carbon (S.M.B.C) on rice-wheat cropping system.

A field experiment was conducted in randomized block design in rice-wheat cropping system to assess the increment in Soil Microbial Biomass Carbon (S.M.B.C) due to application of amendments. The trial comprising of eight treatments, T_1 control (No nutrient application), T_2 -Recommended dose of N, P, K through fertilizers, T_3 -FYM @ 20 ton/ha, T_4 -FYM @ 10 ton/ha, T_5 -Crop Residue (30%), T_6 -Crop Residue (15%), T_7 -GM (Sesbania after 40 days) T_8 -GM (Sesbania co-culture). The soil texture was silty clay loam with mean pH value 7.22, EC 0.11 dSm⁻¹ (1:2.5 soil water ratio) organic carbon 0.71 percent, available N, P and exchangeable K is 221.4, 20.64 and 181 Kg/ha⁻¹ respectively. The SMBC of initial soil sample was 81 mgC-CO₂kg⁻¹soil 2 days⁻¹.

The highest paddy grain yield 7.48 t/ha was recorded in T_7 , followed by T_3 , T_4 i.e 7.28 and 7.21 t/ha, respectively.

The impact of treatments and crop stages on soil microbial biomass C was significant. Application of treatments has more pronounced impact on soil microbial biomass C ($F_{1/4} 59$, $df_{1/4} 4$, $po0.001$) compared to variation due to season ($F_{1/4} 29$, $df_{1/4} 10$, $po0.001$). The seasonal variations in microbial biomass C were similar across all the treatments. In both crops, microbial biomass C significantly decreased from seedling to grain-forming stage, and then increased till crop maturity. The pre-grain-forming decrease was more marked during the rice period. Soil amendments distinctly increased microbial biomass compared to control throughout the annual cycle. During the rice crop season, microbial biomass C was significantly higher in T_7 , followed by T_3 (72% and 55% increase over control, respectively). In Wheat, maximum increase in microbial biomass C was observed in T_7 , followed by T_3 i.e., 59% and 53 % increase over control, respectively. During summer fallow, the maximum increase in microbial biomass C over control recorded in T_7 (+64%) and the minimum in T_1 (+21%). In terms of cropping

season averages, in all the treatments, microbial biomass C increased from rice crop season to summer fallow through wheat cropping season period, except Sesbania treatment where a slight decrease was noticed during wheat growing period. On annual mean basis, microbial biomass C was higher in T₃ and T₅, which was 71% and 64% higher over control, respectively (Fig. 76).



Fig. 76. Bar diagram representing SMBC (mg C-CO₂/kg Soil/ 10 days)

Improving Livelihood Security in the Salt Affected Watershed of Muzaffarpur and Sheohar Districts of North Bihar (NAIP)

Muzaffarpur and Sheohar districts are potentially sugarcane and wheat growing districts. Land degradation problems such as salinity/sodicity reduced the productivity of crops in the study area. Baburban and Mathina clusters of Motipur block and Bahura and Bimalpur clusters in Kanti block were selected for the study. Salinity was recorded up to 5.5 dSm⁻¹ and sodicity was recorded up to the ESP of 35 with pH more than 9.5. Hence, farmers abandoned cultivation of sugarcane in the affected areas due to low yield (25 to 30 t/ha) (Fig. 77). The area under mustard and vegetables got reduced in these salt affected areas due



Fig. 77. Land abandoned from sugarcane cultivation due to sodicity in Kanti block, Muzaffarpur district

to heavy yield loss. Presently, paddy is being cultivated in the salt affected lands. Wheat is found slowly unsuitable for this soil due to sodicity. Wheat crop grown in this soil was observed with yellow leaves, stunted and uneven growth in the entire field (Fig. 78 and 79).

Reclamation measures were adopted for sodic soil with gypsum. There was 30 ha of sodic land in the study area which was reclaimed with 200 tonnes of gypsum. In the reclaimed areas per hectare sugarcane crop yield up to 50 tonnes was observed. Soil pH reduced up to 6.4. Bund height was increased in the saline soil areas for storing more water for salt leaching. Farmers started growing mustard in the reclaimed areas. Wheat cultivation was taken up by the farmers after the application of gypsum and good crop stand was observed.



Fig. 78. Yellowing with stunted growth of wheat in salt affected areas



Fig. 79. Yellowing with uneven growth of wheat in salt affected areas

Characterization and Classification of Ground Water Quality of Some Parts of Maner Block, Patna District, Bihar

Under characterization and classification of ground water quality in various parts of Maner block of Patna district, it was observed that arsenic content was accumulating in different crops grown in the study area due to irrigating with arsenic contaminated water. Arsenic content was analyzed in different plants parts of jowar, maize and paddy; vegetables, and oilseed (Til) (Fig. 80). Arsenic content was also estimated in congress grass, which was found wildly as a major weed in the study area.

It was observed that arsenic content in above ground parts of vegetables, oilseeds and congress grass was found higher as compared to below ground part i.e. root. It was observed that arsenic content was highest (0.52 mg/kg) in above ground parts, i.e., leaf+ stem of oilseed (Til) as compared to below ground part (0.24 mg/kg). Contrary to this, in cereals, arsenic content was found marginally low in above ground part (0.28 mg/kg) in comparison to below ground part (0.30 mg/kg). Arsenic content in cereals grown in the study area were analyzed and results revealed that among the cereals, paddy had highest content of arsenic of 0.36 and 0.56 mg/kg in above ground and below ground parts, respectively (Table 53).

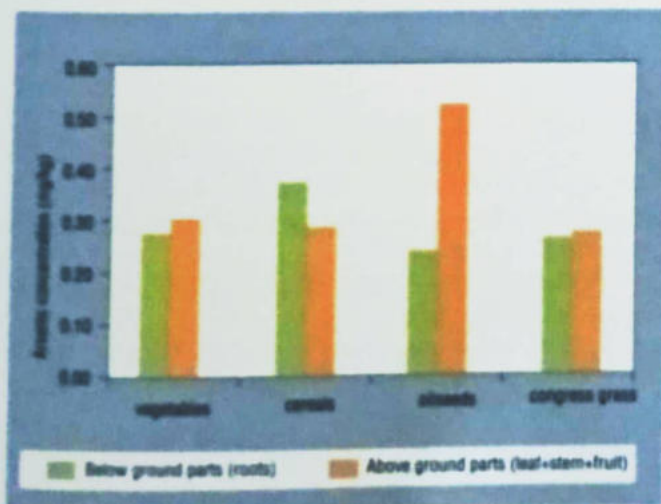


Fig. 80. Distribution of arsenic content in different crops

Table 53. Arsenic concentration mg/kg in cereal crops grown in the study area

Cereal crops	Below ground parts (roots)	Above ground part (leaf+stem)
Jowar	0.32	0.26
Maize	0.26	0.29
Paddy	0.56	0.36

Distribution of Arsenic content was shown in different plant parts of vegetables (Fig. 81). It was observed that arsenic content was high in above ground part which was used for the consumption in comparison to below ground part of vegetables.

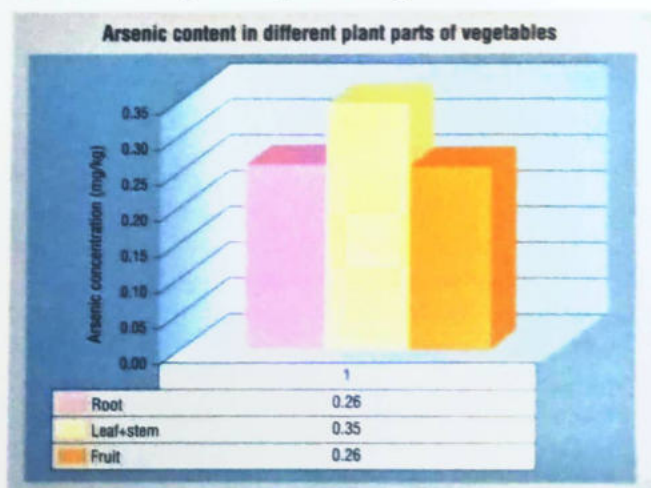


Fig. 81. Distribution of arsenic content in different plant parts of vegetables

Enhancing and Sustaining the Land and Water Productivity through Multiple Use of Water

Assessment of land and water productivity under multiple water use systems

Field experiment was conducted to study water productivity with exchanged water applied to different crop sequences under two doses of fertilizer (100% and 75%) and tube well water used for irrigating crop sequences.

Water Productivity of different crop sequences was analyzed and data has been shown in Table 54. In terms

of monetary gains, rice-cabbage-cowpea and rice-potato-onion were found the best cropping sequences.

Table 54. Rice equivalent yield and Water productivity of different crop sequences

Treatments	Rice eq. yield of sequence	WP of sequence (kg/m ³)	WP of sequence (Rs/m ³)
C1 (Rice-wheat-gram)	192.04	1.21	12.1
C2 (Rice-potato-onion)	296.69	1.73	17.3
C3 (Rice-cabbage-cowpea)	309.21	1.79	17.8
CD	25.51	0.16	1.48
F1(100% fertilizer with pond water)	285.89	1.69	16.9
F2 (75% fertilizer with pond water)	248.04	1.48	14.7
F3(100% fertilizer with tubewell water)	264.01	1.56	15.6
CD	25.51	0.16	1.48

Design and development of low pressure sprinkling nozzle

In general, available technological options are limited for efficient irrigation of crops sown in small and fragmented farm sizes due to lack of the applicability and accessibility as well as priorities and financial capabilities. This makes imperative to develop a substitute to existing technologies that could be cost effective, simple, less capital intensive as well as applicable to small farms. Keeping this fact in view, nozzles were modified based on inverse of turbine model and few prototypes were designed and tested in laboratory over the operating pressure range of 0.6 to 1.0 kg/cm². Testing showed that over the pressure range of 0.6 to 1.0 kg/cm², throw diameter of device was found in the range of 9.2 m to 11.2 m (Fig. 82), with application rate of 2.6 to 2.7 cm/h when mounted on riser of one metre height. Its water application rate was high, therefore, it could be used for irrigating field crops, such as rice, in which the application rate should exceed the infiltration rate for sufficient ponding in the field. The devices were also tested for surface uniformity at the same operating pressure and corresponding to operating pressures of 0.6 kg/cm², 0.8 kg/cm², and 1.0 kg/cm² the Christiansen Uniformity (CU %) was found to be 69, 72 and 70%, respectively. Since, satisfactory water spread over the wetting front CU should be 70% or more; 0.8 kg/cm² operating pressure device performance is supposed to be satisfactory. The radial water distribution pattern of device at varying operating pressures is shown in Fig. 83. The radial water distribution pattern showed that the peaks shifted away from the riser and height of the peaks decreased once the operating pressure increased. The discharge of the device at the operating pressure of 0.8 kg/cm² was found to be 2.2 m³/h, and head discharge relationship of the device over the pressure range of 0.6 to 1.0 kg/cm² was shown in Fig. 84. Further refinement and testing of device is in progress.

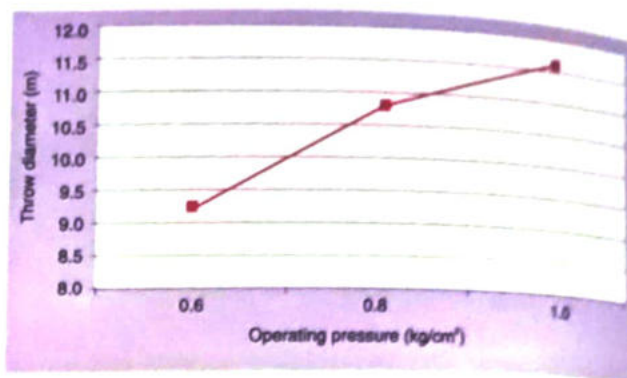


Fig. 82. Throw diameter at varying operating pressures

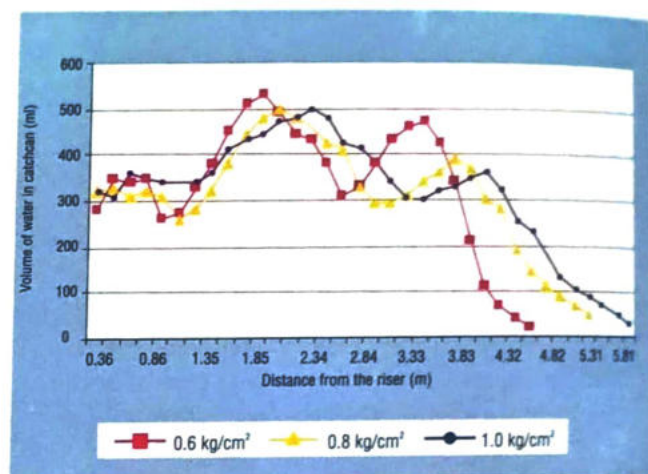


Fig. 83. Radial water distribution pattern of device at varying operating pressures

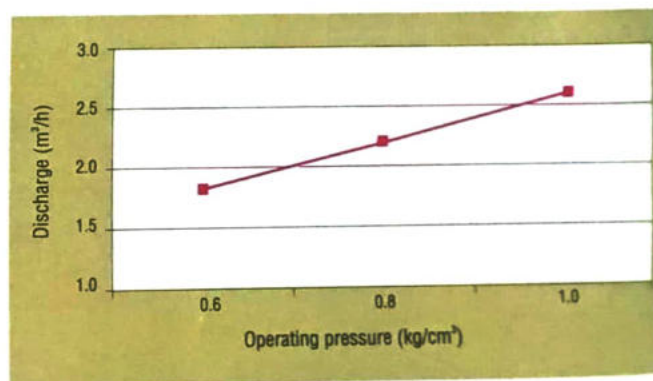


Fig. 84. Head discharge relationship of the device

Gravity Subsurface Drip and Fertigation for Cucurbits in Sandy Loam Soils of Eastern Plateau Region

An experiment was conducted for sub-surface drip irrigation (SDI) with fertigation in bitter melon. Four depths of lateral placement *viz.* 0 cm, 5 cm, 10 cm and 15 cm below ground surface and four fertigation treatments with different fertilizer doses were adopted. A treatment on surface drip irrigation was also included to act as a control. In order to have easy operation and proper scheduling of fertigation, split plot

statistical design was used to lay out the experiment in the field. Quantity of fertilizer applied in each fertigation was varied as per the growth stage of the crop.

In order to get better market prices crop needs to be harvested from second week of February and to achieve that the bitter gourd crop was sown on 19th October 2009. This was the period when winter was very severe and to protect the plants from frost injury, the protection measures like plastic mulching were used in the field.

The root zone soil moisture profile was observed in all depths of lateral placement. Sub surface placement of laterals at 10 cm and 15 cm showed increasing trend in moisture content with root zone depth. In case of surface drip and 5 cm SDI, moisture content was decreasing in the top soil (up to 30 cm) and then it became almost constant. This shows that despite of applying equal quantities of water in each irrigation treatment, SDI with lateral placement at 10 cm and 15 cm provides more moisture in the portion of the root zone where maximum root activity takes place (20 to 45 cm). This situation is favorable for optimum crop growth and all round development of the plants (Fig. 85).

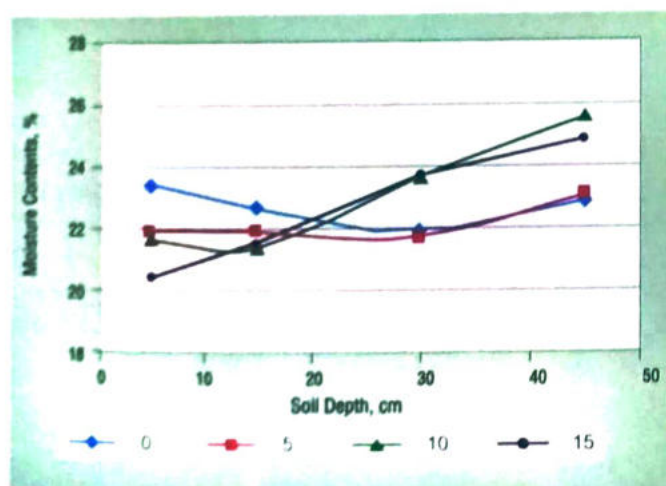


Fig 85 Variation in soil moisture in the root zone for different depths of lateral placement

Vine lengths were recorded at 30, 60, 90 and 180 days after sowing. Initially, since the plant roots were present in top 5-10 cm of soil, the vine length was higher in case of surface irrigation and 5 cm SDI. At 60 and 90 days after sowing, the difference in vine lengths under different lateral placement treatments was statistically insignificant. Also, at the end of 180 days, placement of laterals at different depths did not exhibit any significant difference in vine lengths but vine lengths in fertilizer dose F3 and F4 were significantly better over control. Maximum vine length of 2.85 m was, however, observed in case of 15 cm SDI and in fertilizer dose F3 (Table 55).

Table 55 Bitter gourd vine length (m) at 180 days after sowing

Depth of lateral placement	Fertilizer dose				Average
	F ₁	F ₂	F ₃	F ₄	
D1	2.21	2.44	2.35*	2.55*	2.39
D2	2.17	2.02	2.41*	2.65*	2.31
D3	2.26	2.68	2.33*	2.43*	2.43
D4	2.00	2.20	2.85*	2.73*	2.44
Averages	2.16	2.34	2.49	2.59	

*Statistically significant at $t_{0.05}$

The fresh market yield of the bitter gourd is given in Table 56. It was observed that the yield of cucumber increased due to subsurface placement of the laterals. The one way analysis of variance (ANOVA) performed on yield data indicated significant effect of placement depths of laterals on yield. The highest yield of 27.7 t/ha was observed in case of subsurface placement of laterals at 10 cm and in fertilizer dose F4. This was followed by 27.0 t/ha in 15 cm SDI in fertilizer dose F3.

Table 56. Yield (t/ha) of bitter gourd at various depths of lateral placement and in different fertilizer treatments

Depth of lateral placement	Fertilizer dose				Average
	F ₁	F ₂	F ₃	F ₄	
D1	9.2	12.8	19.0	19.5	15.12
D2	6.5	16.1	24.3	23.9	17.69
D3	8.8	20.8	25.9*	27.7*	20.82
D4	11.3	19.9	27.0*	24.8*	20.75
Averages	9.0	17.4	24.0	24.0	

*Statistically significant at $t_{0.05}$

The higher yield under SDI may be attributed to uniform moisture distribution and availability of water and fertilizer near the root zone. Also, placing the laterals below soil surface, reduced the loss of water due to evaporation which increases the water availability to plants under SDI.

Improving Water Productivity, Reducing Poverty and Enhancing Equity in Mixed Crop-Livestock Systems in the Indo Gangetic Basin

For the study, three states (Haryana, Uttar Pradesh and West Bengal) representing typical mixed systems were identified in the Indo-Gangetic Plains as per the rainfall gradient. Within these states, districts with homogeneous sub-systems and representing the different intensification categories were selected (*Hisar* in Haryana, *Etawah* in Uttar Pradesh and *Bankura* in the West Bengal). Livelihood strategies in the three study districts were predominantly based on crop and livestock production but at different levels of intensification.

Herd structure

The herd structure showed a high degree of diversity in its composition. According to the 2003 census, aggregated for all study areas, cattle dominated with 1.3 million Standard Livestock Unit (SLU) (51%), followed by buffalo 1.1 million SLU (44%), goats 0.94 million SLU (4%) and sheep 0.17 million SLU (1%). At the system's scale, the importance of these livestock groups varied. For example buffaloes constituted ~80% in the *intensive* systems, whilst in the *semi-intensive* systems cattle had the major share of total SLU (81%) (Fig. 86).



Fig. 86. Wallowing of buffaloes

Value of livestock products

The total value of livestock products and services, for all the study systems, was USD 438 million for census year 2003 and, overall, milk contributed >90% in *intensive* and <50% in *semi-intensive* systems. In the *semi-intensive* system, the major share came from traction services. Temporal analysis of the value of livestock products and services for 1992-2003, showed a mixed picture in *intensive* system: decrease in Hisar and increase in Etawah. Contrastingly, the *semi-intensive* system did not show marked changes in overall values of products and services, in spite of declining milk production.

Feed sourcing

Overall, green fodder and crop residues were the most important feed resources in 2003, contributing 59% and 31% of total ME, respectively when combined for all study systems. At system scale, the diet of ruminants depended largely on agro-ecology and on the level of intensity of the production system. For example, in 2003, for the *semi-intensive* region, major ME sources were residues (mainly rice, 29%), greens (mainly grazing and open forest, 61%) and concentrates (5%). In the *intensive* regions, the feed composition was more complex and consisted of green fodder (55%) (cultivated, 49%), concentrates (e.g. grain, cakes and bran, 9%) and food/feed crops (33%).

Depleted water

The volume of water depleted varied among the study systems and was highly affected by the type of feed and the attendant agronomic factors (e.g. cropping pattern, yield). The value of depleted water for feed production ranged from 300 to 2300 m³/ha/yr for the *intensive* system and from 100 to 4600 m³/ha/yr for the *semi-intensive* system. The highest water consumer in the *intensive* system was green fodder (2350 m³/ha/yr for Hisar and 4190 m³/ha/yr for Etawah), and similar trend was observed in the *semi-intensive* system (~4680 m³/ha). Contrastingly, concentrates depleted the smallest volume of water preceded by crop residues.

Livestock water productivity

The mean value of LWP, using biomass based partitioning and ME requirement for 2003 for all study systems, was USD 0.06m³. Differences among the study systems were also prominent with intensive systems viz. Hisar) showing significantly higher value than the *semi-intensive* ones. Water productivity of livestock for milk production varied as per scale, time and species of dairy animals. Milk water productivity for cross-bred cows varied from 0.81 litre per m³ in Hisar and Etawah (intensified system) to 0.34 litre per m³ in Bankura (semi-intensified system). In case of buffalo. The milk water productivity ranged from 0.72 litres per m³ in Hisar to 0.33 litres per m³ in Bankura. For indigenous cows, the milk water productivity showed highest value (0.76 litre per m³) in intensified system. Lowest value (0.19 litre per m³) was, however, recorded in semi intensified system.

Scaling up of Water Productivity in Agriculture for Livelihoods through Teaching-cum-Demonstration

Demonstration on adoption of drip and mini sprinkler irrigation

Drip irrigation system was installed at Vill.-Bishunpura, Bihta, Patna district and its performance was compared with conventional surface irrigation system in vegetable based cropping system (Okra-Cauliflower-Chillies system) and rose (Fig. 87). The highest pod yield of okra (5.0 t/ha) was recorded in drip irrigation which was higher by 40 % over the surface irrigation with 32 kg/ha/mm water-use-efficiency. The highest curd yield of cauliflower (10.0 t/ha) was recorded under drip irrigation which was higher by 32% over the surface irrigation.

The performance of drip irrigated rose was compared with conventional surface irrigation method in established rose (var. Minipal, 2 year old). The



The person is wearing a dark, long-sleeved shirt and is using a tool to work on the object. The object has a rough, textured surface and is dark in color. The background is dark and indistinct.

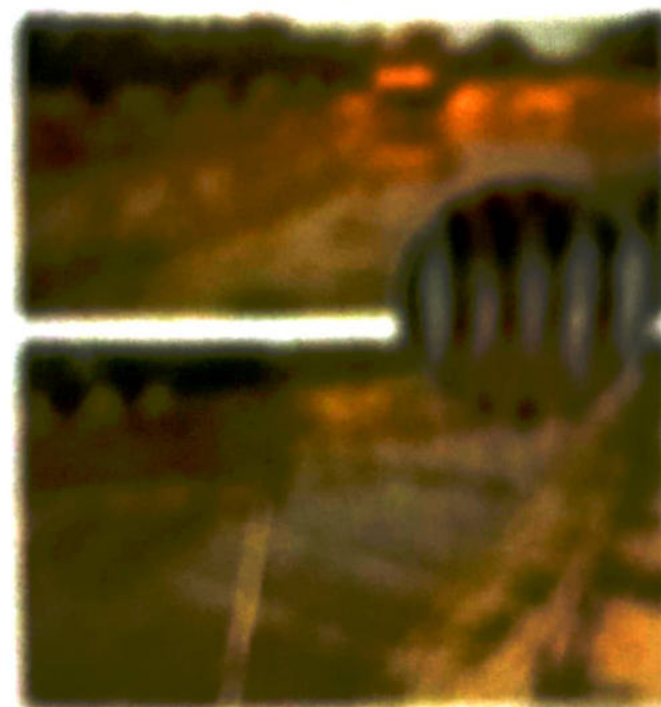
The person is focused on their work, and the lighting is low, creating a somber and intense atmosphere.

Integrated Land and Water Management

The integrated land and water management approach is a holistic way of managing land and water resources. It takes into account the physical, biological, and social aspects of the landscape and the interactions between them. This approach aims to achieve sustainable development by balancing the needs of the environment, the economy, and society.

The integrated land and water management approach is based on the following principles:

- 1. **Integration:** Land and water resources are managed as a single system, rather than as separate entities.
- 2. **Sustainability:** The management of land and water resources should be sustainable, meaning that it should meet the needs of the present without compromising the ability of future generations to meet their own needs.
- 3. **Participation:** The management of land and water resources should involve the participation of all stakeholders, including government, the private sector, and the community.



The person is wearing a dark, long-sleeved shirt and is looking at the object with a focused expression. The object is dark and textured, and the background is dark and indistinct.

Delivery and Rolling Out of Conservation Agriculture Based Resource Conserving Technologies

CSISA project is an initiative to strengthen the South Asian food security.

Evaluation studies on following resource conserving technologies in project area were conducted during summer & *kharif* seasons of 2010 (Fig. 89).

- Crop intensification through spring maize, summer green gram (moong) & cowpea cultivation through ZT machines after rice – wheat-cropping system was introduced in South Bihar.
- Effect of various zero tillage methods (equal row and paired row) on yield and economics of direct seeded zero till rice (ZTDSR) /direct seeded rice (DSR)
- Use of pre-sowing (Glyphosate) + pre-emergence herbicides (Pendimethylene); and bispyriback sodium & ethoxysulfuron
- Brown manuring through co-culture of *Sesbania sesban*
- Nitrogen management through LCC
- Crop diversification (Potato + Maize)

During 2010, on - farm participatory trials were taken in 12 villages of Patna district. Rice was planted



Fig. 89. Experimental site of CSISA Project

in sixty-six farmers occupying an area of 90 acres. The crop of 9 farmers failed due to drought & non-availability of irrigation water. Rainfall during *kharif* season in 2010 was 671 mm that is 35 per cent less than the average and created a drought like situation throughout the *kharif* season and canal water was not released during this season. Due to shortage of water, many fields could not be brought under ZTDSR. However, only patches of ZTDSR were seen and most of the fields were bare and not cultivated during the *kharif* 2010. The sowing was continued since 17th June 2010 to 26th July 2010. The rice yield recorded 3.2 to 4.0 t/ha.

The use of LCC and brown manuring through *Sesbania* could save the nitrogen use through chemical fertilizer in rice crop, which ultimately saved the resources of the farmers and there was increase in yield with saving of 41 kg N/ha due to LCC and 38 kg N/ha due to *Sesbania* co-culture. Farmers also found that there was fewer incidences of pests due to the brown manuring and co-culture reduced the weed population by nearly half without any adverse effect on crop performance.

Adaptive trial was taken to assess the suitability of molecules for weed control under ZTDSR. *Bispyriback sodium* was most effective molecule to control the weeds after 25-30 days under ZTDSR (Table 57).

Table 57. Weed management in direct seeded rice cv. Satyam (Kharif 2010)

Sl. No.	Treatments	Yield (t/ha)
1.	DSR-weedy	1.04
2.	DSR-pendimethalin 1 kg ai/ha followed by one hand weeding at 30 days	2.48
3.	DSR -pendimethalin 1 kg ai/ha pre emergence followed by ethoxysulfuron 18g ai/ha at 20 DAS	2.69
4.	DSR-pendimethalin 1 kg ai/ha pre emergence followed by bispyriback sodium at 25 gai/ha at 20 DAS	2.96
5.	Weed free	2.99
	SEM $\pm$	0.02
	CD at 5 %	0.07

Evaluation of rice cultivars under different resource conservation system

Different rice cultivars were evaluated under two-resource conservation technologies (RCTs) i.e. dry seedling with 50 % mulch and dry seedling without mulch. The crop was sown as zero till direct seeded rice (ZTDSR) and was compared with transplanted rice (wet seedling /puddle condition). Few promising varieties i.e. IET 21299, IET 20800 were identified for mulch condition whereas, BPT 5204, IET 21299, Silwamani were found promising without mulching condition (Table 58). The evaluation will be continued in ensuing *kharif* seasons for identifying the suitable varieties for zero till direct seeded rice.

Table 58. Evaluation of rice cultivars under different resource conservation system (*kharif* 2010)

Varieties	Yield (q/ha)		
	Dry seedling with 50% mulch	Dry seedling without mulch	Wet seedling/ puddle condition
IET 20760	19.71	17.68	22.44
IET 21299	29.85	30.37	30.85
RM-1	20.37	21.51	20.90
BPT 5204	26.28	31.38	26.17
IET 20800	29.19	27.86	29.67
IET 20761	17.63	19.97	22.38
Silwamani	25.50	29.82	24.77
IET 21248	16.95	20.77	20.73
Swarna Sub-1	23.89	29.40	24.65
SEM $\pm$	0.255774	0.211745	0.243113
CD at 5 %	0.766844	0.634840	0.728887
CV	1.904492	1.442879	1.702806

LIVESTOCK

Improvement of Black Bengal Breed of Goats by Selective Breeding through Artificial Insemination

Livelihood status of small farmers and landless labourers could be improved by goat rearing. Among the 23 recognized goat breeds in the country, Black Bengal, though smaller in body size, has the potential for multiple kidding and fast horizontal expansion of herd size. When compared with the other breeds in relation to kidding percentage and meat yield, the Black Bengal goats are superior.

In order to improve the growth performance of Black Bengal goats through selective breeding, genetically superior bucks in the selected traits were procured from the farmers' flocks. The semen collected from the bucks was transferred after 1:20 dilution with Goat-milk extender to the village flocks and the goats being reared at the experimental farm of the complex. The performance of kids born from selective breeding was evaluated in terms of height at withers, body length, girth and body weight. The three major body measurements in the base and the selected populations were 39.5 ± 0.67 and 40.6 ± 0.68 cm; 34.0 ± 0.71 and 34.8 ± 1.20 cm; and 39.6 ± 0.91 and 40.6 ± 0.92 cm respectively at 3 months of age. The body weight at the age in the base and selected populations were 5.6 ± 0.28 and 6.4 ± 0.32 kg (Fig. 90).

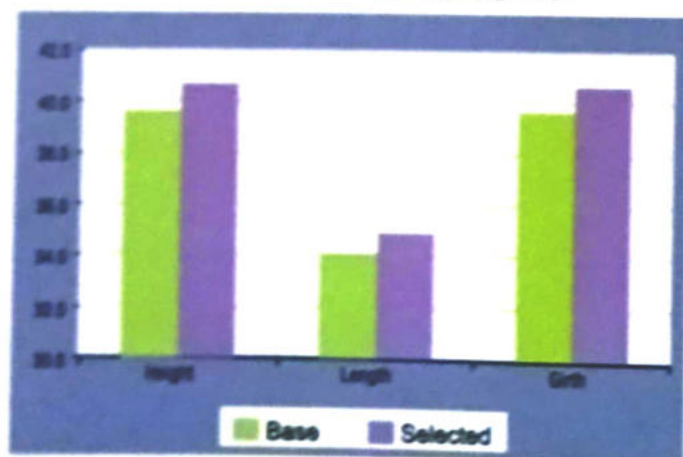


Fig. 90. Growth of Black Bengal kids in base and selected population at 3m of age

The improvement in the performance shall further be accelerated through continuous selection and breeding using genetically superior germplasm. Alternatively, Black Bengal breeders' cooperative society shall be formed for channeling best germplasm to large number of herds.

Studies on Reproductive Diseases of Cattle under Field Conditions of Bihar

With the objective of studying the seroprevalence of selected infectious diseases causing infertility in cattle, this project was undertaken. It is very essential to study the seroprevalence of Brucellosis, Leptospirosis, Infectious Bovine Rhinotracheitis-Infectious Pustular Vulvovaginitis (IBR-IPV) and Bovine Virus Diarrhoea (BVD) to ascertain the infectious cause of infertility.

Till date, 500 serum samples were collected from cows and buffaloes reared in Katihar, Purnia, Begusarai, Patna, Khagaria, Arwal, Darbhanga, Jamui and Saharsa districts of Bihar. From Patna district, samples were collected from 2 organized farms. All the samples were stored at -20°C till they were analyzed. For Brucellosis and IBR, kits were procured from Project Directorate on Animal Disease Monitoring and Surveillance (PDADMAS), Bengaluru and Avidin - Biotin ELISA was carried out as per the standard procedure (Fig. 91). Samples were tested in duplicate.



Fig. 91. ELISA for Brucellosis

Among them, it was found that 6.1% samples were positive for IBR antibodies and 12.20% samples for Brucellosis. Among the organized farms, up to 20.83% samples were positive for these diseases. ELISA for BVD showed that a prevalence of 6.4% in Bihar and DAS-ELISA for *Leptospira bardjo* revealed 9.1% positives. With potent zoonosis implications, Leptospirosis needs to be given special attention. Although, there was no phenomenal increase in the seroprevalence of Brucellosis and IBR, it is recommended that a continuous serosurveillance should be in place. Further, it is recommended that vaccination in organized farms is essential due mainly to higher prevalence compared to unorganized herds.

Studies of Peste des Petits Ruminants (PPR) and Blue Tongue in Goats and Sheep in Bihar

Peste des Petits Ruminants (PPR) are an important viral disease of goats and sheep characterized by fever, erosive stomatitis, oculo-nasal discharges, enteritis, and pneumonia. Investigation was undertaken to study the epidemiology of PPR and Blue Tongue in various districts of Bihar. Four outbreaks were reported in 2010, one each in Patna, Motihari, Supaul and Jehanabad Districts. Sera samples were collected randomly as well as from outbreak areas from the animals showing signs of pneumo-enteritis. The various signs recorded in animals in natural disease were high fever (105-106°F), erythema of oral mucosa, conjunctivitis, nasal discharge – which was serous to start with and later turned to muco-purulent, respiratory distress characterized by dyspnoea and coughing followed by Diarrhoea (Fig. 92). Less commonly observed signs were necrotic lesions in buccal mucosa, lips and dental pads. Various gross lesions were found in upper respiratory tract, lungs and digestive tract. Lungs showed pneumonia of antero-ventral portion and oedema with presence of frothy fluid in the trachea.

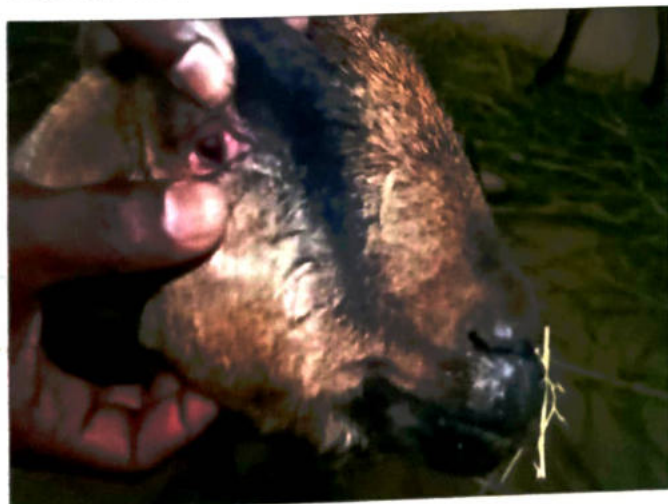


Fig. 92. Goat suffering from PPR

Trachea and bronchi were congested with occasional presence of mucoid secretions. The intestines showed congestion and hemorrhage but these lesions were restricted to small intestines. Morbidity in various flocks was from 65-100%. Mortality ranged from 55% to 71%. A Total of 341 sera samples were analyzed by c-ELISA for the prevalence study of PPR. Out of 55 sera samples collected from outbreak areas, 46 (83.63%) were found positive whereas 79 samples out of 286 randomly collected samples were found positive (27.62%). The overall prevalence of PPR was found to be 36.65%.

Formulation of Poultry Broiler and Goat Feed Using Makhana By-products

Makhana bran was used for evaluation of its acceptability in goat feed. For the study, 12 male Bengal breed of goats of 4-6 months of age were divided into 3 groups and assigned to three iso-nitrogenous concentrate mixtures, respectively. Concentrate mixture 1 (control) was prepared using maize, rice bran, soybean cake, salt and vitamins & minerals mixtures. In concentrate mixtures 2 and 3, rice bran was replaced by makhana bran at 75 and 100% levels. The experimental feeding was continued for 35 days after which a digestion trial was conducted for 4 days to estimate the nutrients digestibility. The dry matter intake of goats (kg/100kg b.wt) as well as the final body weight did not differ significantly ($p > 0.05$) among the groups. The digestibility of dry matter, organic matter and crude protein did not differ significantly ($p > 0.05$) among the groups. It may be concluded that makhana bran can be used in the concentrate mixture of goat up to 40% replacing rice bran without affecting growth, feed intake and nutrient digestibility (Fig. 93).



Fig. 93. Feeding of makhana by-products

Performance Potential of Integrated Aqua-culture having Mono-culture of Indian Magur and Poly-culture of Carps with Special Reference to Jayanti Rohu

Among six species of carps stocked, silver carp was fastest growing followed by catla, Jayanti rohu, grass carp, mrigal and rohu in the sequence. Growth rate of Jayanti rohu was ~ 45% higher than that of rohu and ~ 32% of mrigal (Fig. 94-96). It has also been found that integrated aquaculture is suitable for agro-climatic conditions of South Bihar and Jayanti rohu perfectly adapts as one of the species in multi-species carp aquaculture.

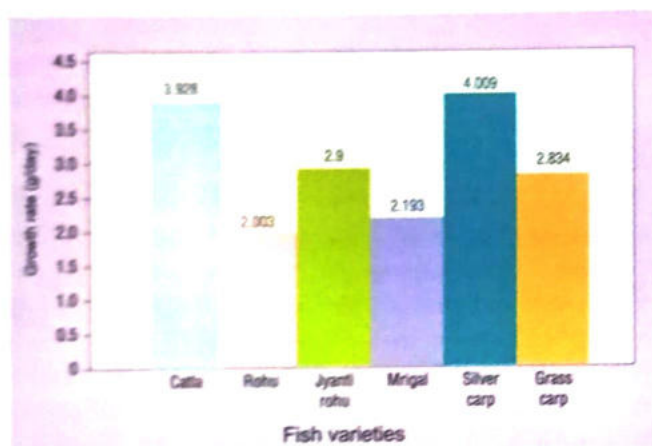


Fig. 94 Growth rates of fishes (body weight)

Similar was the trend for total productivity after eight months' of culture period.

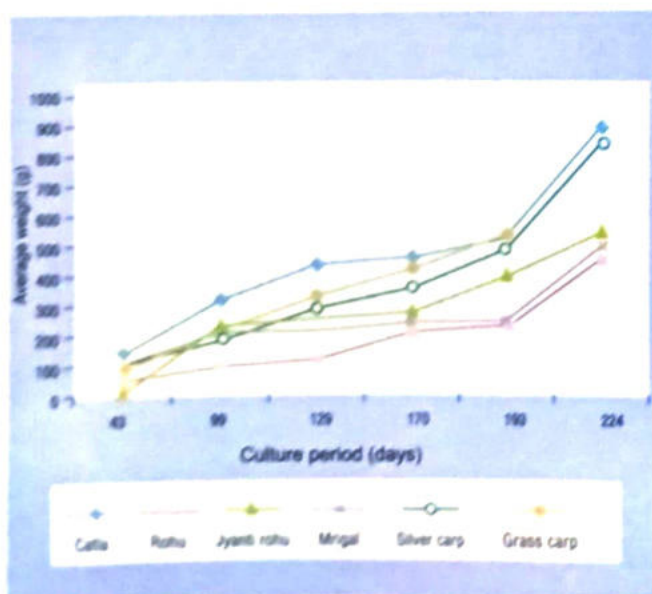


Fig. 95 Growth comparison of fishes



Fig. 96. Different fish species reared in integrated agro-aqua culture

Monoculture and polyculture of high value shellfish species under multiple water use system

Two experiments under the project were continued for examining how best the waterlogged areas along the canal command can be utilized for sustaining productivity in order to improve the livelihoods of the people living in proximity of waterlogged area.

Service Reservoirs

Monoculture as well as polyculture of prawn (*M. rosenbergii*) in two ponds of 40 x 20 m size was undertaken (Fig. 97). PL-20 of *M. rosenbergii* @ 50000/

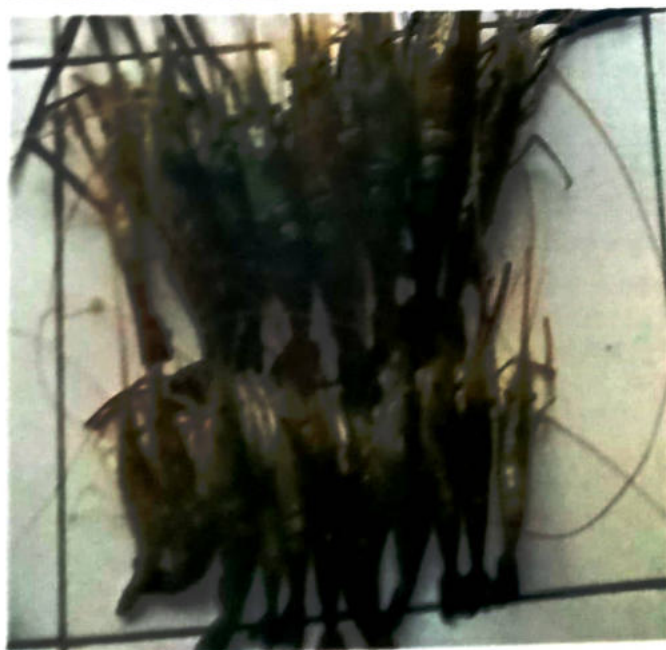


Fig. 97 Prawn culture in fresh water

ha were stocked in a pond in the month of July for monoculture experiment while in case of polyculture, the stocking rate was @ 40000/ha. The average weight of PL-20 was 0.5g. In polyculture, silver carp, catla and rohu were stocked in the ratio of 1.5:1.5:2 @ 9000/ha. The scampi PL-20 were fed with starter-I, 3-4 times in a day @ 6-10% of body weight initially for two months and then the prawn were fed with pelleted "Sudha feed" @ 6% of body weight. Fishes were fed @ 3% of body weight with feed composed of mustard oil cake and rice bran in the ratio of 1:1.

Prawns after 120 days of rearing in monoculture (Fig. 98) attained an average weight of 21.3 g and size of 120 mm. In Polyculture (Fig. 99), it attained average weight of 18.6 g and size of 118 mm. In monoculture, prawn yield was 0.61 t/ha and survival rate was 50%. In polyculture, prawn yielded 0.73 t/ha with survival rate of 69%, alongwith 3.32 t/ha yield of other fish species. The adaptive research on culture of scampi (*M. rosenbergii*) has paved way for its farming beyond December.

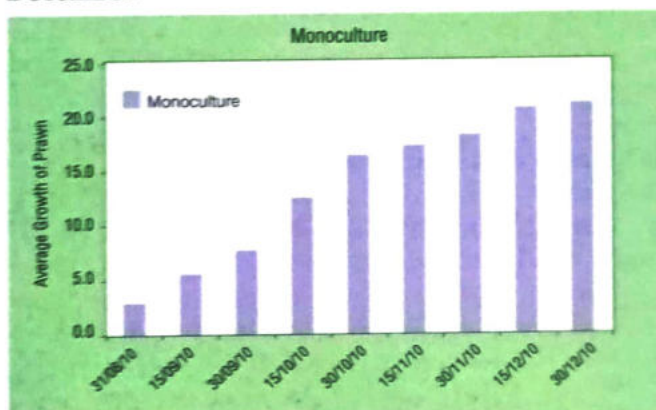


Fig. 98. Growth of prawn in pond-monoculture

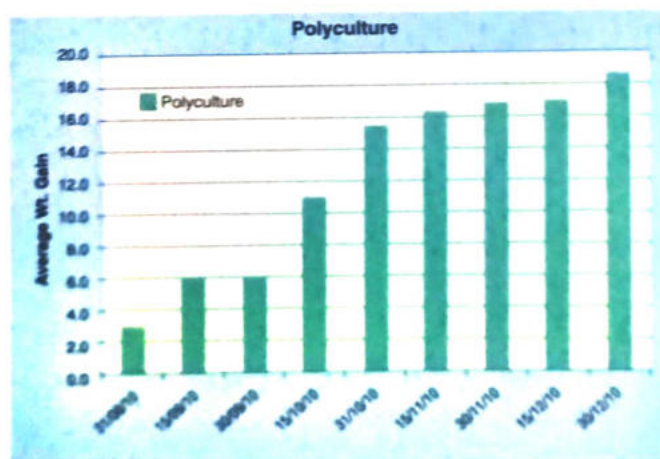


Fig. 99 Growth of prawn in pond-polyculture

After rearing of fish for 120 days, observations on growth of fishes revealed that silver carp and rohu indicated better growth with an average weight of 385g and 250 g respectively. With prawn polyculture system, Khaki Campbell ducks were integrated at the rate of 200 ducks per ha water area. Whole rice grain was fed to all ducks @ 100 g/head/day, besides foraging in

the pond for 4 hours per day. On an average a female laid 150.3 eggs per year with an average weight of 66.2g.

Fish Seed Production

A progressive farmer who was imparted training on integrated aquaculture with special emphasis on running of eco-hatchery for fish seed production under FPARP was further given technical inputs for establishing a commercial hatchery for fish seed production in participatory mode, with a capacity of 40-60 lakhs spawn per day at Jandha in Vaishali district of Bihar (Fig. 100-101). The farmer was imparted technical know-how for the fish seed production illustrating following important steps.



Fig. 100. Portable eco-hatchery



Fig. 101 Hatching tanks in farmers' field

- i) **Selection of brooder** The right selection of the female and male brooder is quite important for seed production and farmers were trained for identifying ideal pair of brooder by pressing the abdomen as well as rubbing of the pectoral fin (Fig. 102).
- ii) **Administration of Ovaprim** The art of giving injection of ovaprim to induce fishes for breeding and its doses applied to the male (0.5 ml/kg) and female (0.8 ml/kg) brooder were taught to the farmer (Fig. 103).
- iii) After the release of the eggs, the demonstration of hatching of fertilized eggs in the hatching tank was given. Fertilized eggs were hatched in 48-72 hrs in hatching tank. The newly hatched spawns were transferred to nursery tank for further rearing.



Fig. 102. Selection of brooders



Fig. 103. Administration of ovaprim

Formulation, Development and Assessment of a Pollen Substitute Meeting the Nutritional Needs of Honey Bees (*Apis mellifera*)

The data collected on weather parameters revealed that 6.7°C to 41.2°C temperature, relative humidity from 50-90%, and sunshine of 2 to 9 hrs were observed suitable for apiculture and the bee colonies were found in healthy condition (Fig. 104). However, temperature below 6°C for more than one week was not congenial for maintenance of bee colony. Activity of honey bee started in between 5 AM to 6 AM when temperature remained $20^{\circ}\pm 5^{\circ}$.

To supplement the natural food through low cost artificial food, trial is being conducted with different combination of locally available raw material viz. soya flour, potato flour, makhana flour and maize flour and gram flour (Fig. 105). Results revealed that:

- Honey bee preferred the soya bean flour over the other combination.



Fig. 104. Bees hive frame maintenance in experimental apiculture unit.

- Honey followed by gur (Jaggery) is the most preferred nectar substitute for the bees.
- More brood development was reported from soybean flour – sugar feeding colonies.
- Severe winter period December/January is critical for survival of the bees and over 30% population was lost due to low temperature.

Enemies/diseases of Honey bee

Four species of wasp (a) Yellow Banded Brown Wasp (b) Yellow Banded Wasp (c) Large Black Wasp and (d) Golden Wasp were recorded as major pest problem during dearth period. Beside Wasp, rock Bee (*Apis dorsala*) was also found robbing the honey collected in hives. Acarine disease was also observed which damages the brood stage of honey bee.



Fig. 105. Bee colony on artificial diet during dearth period

Process Development for Dried Products from Selected Fruits and Vegetables

The project was undertaken with two objectives (i) to develop process for production of dried products from jackfruit, mushroom, tomato and drumstick; and (ii) to study the storage stability and shelf life of dried products.

Process for producing dried instant mushroom soup-mix

Processing of mushroom provides an opportunity to extend shelf life by producing value added and shelf stable products. Dry-soup mix is a highly acceptable, convenient and appetizing product among various processed products of mushrooms (Fig. 106). Hot air drying of milky mushroom (*Calocybe indica*) slices was carried at 50-55°C in a partially ventilated oven and dried mushrooms was grounded to make powder of uniform particle size. Dry soup-mix was prepared by using 20-22% mushroom powder with other common ingredients of dried vegetables and spices in stock to achieve thick consistency with good appearance and taste after reconstitution. Study indicated that predrying of mushroom under microwave condition prior to hot air drying gave comparatively good quality soup-mix compared to mushroom dried only in hot air. This was due to the effect of blanching that may accomplish during the process of microwave predrying. The soup-mix was prepared without any

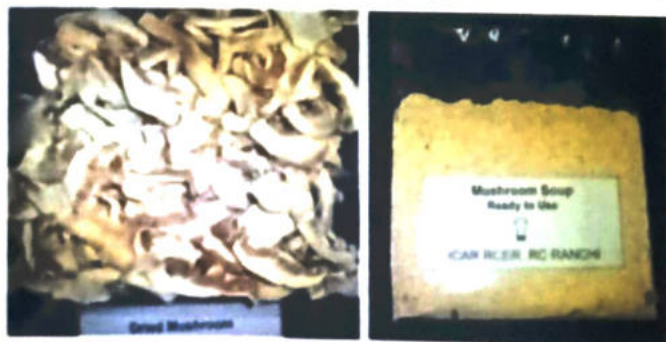


Fig. 106. Dried slices of milky mushroom and mushroom soup mix

chemical preservatives and additives. The change in apparent and bulk density was measured before and after drying of mushroom to evaluate the shrinkage or volume reduction. The shrinkage percentage upon drying of milky mushroom slices found to be in the range of 76.8-77.3%. The change in apparent density of milky mushroom at different stages of processing is shown in Fig. 107. The apparent density of whole fresh mushroom was evaluated to be 0.72 g/cc while of sliced mushroom was found to be 0.28g/cc and this was because of increase in volume after slicing. The prepared dried instant soup-mix was packed in polyethylene bags under convenient serving size for further studies on its shelf life and organoleptic evaluation.

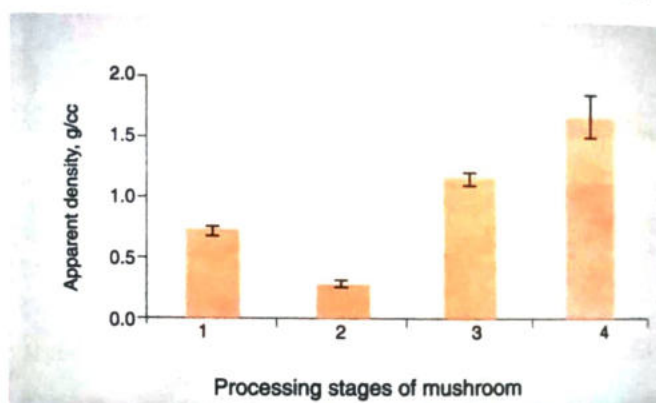


Fig. 107. Changes in mean apparent density as an effect of processing (1. Whole fresh mushroom; 2. Sliced fresh mushroom; 3. Sliced dried mushroom, and 4. Dried powder mushroom)

Development of Post-harvest Processes and Machinery for Makhana

Instant makhana kheer mix

Inter Institutional collaborative research project with C.I.P.H.E.T, Ludhiana has led to development of an innovative value added product of makhana which has been named as instant makhana kheer mix. The nutritional content (g/ 100g) of this product has been worked out as carbohydrate: 64.74; fat: 7.64; protein: 11.59; Ca: 0.1626; Na: 0.1325; K: 0.1111; Mg: 0.0321;

Fe: 0.0065; Cholesterol: 0.02; saturated fatty acid 4.36; trans fatty acid: 0.25; PUFA: 0.16 & MUFA: 1.68, respectively. It has the potential of commercialization as a value added product in national & international market due to its nutritive profile, procedure for easy preparation and its property of ready to serve beverage.

The optimum particle size of makhana (0.83 – 1.4 mm) with different constituents formulated the instant makhana kheer mix. Ready to constitute makhana kheer mix with major parts of makhana were standardized by using sensory score. The makhana kheer mix having the sensory scores of 8 or more was selected for shelf life studies in refrigerator and ambient conditions. The makhana kheer mix having moisture content of 14 – 15 % and stored for 3 months in refrigerator was found to be acceptable with sensory score of more than 6.5. The same product when stored at ambient condition was not acceptable after one month. The microbial load in the first case was found to be negligible. The instant makhana kheer mix having moisture content of 5 – 6 % showed the same level of acceptability even after six months when stored in ambient and for one year in condition of refrigerator. As a result of deterioration, the colour became darker and time of stirring for preparation of instant makhana kheer mix increased from 0.5 minute to 5 minute in warm water.

The kinetics of absorption of milk by whole as well as ground makhana were recorded by using response surface methodology to optimize the particle size of makhana, total solids and temperature of milk for development of ready to constitute instant makhana kheer mix. The milk absorption rate by whole popped makhana reduced drastically after about 10 second of absorption. The major dimensions and geometric mean diameters after absorption of milk decreased, which is in contrast with absorption of moisture by major agricultural products. The results showed that makhana particles of size between 0.83 to 1.4 mm absorbed maximum milk and is suitable for making instant (ready to constitute) kheer taking sensory score as the major parameter. The sensory scores of the product in most of cases were found to be more than 8.

The licence for manufacturing instant makhana kheer mix from C.I.P.H.E.T, Ludhiana, Punjab has been given to a young women entrepreneur Smt. Gauri Mahto Proprietor of M/s Vijay Raj & Company, Darbhanga, Bihar for commercial manufacturing of this newly developed value added product. The invention of instant makhana kheer mix has been applied for patent.

Promoting Sustainable Livelihood Development (Rojiroti)

Main objective of the project is to improve livelihood of resource poor rural families through formation of SHGs, micro finance, income generating agricultural activities and convergence with social welfare developmental schemes.

Based on the success cases in nearby areas, five video films (15-18 mints) were prepared on the Cultivation of marigold and horticultural crops, poultry, bangle making and Kishan Soochna Kendra (KSK). To test these videos, a feed back session was organised at Sakaria village for SHGs members, volunteers and other villagers. The feedback was used for the editing of the matter.

Workshop on "Exploring Opportunities for Kishan Soochna Kendra (KSK)" was also organized in which KSK operators, representatives from fertilizer and pesticide firms, agri clinics, NGOs, NABARD, volunteers and coordinators of SHGs had participated and discussed on basic infrastructure of KSKs, probable market, need and opportunities of linkage etc. (Fig. 108-110)

Tracking change in rural poverty in household and village economies in South Asia

The study aims to increase the availability of relevant data for decision-making on governmental issues to reduce the impoverishment in poverty-laden regions in semi-arid and humid tropics of South Asia.



Fig. 108. SHGs member watching video film at Sakaria (Patna)



Fig. 109. Kishan Soochna Kendra, Vikram, Patna



Fig. 110. Exploring KSK Opportunities at ICAR-RCER, Patna

Three complementary objectives of the project include:

- Enhance the availability of reliable household, individual, and field specific high frequency, time series data in purposively selected villages;
- Increase the availability of updated and expended meso-level agricultural data in India, and
- Nurture policy analysis and strengthen capacity building to fully exploit the collected data.

Secondary information on infrastructure facilities, land-use, cropping pattern, livestock and other related aspects of agriculture at meso and macro level have

been collected for Bihar and Jharkhand. Village profiles of eight randomly selected villages are being prepared. Monthly and yearly data collection, and compilation is going on for selected villages with the help of NCAP, New Delhi for further analysis..

Performance and Status of SHGs in Disadvantaged District of Bihar

The study was undertaken with the objectives (i) to study the demographic attributes of group members (ii) to determine the attitude and behavior of SHGs member (iii) to identify the constraints faced by group members, and (iv) to develop a pool of case studies. Data were solicited from 792 SHG members. Study revealed that majority of group members were male having age group of 29 to 43 years. The incomes of group members were below Rs. 5000/month. Most of the SHG members contributed less than Rs. 139 per month and saving less than Rs. 3612/-month. Most of the SHG members obtained short-term credit and diverged it for treatment of their family members followed by agriculture and education of children. Mostly group members repaid the loan regularly. Marketing of produce was done by group members themselves followed through traders and middleman. Products were marketed in the nearby city followed by local market. Members received information from progressive farmers followed by Kisan mela/exhibition/seminar and scientists of ICAR/SAUs. SHG members properly followed the guidelines of group formation, stabilization and smooth functioning of SHGs. Study indicates a significant change in attitude of SHG members in the area namely; (i) Socio-economic upliftment (ii) Educational and training (iii) Marketing and entrepreneurship qualities (iv) Technology adaptation and participatory research, and (v) Banking /credit aspect. Overall, most of the group members had positive attitude (Agree: 79%, Strongly Agree: 19%) towards SHG activities. However, only few of them (2%) were undecided about the benefit of SHG activities.

Capacity Building of Farmers' and Field Functionaries for Scaling-up of Water Productivity

The project was undertaken to study the demographic attributes, knowledge level, water management skills and to organise and evaluate the training programme on scaling up of water productivity (Table 59). A total of 15 trainings were conducted in collaboration of Krishi Vigyan Kendra, Bihar Veterinary College, Patna and Non-governmental Organizations. A total of 750 farmers and farm women were trained. Data were also solicited to assess the impact of training in terms of knowledge, attitude, skills, and aspiration level of farmers' trainees.

Table 59 Training programmes organized on scaling up of water productivity in agriculture

Name of institutes	Seven day duration	No. of participants	
		Male	Female
KVK, Buxar	12-18 August, 2010	46	4
KVK, Buxar	25-31 August, 2010	50	0
KVK, Jehanabad	1 -7 Sept. 2010	40	10
KVK, Ara	13-19 September, 2010	50	0
KVK, Ara	22-28 September, 2010	50	0
KVK, Jehanabad	24 - 30 Sept. 2010	36	14
KVK, Jamui	25 Sept-1 Oct., 2010	49	1
KVK, Barh	13-19 Sept. 2010	45	5
KVK, Vaishali	21-27 Sept., 2010	46	4
KVK, Madhepura	5-11 October, 2010	43	7
BVC, Patna	6-12 Oct. 2010	50	0
KVK, Saraiya	29 Sep.-5 Oct., 2010	36	14
PRADAN, Gaya	26 Nov.- 2 Dec, 2010	49	1
KVK, Nawada	1-7 Dec, 2010	47	3
KVK, Nawada	7-13 Dec, 2010	47	3

Training needs assessment of farmers and field functionaries in different eco- systems of Bihar

The Project has been undertaken with the objectives (i) to study the socio-economic attributes of farmers and field functionaries, (ii) to identify the training needs of farmers and field functionaries, and (iii) to suggest suitable policy recommendations. Altogether two types of schedules have been developed to record data on various socio-economic aspects like age, education, background, sex, income, trainings obtained, source of information etc. apart from information related with their training requirements. Pre-testing of the schedules has been completed and modified accordingly. Data from six districts covering two districts from each agro climatic zone is to be collected for the study. Data collection from Jamui district is under progress.

Socio-economic Analysis of Access to Farm Credit in Patna and Vaishali District of Bihar

The project was undertaken with the objectives: (1) to study the type, extent and structure of farm credit and their utilization pattern, (2) to study the borrower's repayment behaviour and reasons of non-repayment, and (3) to identify constraints to borrowing and lending from institutional sources and suggest remedial measures to overcome them. Based on stratified random sampling technique, 105 borrower farmers consisting of 35 marginal (<1 ha), 35 small (1-2 ha) and 35 medium/large (>2 ha) categories from four villages i.e. Chakramdas, Dharhara, Rahimpur and Manpura (Vaishali block) of Vaishali district were selected. They along with heads of local institutional sources of finance were interviewed for collection of pertinent data on various parameters of access to credit with the help of pre-structured schedule. The institutional source of credit was observed to be a predominant source of credit among farmers

except in case of marginal farmers who were borrowing more from non-institutional sources. It was observed that total credit as well as institutional credit obtained increased with the farm size, while reverse was the trend with non-institutional credit. The examination of purpose wise credit off take indicated that Kisan Credit Card (KCC) was the most predominant form of credit, followed by livestock and machinery/equipment.

The repayment of loan by majority of farmer was irregular, followed by no payment at all. Only a small proportion of borrowers, i.e., 16% of them were observed to be regular repayers. Crop failure was found to be the most important reason for non/irregular repayment of borrowed fund, followed by low crop yield, low price of the produce and lack of irrigation. Regarding the constraints in borrowing as expressed by responders, it was observed that delaying tactics and non-cooperation by bankers were major constraints to borrowers. However, farmers' ignorance/illiteracy and unwillingness to borrow were also major constraints to borrowing.

Constraints to lending in Vaishali district (banker's perspective) were (1) unclear intention and enterprise to be undertaken by borrowers, (2) loan-waiving scheme of the government (3) unviability of the project proposed by borrowers, and (4) willful loan defaults. Suggestions to overcome farmers' access to credit problem in Vaishali may be (1) bankers should be borrowers friendly, i.e., they should help in making bankable projects for farmers, (2) banks should organize credit camps in villages sometimes, (3) loan-waiver scheme should be discouraged, (4) farmers should be sensitized to banking, its proceedings, importance of borrowing and timely repayment, adverse consequences of non-repayment, and also entrepreneurship, and (5) government should extend cooperation in loan recovery process.

Value Chain Study of Selected Commodities: Case of Milk and Vegetables in Bihar

The study has been undertaken with objectives: (i) to study the market structure of milk and vegetables (ii) to examine marketing cost, margins and price spread of milk and vegetables and factors affecting them and (iii) to identify different marketing channels and constraints to milk and vegetable marketing. Suitable schedules have been developed to survey wholesale market, vegetable producer, vegetable collector-cum-trader, vegetable wholesaler, vegetable retailer, vegetable consumer, milk producer, milk collector-cum-trader, milk wholesaler, milk retailer and milk consumer. The data collection with the help of these schedules is in progress.

Constraints and Issues of Water Management in Crop Production in Bihar

This project attempts to identify constraints and issues of water management in canal as well as tubewell operated area and to study the ground wa-

ter marketing pattern in tubewell operated area. The study is being undertaken in Patna and Vaishali districts of Bihar through interview schedule, focus group discussion and interaction with concerned officials / water managers. The major objectives of the study are:

- To ascertain the constraints to water management;
- To study the process of ground water marketing, and
- To suggest suitable measures to overcome the problem of water management and marketing.

Initial discussion with the farmers and officials related to issues and constraints to water management has been done. Variables (Personal variables are - Age, Education, Family type, Size of Land holdings, Exposure to mass media, Institutional membership and Training undertaken; Water management variables are - Area under irrigation, Method of irrigation, number of irrigation, Time /Stages of irrigation in different crop and depth of irrigation) for the study have been identified for incorporation in the schedule. Interview schedule for data collection has been pretested and finalized.

Demonstration of Vegetable Cultivation in Jharkhand

The pointed gourd, a perennial cucurbit was introduced as a new crop in NAIP area in 3 farmers' fields and its cultivation was found to be remunerative. Sh. Churamani Prasad Yadav of Jama Block of Dumka harvested 123 kg produce from 2.75 decimal (110 sq.m) area and earned Rs. 2583/- during harvest period from 7.5.10 to 25.9.10. The sale price of parwal was Rs. 20-25/- per kg.

Low poly tunnel cultivation of bottle gourd in winter for early harvest in spring-summer season has proved to be highly remunerative when demonstrated in 25 farmers' fields. The maximum income obtained by Sh. Madan Mohan Majhi of Palasi in Jama Block of Dumka district was Rs. 4913/- from 1.25 decimal (50 sq. m) area. The crop was sown on 15.12.2009 and the harvest duration was from 10.2.10 to 30.5.10. Each bottle gourd fruit (1.5 kg) was sold @ Rs. 15-20/- in the local market.

In summer season, 1.0 ha was covered under vegetables in 57 farmers' fields. The maximum gross income obtained by Janvir Manjhi of Gajanda in Jama Block of Dumka district was Rs. 21,995/- through cultivation of okra in 12.5 decimal area. In kharif season, the total area covered under vegetables in 116 farmers' fields was 5.8 ha. The maximum gross income obtained by Har Prasad Murmu of Baramajhladih in Narayanpur Block of Jamtara district was Rs. 18,599/- through cultivation of brinjal and tomato in 44 decimal area.

In Cluster-1 (Jamtara), the maximum income of Rs. 13,287/- was obtained by Sh. Wakil Hembram through cultivation of brinjal and tomato. In Cluster-2 (Narayanpur), Sh. Bhim Roy earned the maximum

income of Rs.44,495/- from cultivation of summer and winter vegetables, sale of seedlings of papaya, forest plants and vegetables raised in poly houses and growing of fruits and vegetables in multi-tier system. In Cluster-3 (Dumka), Sh. Samu Hembram earned the maximum income of Rs.32,744/- from cultivation of cauliflower, brinjal and tomato and sale of poly house raised seedlings of papaya and vegetables. In Cluster-4 (Jama), the maximum income of Rs.7500/- was obtained by Sh. Barish Chand Tudu from cultivation of vegetable soybean, lima bean, radish, bottle gourd and cowpea in summer and kharif seasons (Figs. 111-115).



Fig. 111. Ridge gourd in Moiratola, Narayanpur, Jamtara



Fig. 112. Pointed gourd in Barapalasi, Jama, Dumka



Fig. 113. Poly tunnel cultivation of cucurbits in Roytola, Narayanpur, Jamtara



Fig. 114. Lima bean in Sinjootola, Jamtara



Fig. 115. Evaluation of bacterial wilt resistant brinjal lines in farmers' field

Consultancy, Patents and Commercialization of Technology

Parental lines of tomato (F_1 Swarna Sampada) were sold to Krishi Gram Vikash Kendra (NGO) for hybrid seed production.

Technology profiles have been prepared and sent to Zonal Technology Management Committee (ZTMC) of East Zone for business evaluation.

1. *Swarna Sampada* (Tomato Hybrid)
 2. *Swarna Shakti* (Brinjal Hybrid)
 3. *Swarna Rekha* (Pointed Gourd)
 4. *Swarna Alaukik* (Pointed Gourd)
 5. *Swarna Priya* (French Bean)
 6. *Swarna Mukti* (Garden Pea)
 7. Low Energy Water Application (LEWA) Device.
- Patent application has been drafted for Low Energy Water Application Device and sent to ZTMC for legal preview.
 - Decision support tool is under prior art search to file a patent for the software.

The training programmes conducted at Ranchi centre of the Complex are depicted in Table 60.

Table 60 Training programmes organized at ICAR RCER - RC, Ranchi

Subject	Date of training	Sponsored by	Block	No of participants
Vegetable cultivation in rabi season	27-31 st Jan ,2010	Project Director , Diara Vikash Pariyojna, Patna	Danapur ,Lalganj, Vaisali , Mokama Harkushpur, Palyganj Patn Sadar ,Shahpur and Arrara sadar	26
Vegetable cultivation in rabi season	9-13 th Feb,2010	Project Director, Diara Vikash Pariyojna, Patna	Khagauli,V ikram,Bariarpur, Raghunathpur, Phulwarisarif, Phatuah, Naubatpur,Sisvan, Gharwari, Ghoswari, Mokamah and Maner,	27
Rejuvenation of new and old orchard	16-20 th Feb.2010	National Horticulture Board, Jharkhand	Ormanjhi, Angara, Ratu, Sonahatu,Budmu, Khijri, Chandwa, Kudu,	30
Vegetable production	23-25 th Feb.2010	NAIP	Jama, Dumka,Narayanpur, Jamtara,	17
Mushroom production and vegetable preservation	10-12 th Mar,2010	NAIP	Dumka and Jama	18
Vegetable cultivation in rabi season	26-30 th Mar,2010	Project Director, Diara Vikash Pariyojna, Patna	Minapur, Lalganj,Jamalpur and Kutni	22
Vegetable cultivation in rabi season	3-4 th Sept.2010	National Agricultural Vikash Pariyojna ATMA Dumka	Jama Jarmundi	31
Vegetable cultivation in rabi season	6-7 th Sept.2010	National Agricultural Vikash Pariyojna ATMA Dumka	Jama ,Sikaripara,Jarmundi, Gopikander	31
Mushroom cultivation	22-24 th Nov. 2010	Project Officer, ATMA Jamtara, Jharkhand	Bero,Phatehpur andBundu	18
Drip irrigation		NABARD	Master Trainers from all over Jharkhand	100
Total				320

Training was also imparted on canopy management in mango (Fig. 116) besides the training programmes on rejuvenation of mango orchards (Fig. 117).

Participation in Kisan Mela

Participated in exhibition to display live exhibits of horticultural crops in Kisan Mela from January to December 2010. The Institute/Centre participated by putting up exhibition stall in Kisan Mela/Exhibition to disseminate the technologies developed by the station in horticultural crops (Table 61; Fig. 118-119).

Table 61. Participation in Kisaan Mela during Jan.-Dec.2010

Name of fair	Venue	Organised by	Date
Rose show	Ranchi Club	Horticultural Society, Ranchi	9-10/01/10
National farmers' fair	IIVR, Varanasi	IIVR, Varanasi	30-31/01/10
Kisan fair	Khelgaw-Lagam Silli	Pratibha-darsan Mahotsaw, Khelgaw-Lagam, Silli	06/02/2010
Kisan fair	Getalsut	R.K.Mission	10-11/02/10
National kisan fair	Varanasi	IIVR	9-10/02/08
Kisan fair	Namkum	IINRG Namkum	23-25/02/10
Kisan fair	Saraikela-Kharsawa	ATMA-Saraikela	17-18/02/10
Kisan diwas	Manatu	IIFCO	09/02/10
Agro-tech 2009	BAU Kanke	BAU, Kanke, Ranchi	26-28/03/10



Fig. 116. Demonstration at farmers field in Lohardaga



Fig. 117. Training program on management of old and new mango orchards organized at ICAR-RCER, RC Ranchi



Fig. 118. Participation in Agro-tech 2009, BAU, Kanke



Fig. 119. Participation in National farmers' fair, IIVR, Varanasi

KVK - Buxar, attached to the complex, has organised various training programmes during the period under report and details of the same is shown in Table 62-65.

Table 62. Sponsored training Programmes organized by KVK, Buxar

Training programme	Date	No. of participants
Krishak Vaigyanik Vartalap	04-05.08.2010	25
Scaling up of water productivity in agriculture for livelihood through teaching and demonstration	12-18.08.2010	50
Scaling up of water productivity in Agriculture for livelihood through teaching and demonstration	25-31.08.2010	50
Fruit and vegetable preservation	22.01.2011	38

Technology Dissemination through Mass Media

Scientists of the centre delivered sixteen Doordarshan talks on various specialized topics related to vegetable cultivation, mushroom production, management of unproductive orchards, application of drip irrigation technology, Drum Kit drip irrigation system etc. and four interviews on various aspects of fruit, vegetable and mushroom cultivation on All India Radio.

Transfer of Technology

OTHER ACTIVITIES

Strengthening Statistical Computing for NARS

For exploiting and sustaining statistical computing, a high end general purpose Statistical Software Package SAS has been provided with perpetual license under the NAIP project *Strengthening Statistical computing for NARS*. A nodal officer has also been nominated to look after the work of SAS installation/uninstallation and its functioning. The software has been installed on the 10 potential computers of the institute and is ready for the use.

National Knowledge Network (NKN)

Recently, the institute has been provided with 1Gbps NKN connectivity under the National Knowledge Network project of Ministry of Information and Communication, Government of India. The NKN router is directly connected to the NKN router of NIC Kolkata with 1Gbps connectivity through BSNL dark fibre cable. The link was further driven to the wireless local area network of the institute for facilitating the connectivity at the user end. The network has been designed by the NIC Kolkata in such a manner that in the case of NKN link fails, the Internet connectivity will automatically switch over to the existing 512 kbps ERNET BB VSAT connection. Now, by utilising 1 Gbps NKN connection, it could be possible to undertake low latency and high bandwidth requiring work such as large data transfer, content sharing and research coordination locally as well as globally. It would enable scientists and researchers from diverse spheres across the country to work together for advancing human development in critical and emerging areas. It would also catalyze knowledge sharing and knowledge transfer between stakeholders seamlessly – that too across the nation. A large section of research and educational institutions is expected to create intellectual property. It would enable the use of specialized applications, which allow sharing of high performance computing facilities, e-libraries, virtual classrooms and very large databases. It would facilitate the creation of national web based portals for basic needs on certain key sectors such as Water, Energy, Environment, Education, Food, Health, Agriculture, Employment, and Citizens' Rights etc.

NAIP Project on Developing, Commissioning, Operating and Managing an Online System for NET.ARS Prelim Examination for ASRB, ICAR

Under above project the institute has been selected for Online ASRB examination having the capacity of 50 examinees. The examination hall and the server room have been developed for this purpose. The terminals, servers, UPSs and the dedicated link are expected to be installed soon.

Table 63. OFT conducted at KVK, Buxar

Topic	Area/No. (ha.)	No. of beneficiaries	Villages covered
Varietal Evaluation of Papaya in Buxar District	105	07	Bharkhar, Kukudha and Jagdishpur
Varietal Evaluation of Tomato in Buxar District	0.12	05	Atimi, Lalganj and Pawani
Effect of Nutrient Management Practices on yield	1.5	12	Nadaon, Barki Basuli, Bharchakia, Ramobaria, Chhutka
Attributing Characters of Lentil			Dhakaich and Bishrampur
Effect of Zinc & Boron on the Yield of Chickpea	0.75	10	Bharchakia, Ramobaria, ChhutkaDhakaich, Nat, Kukurha and Itahri
INM in Wheat	2.5	16	Dullapur, Hajipur, Gosainpur, Bijhaura, Naya Bhojpur, Atimi, Pokhara and Nadaon
Efficacy of low cost weaning foods developed from low cost available agro products using simplified techniques (6-2 years babies)	—	10	Lalganj and Nadawn
Anoestrus condition in cattle	20	20	Hukaha, Lalganj, Baruna, Mahdah, pawani and Bharchakiya
Effect of various ectoparasiticide in tick control in cattle	20	15	Bharchakiya etc.
Insect pest management in chick pea	0.5	06	Mahila, Nadaon, Manjharia, Bijhaura and Kukurha

Table 64. FLD conducted at KVK, Buxar

Topic	Area/No. (ha.)	No. of Beneficiaries	Villages covered
Varietal Demonstration of NDA-1 (Component)	0.75	12	Ramuvariya, Vishrampur, Majharia and Kukudha
Varietal Demonstration of NDA-1 (Full Package)	0.5	10	Majharia, Khairati, Pawani, Majharia and Dullahpur
Effect of Weedicide on the Yield of Onion (<i>Allium cepa</i>)	0.78	21	Kukudha, Bharchakiya and Nat
Effect of Seed Treatment on the Yield of Onion (<i>Allium cepa</i>)	0.75	20	Dhakaich, Bharchakiya, Kulharia, Jagdishpur, Nadaon, Khairati, Ramuvariya and Hazipur.
Role of Azolla in Rice	2.5	20	Vharchakiya, Vishrampur, Bijhaura, Kukudha, Fatehpur and Ramuvariya
Role of Rhizobium Culture in Urd bean	0.5	08	Kachainiya, Rampur and Ramuvariya
Role of Rhizobium Culture in Urd bean	0.5	08	Rampur, Ramuvariya and Nachap
Effect of PSB on the yield of wheat	4.0	32	Parwat Nath, Varuna, Ahirauli, Hukaha, Khairati, Jagdishpur, Ramuvariya, Chakrahansi, Pawani, Kulharia, Kukudha, Chhotka Dhakaich and Naya Bhojpur
Effect of Rhizobium culture on the yield of spring /summer mung bean	03	26	Basaon Khurd, Hukaha, Mahila, Jagdishpur, Turpurva, Kukudha and Bharchakiya
Nutritional Garden	20	20	Pawani, Bankat and Kukudha
Vermiculture	15	15	Pawani, Atimi, Kulharia, Bharchakiya, Hemdapur, Chnada, Parsiyaan & Sonvarsa
Dhingri Mushroom Cultivation	41	41	Dhansoi, Hukaha, Bharchakiya, Naya Bhojpur and Dhakaich
Fodder crop Berseem (BL-10)	1.25	24	Chotka Dhakaich, Nadaon, Hitenpadri, Naat, Mahila, Hukaha, Umapur, Bhatauliya, Baruna, Sarasti and Manjharia
Performance of Var. <i>Rajendra Anukul</i> on yield of Toria (Oil & Pulse Programme)	2.5	22	Nadaon, Niyazpur, Chakki, Nayabhojpur, Badki Basauli, Bharchakiya, Deodia, Lalganj, Khurchia, Kukurha, Dhakaich, Chhotka, Dhakaich, Bharkhara, Bishrampur, Sarasti and Mahila
Performance of Var. <i>Pusa Bold</i> on yield of Toria (Oil & Pulse Programme)	2.5	20	Ramobaria, Khairati, Naya Bhojpur, Kukurha, Hookaha, Pawani, Mahadah, Bhithara, Nath, Nadaon, Bharchakia, Bijhaura, Bishrampur and Mahila
Performance of Var. <i>Pusa 362</i> on yield of Chickpea (Oil & Pulse Programme)	1.0	15	Kukurha, Kulharia, Sahopra, Padri, Kamarpur, Mahadah and Naya Bhojpur
Performance of Var. <i>Pusa 362</i> on yield of Chickpea (ATMA Funded)	1.0	08	Pokhahara, Manjharia, Gosainpur, Bharchakia and Kulharia.
Demonstration of Bee hives for bee keeping to rural youth in Buxar	10	10	Gosainpur, Nagpur, Sarenja, Baghelwa, Bakasara, Rasen and Sauri,
Demonstration of Pheromone Traps with Heli lure (<i>Helicoverpa armigera</i>)	50		Mahadah, Bharchakia and Gosainpur

Table 65 Sensitization / training capacity building to provider farmers and services

Training Programme	Training Date	No. of Participants
Farmers' Training on ZT DSR	28.05.10	35
Training on Residue Management	05.12.10	30
Training on Residue Management	16.12.10	26
Field day on 14/07/10 at ICAR-RCER, Patna for the farmers of Vaishali under NAIP Component-3 (50 participants)	14.07.10	50
Roti (Sarson) ki unnat kheli	06.10.10	45

Workshops/Symposia/Conference/Seminar/Scientific Meeting/Training/Farmer's Day etc. Organized

Organization of Vegetable Soyabean Mahotsav

The Vegetable Soyabean Mahotsav was organized on 23rd September, 2010 in collaboration with AVRDC (World Vegetable Centre).

Training programmes/workshops organized:

- Fifteen farmers training programme on "Scaling up of Water productivity in Agriculture for Livelihoods" were Coordinated at different institution.
- Two farmers training programme for farmers of Jandaha under NAIP were organized having theme on Crop management in Kharif and Improve potato cultivation on 25th May and 1st October 2010, respectively.
- Workshop on Procurement related matters & Financial Management System under World Bank funded project of NAIP (17-18 August 2010)
- *Roji Roti* Interaction workshop on "Exploring opportunities for KSKs", at ICAR-RCER on 28th August 2010.
- One day farmers training on Zero Tilled Direct Seeded Rice at ICAR-RCER, Patna on May 28, 2010.
- One day SAS training for the Scientists of ICAR-RCER, Patna on 24th November, 2010 at ICAR-RCER, Patna.
- Brain Storming on Second Green Revolution: Strategies for Agricultural Transformation of Eastern Region, 11-12th December, 2010 at ICAR Research Complex for Eastern Region, Patna.
- Model Training on "Information and Communication Technology and Improved Agricultural Practices for Enhancing Productivity under Changing Climate Situation" Sponsored by Directorate of Extension, Ministry of Agriculture, New Delhi from 15-22 December, 2010.

Award and Recognitions

A.K. Singh, Sr. Scientist (Agronomy) awarded *Kunwar Sexana Babadur SRDA Award -2010*, for understanding and recognition in the field of Agronomy on the occasion of First National Congress on Emerging trend in Agricultural Research organized by Society for Recent Development in Agriculture, Meerut (UP), held during 11-12 September, 2010, at PDFSR Modipuram Meerut.

Dr. R. Elanchezhian, Sr. Scientist awarded Best Poster by the Indian Society for Plant Physiology at National Conference of Plant Physiology entitled Physiological and Molecular Approaches for Crop Improvement under Changing Environment" organized by Indian Society for Plant Physiology held at Banarus Hindu University, Varanasi, India during Nov 25-27, 2010.

Dr. Ramakrishna Roy was awarded the provisional Post Graduate Diploma in Marketing Management from Indira Gandhi National Open University, New Delhi

Education and Training of Staff Undertaken in India/Abroad

- Er. Santosh S. Mali. Geospatial Knowledge management for sustainable livelihoods security. NAARM Rajendranagar, Hyderabad, Feb. 16 to 26, 2010.
- Dr. R.C. Bharati. Strengthening Statistical Computing for NARS. DWM, Bhubaneswar, June 18 to 19, 2010.
- Dr. Ujjwal Kumar. Science & Technology for Rural Societies. Lal Bahadur Shastri National Academy of Administration, Mussoorie, June 28 to July 9, 2010.
- Dr. Nitu Kumari. Summer school on 'Wild and Underutilized Fruits. Dr. Yashwant Singh Paramar University of Horticulture and Forestry, Nauni, Solan, July 22 to 11 August, 2010.
- Dr. Ramakrishna Roy. Winter school on 'Recent concepts in Veterinary Laboratory diagnostics' Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Oct. 12 to Nov. 1, 2010.
- Dr. R.C. Bharati. Strengthening Statistical Computing for NARS, IASRI, New Delhi, Oct. 25-30, 2010.
- Dr. A. Upadhyaya. Training programme on "High Performing Teams: for Scientists & Technologists working in Government Sector" MDI Campus, Gurgaon, Nov. 08-11, 2010.
- Dr. Deokaran. National Training Programme on "Bioinformatics and Computational Biology in Microbiological Research" NBAIM, Mau Jan. 29 to 4 Feb., 2011.

Linkages and Collaborations in India/Abroad

- Impact, adaptation and vulnerability of Indian agriculture to climate change – ICAR network project with IARI as main centers and Patna as sub centre.
- Modeling the performance of a few major cropping systems in Eastern India in the light of projected climate change- a project under NAIP Component 4 with OUAT, Bhubaneswar as main centre and Patna as sub centre.
- Impact, adaptation and vulnerability of Indian agriculture to climate change – ICAR network project with IARI as main centers and Patna as sub centre.
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- Modeling the performance of a few major cropping systems in Eastern India in the light of projected climate change- a project under NAIP Component 4 with OUAT, Bhubaneswar as main centre and IIT, Kharagpur, Institute of Life Sciences, Bhubaneswar and ICAR-RCER, Patna as sub centres.
- International Water Management Institute.
- International Livestock Research Institute.
- Indian Veterinary Research Institute, Bareilly.
- Central Institute of Research on Buffalo, Hisar.
- Directorate of Veterinary and Animal Husbandry, Government of Bihar, Patna.
- Directorate of Fisheries, Government of Bihar, Patna.
- Directorate of Agricultural, Government of Haryana, Hisar.
- Directorate of Animal Husbandry, Government of Haryana, Hisar.
- Bill and Melinda Gates Foundation/USAID / IRRI for CSISA 2 (Platform Research).
- OUAT, Bhubaneswar.
- IIT, Kharagpur.
- IARI as main center for ICAR network project on Impact, adaptation and vulnerability of Indian agriculture to climate change.
- Bihar Veterinary College, RAU, Patna.
- IIPR Kanpur for AICRP on Pigeon Pea.
- DWR Karnal for AICRP on wheat.
- DRMR Bharatpur for AICRP on Mustard.
- Consortium partners like RAU Pusa, BAIF Patna, CIFRI Barrackpore, IWMI and IFPRI New Delhi, CPRS Patna for implementation of the project under NAIP.
- Rajendra Agricultural University Pusa for Capacity Building of 30-farmers through training on Apiary.
- Vaishali Small Farmer Development Agency.
- ATMA, Darbhanga.
- NABARD, PRADAN, IFFCO.
- Ministry of Water Resources, Govt. of India.
- Birsa Agriculture University.
- Department of Forest, Govt. of Jharkhand.
- Ramakrishna Mission Ashram, Narayanpur, Chhatisgarh.
- Krishi Gram Vikas Kendra, Ranchi.
- ATMA, Hazaribagh.
- Department of Agriculture, Govt. of Bihar.
- Bihar Agriculture Management Extension and Training Institute (BAMETI), Patna.

Participation of Scientist in Conference Seminar/Workshops/Symposia/Meetings in India and Abroad

- Dr Ujjwal Kumar. Annual Review Workshop of NAIP Comp-3 ICAR-RCER, Patna, January 22, 2010.
- Dr. A. Upadhyaya. To present a paper and participate in XLIV ISAE Convention, KAB-II, IARI, New Delhi, January 28-30, 2010.
- Dr. A.K. Singh. Meeting cum workshop organized by ICAR IINRG, Namkum, Ranchi, February 19-20, 2010.
- Dr. K. M. Singh. Workshop on Tracking Changes in Rural Poverty in Household and Village Economies in East India, held at NCAP, NCAP, New Delhi, February 20, 2010.
- Dr. A.K. Jain. National seminar on Applications of biotechnology and development of Bihar, Central University of Bihar, Patna, March 22-24, 2010.
- Dr. A. Upadhyaya. 1st Meeting of the reconstituted ICAR-CWC Joint Panel Meeting, Pusa, New Delhi, April 21, 2010.
- Dr. R. Elanchezhian. National seminar on Impact of Climate Change on Water Resources, Irrigation Division, Govt. of Bihar, Patna, April 23, 2010.
- Dr. A. R. Khan, Dr. Ujjwal Kumar, Dr. R.C. Bharati. Workshop on CSISA Delivery and Adaptive Research Belia, Tarapith, Birbhum, West Bengal, May 11-12, 2010.
- Dr. R.D. Singh. Workshop on Common Format for Preparation of District Level Contingency Plans for Northern States organized by Project directorate for Farming Systems Research, Modipuram, Meerut (U.P.), PDCSR, Modipuram, June 3, 2010.
- Dr. Nitu Kumari. Seminar cum Training Programme on 'Canopy Management and Propagation of Quality Planting Material' organized by Department of Agriculture and Cooperation, Ministry of Agriculture, GOI, New Delhi in collaboration with Department of Horticulture, Govt. of Bihar. Patna Taramandal, Patna, June 25, 2010.
- Mrs. Punam Tiwari. Training programme on Online Reporting of KVKs, organized by ZPD, Zone II RAU, Pusa, Samastipur, June 26, 2010.

- Dr. K. M. Singh and Dr. S. K. Barari. Launch Workshop of NAIP Consortium on 'Developing, Commissioning, Operating and Managing an Online System for NET/ ARS-PRELIM Examination in ASRB, ICAR' NAAS Complex, New Delhi, July 1, 2010.
- Dr. R.K. Roy. One day orientation workshop for KVKs at CRIDA, Hyderabad to discuss possible interventions in vulnerable districts on climate resilient technology, CRIDA, Hyderabad, July 1, 2010.
- Dr. S.K. Singh. Seminar on Agriculture and Horticulture, organized by Director Agriculture, Bihar Saran, Chhapra, Bihar, July 08, 2010.
- Dr. Janardan Jee. IPR issues in Agriculture National Productivity Council, Patna, July 24, 2010.
- Dr. A.K. Singh. ICAR-Industry Meet Organized by ICAR NASCE Complex, New Delhi, July 28-29, 2010.
- Dr. S.K. Singh. State level Workshop on Organic Farming in Bihar- Business prospects and future direction organized by Organic Mission in collaboration with ECOCERT-India. B.I.A., Patna, August 04, 2010.
- Dr. A.R. Khan. Attended Divisional Committee Meeting to review the foreign aided projects under NRM Division KAB II, ICAR, Pusa, New Delhi, August 10, 2010.
- Dr. R.K.Roy. Review meeting cum workshop of KVKs of Bihar RAU, Pusa, August 12-13, 2010.
- Dr. R. Elanchezhian. 2nd CAC meeting of NAIP Project - Modeling the Performance of a Few Major Cropping Systems in Eastern India in the Light of Projected Climate Change. OUAT, Bhubaneshwar, August 27, 2010
- Dr. A.K. Singh. Participated in First National Congress on Emerging Trend in Agricultural Research organized by Society for Recent Development in Agriculture. PDFSR, Modipuram, Meerut, September 11-12, 2010
- Dr. N. Chandra. Hindi Workshop ICAR-RCER, Patna, September 14, 2010.
- Dr. Janardan Jee. Hindi Pakhwara ICAR-RCER, Patna, September 14-30, 2010.
- Dr. Deokaran. RCM of ICAR, BAU, Ranchi, October 7 to 9, 2010.
- Dr. Janardan Jee. National Food Day Seminar on Food Security in Period of Crisis. Bihar Productivity Council, Patna, October 16, 2010.
- Dr. A. K. Singh. 'Nature Fest' organized by NABARD – NRMK Kolkata, Central Park Salt lake Kolkata October 25 to November 3, 2010.
- Dr. R.C. Bharati. Interactive Meet on Information and Communication Technology in ICAR, NASC Complex New Delhi. November 3-4, 2010.
- Dr. Janardan Jee. Processing and Marketing of Fruit Bihar Industry Association (BIA), Patna, November 15, 2010.
- Dr. A.K. Singh, Dr. R.S. Pan. 4th Indian Horticultural Congress-2010, Horticulture Society of India, New Delhi, November 18 to 21, 2010.
- Dr. S.K. Singh, National Conference on Biodiversity of Medicinal and Aromatic Plants Collection, Characterization and Utilization, Organized by Medicinal and Aromatic Plants Association of India, Anand, Gujarat, November 24 to 25, 2010.
- Dr. R. Elanchezhian. National conference of Plant Physiology "Physiological and Molecular Approaches for Crop Improvement under Changing Environment" Banarus Hindu University, Varanasi, November 25 to 27, 2010.
- Dr. R.D. Singh, Dr. S.S. Singh, Dr. Sanjeev Kumar, Dr. Shivani and Dr. A. Upadhyaya. Participated in XIX National Symposium on Resource Management Approaches Towards Livelihood Security. U.A.S. Bangalore, December 2 to 4, 2010.
- Dr. A.R. Khan. Experts Meet for Formulation of Syllabus of Post-Graduate Courses Central University, Patna, Bihar, December 6 to 7, 2010.
- Dr. Deokaran, Mr. Sarfaraj Ahmad. State Level Workshop of KVK, Zone-II, BVC, Patna. December 10 to 12, 2010.
- All Scientists. Brain Storming Session on Second green revolution: Strategies for agricultural transformation in Eastern region, ICAR-RCER, Patna, December 11 to 12, 2010.
- Dr. Deokaran, Mr. Sarfaraj Ahmad. Brainstorming session on Second Green revolution in Eastern India, ICAR-RCER, Patna, December 12, 2010.
- Dr. (Mrs.) Bhavana P. 'International Symposium on Recent Advances in Cross-disciplinary Microbiology: Avenues & Challenges' and 'International Workshop on rRNA Sequencing, Phylogeny and Next Generation Genome Sequencing' Birla Institute of Technology, Mesra, Ranchi December 14 to 17, 2010.
- Dr. Abhay Kumar. 19th International Conference of FIM on 'Interdisciplinary Mathematical and Statistical Techniques' Department of Statistics, Patna University, Patna, December 18 to 20, 2010.
- Dr. Janardan Jee. IT & Rural Development, Bihar, Times Conclave, Patna, December 19, 2010.
- Dr. Deokaran. 5th National conference on KVK MPUAT, Udaipur, December 22-24, 2010
- Dr. A. Upadhyaya. Global India Scientists and Technologists (GIST) 2010 Convention on Scientific and Technological Approaches for Sustainable Use of Water Resources, Pune, December 26 to 27, 2010.
- Dr. N. Subash, 3rd CIC and CAC Meeting of NAIP project - Modeling the Performance of a Few Major Cropping Systems in Eastern India in the Light of Projected Climate Change, OUAT, Bhubaneshwar, January 6 to 7, 2011.

National Seminar "Climate Change and Food Security: Challenges and opportunities for Tuber Crops" CTCRI, Trivandrum, January 20 to 22, 2011.

- Dr. S.K. Singh. Workshop on Shri Kranti, Organized by Director Agriculture, Bihar, S.K. Memorial Hall, Patna, January 27, 2011.
- Dr. A.R. Khan. Assessment Committee for Category I&II of Technical Personnel as Outside Member CARI, Port Blair, Andaman and Nicobar, January 27 to 30, 2011.
- Dr. Nitu Kumari. Seminar on 'Development of Horticulture in Bihar-Issues and Strategies' organized by Bihar Horticultural Society, RAU, Pusa, BVC, Patna, January 28 to 29, 2011.
- Dr. A.R. Khan. Attended TWG meeting of CSISA ICAR-RCER, Patna. February 2, 2011.
- Mrs. Punam Tiwari. Training cum workshop for SMS, Home Science of KVKs of Zone II organized by ZPD, Zone II, FTC, Kalyani, February 17 to 20, 2011.
- Dr. S. J. Pandian. All India Conference of the Association of Public Health Veterinarians (APHV) and National Symposium on 'Challenges and Strategies for Veterinary Public Health in India' Bihar Veterinary College, Patna, February 18 to 19, 2011.
- Dr. Deokaran and Dr. R.K. Roy. Workshop for finalizing Action Plan of NICRA project for Zone-II, CIFE, Kolkata, February 21 to 22, 2011.
- Mrs. Punam Tiwari. Training Programme on 'Communication and Content Development' organized by CSISA, ICAR RCER, Patna, March 21 to 22, 2011.
- Dr. Janardan Jee. 3 Hindi Karyashalas, ICAR-RCER, Patna, April, September and November 2010.

Abroad

- Dr. K. M. Singh, International Consultations Workshop on Market-Oriented Agricultural Extension, Bangkok, Thailand, May 11 to 13, 2010.

New Entrants, Selection, Promotion, Transfer and Retirements

New entrants

- Dr. Prem Kumar Sundram joined as Scientist (Farm Machinery and power) w.e.f. 23.04.2010.
- Dr. J.J. Gupta Principal Scientist (Animal Nutrition), Joined on 03.06. 2010.
- Sri Ashok Kumar, joined as a Technical Assistant, RCM, Darbhanga.
- Sri Rajesh Kumar Rai, joined as a Assistant, KVK, Buxar on 15.06.2010.

- Shri Rajesh Kumar Rai, joined as Driver KVK, Buxar w.e.f. 12.08.2010.
- Shri Afroz Sultan, joined as Programme assistant (Lab. Tech.) KVK, Buxar w.e.f. 13.08.2010.
- Shri Sarfaraz Ahmad Khan, joined as Driver KVK, Buxar w.e.f. 16.08.2010.
- Dr. Ramkewal, joined as SMS (Plant Protection) at KVK, Buxar w.e.f. 02.09.2010.
- Shri Sarfaraj Ahmad, joined as Programme assistant (Computer) KVK, Buxar w.e.f. 08.09.2010.
- Shri Md. Irfan Alam, joined as Jr. Steno KVK, Buxar w.e.f. 05.10.2010.
- Dr. U. R. Sangle, joined as Sr. Scientist (Plant Pathology) w.e.f. 31.12.2010.
- Dr. B. P. Bhatt, joined as Director on 01.01.2011.
- Dr. Jaipal Singh Choudhary, joined as Scientist (Entomology) w.e.f. 10.01.2011.
- Sh. Amrendra Kumar, T-3 Joined on 13th January, 2011.
- Dr. Shankar Dayal, joined as Sr. Scientist (Animal Genetics & Breeding) w.e.f. 15.03.2011.
- Dr. Binod Kumar Choudhary, joined as Scientist (Fish and Fishery Science) w.e.f. 21.03.2011.
- Shri. U.K. Saxena, joined as FAO w.e.f. 28.03.2011.

Selection

- Dr. T. K. Srivastava joined as Principal Scientist (Agronomy) on 20-05-2009 at DCR, ICAR RCER, Patna.
- Dr. P.K. Sundaram, Scientist (FMPE), joined this Institute on 23.04.2010.

Promotion

- Dr J.P. Sharma was promoted to Principal Scientist (Plant Pathology) w.e.f. .01.07.2003.
- Sri. P.C. Coudhary, Assisnat has been promoted to the post of Assistant Administrative Officer.
- Shri Fulgence Toppo, Assistant has been promoted to the post of Assistant Administrative Officer w.e.f. 03.11.2010.
- Smt. Nilmani Dorothy Barla, P.A. has been promoted to the post of Private Secretary w.e.f. 03.11.2010.
- Smt. Gyanmala Pradhan, Senior Clerk has been promoted to the post of Assistant w.e.f. 20. 11.2010
- Shri. R.S. Paswan, Sr. Clerk has been promoted to the post of assistant.
- Smt. Sangeeta Chakraborty, Senior Clerk has been promoted to the post of assistant.
- Smt. Prabha Devi, Senior Clerk has been promoted to the post of assistant.
- Shri. Bipin Kumar Mishra, SSS has been promoted to the post of T1 (Lab. Tech.)

Transfer (Out side)

- Dr. B. Saha, Pr. Scientist (Soil) transferred on 31.07.2010 from this Institute to NIRJAFT, Kolkata.

Dr. Ranvir Singh, Principal Scientist (Hort.) has been transfer Education Division, ICAR New Delhi w.e.f. 31.07.2010.

Shri A. R. Mesram, LDC has been transfer NISSLP, Nagpur w.e.f 01.11.2010

Shri Rajesh Kumar Rai, Assistant, KVK, Buxar has been transfer IIVR, Varanasi w.e.f 22.02.2011

Smt Anima Prabha, T4- Hindi Translator has been transfer ICAR- RCER, RC Ranchi w.e.f 23.02.2011

Shri Khokan Paul, Personal Assistant has been transfer NRC on YAK, Dhirang w.e.f 01.03.2011

Shri Mithlesh Kumar, FAO has been transfer NDRI, Karnal, Haryana w.e.f 29.03.2011.

Retirements

Dr. M.A. Khan, Director, w.e.f. 31.12.2010

Dr. B.P.S. Yadav, Principal Scientist, w.e.f. 28.02.2011

Resignation

Dr. Sudhir Kumar Singh, SMS, KVK, Buxar resigned on 21.08.2010.

Shri Md. Irfan Alam, Jr. Steno, KVK, Buxar resigned on 27.12.2010.

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On-going Research Projects

In House

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
ICAR-RCER, Research Centre, Ranchi					
1	ICAR-RCER/HARP/2001/03	Plant genetic resource and improvement fruit and ornamental crops	Bikash Das B.R. Jana S. Kumar	2001	March 2007 Ext. continued
2	ICAR-RCER/HARP/2006/33	Evaluation of Advance breeding lines and maintenance breeding in Solanaceous and Cucurbitaceous vegetable crops	A.K. Singh R.S. Pan J.P. Sharma P. Bhavana	2006	2012
3	ICAR-RCER/HARP/2006/34	Management of plant genetic resources and improvement of leafy and underutilized vegetable crops	R.S. Pan A.K. Singh S. Kumar J.P. Sharma Bikash Das	2006	2011
4	ICAR-RCER/HARP/2008/50	Gravity subsurface pipeline fertigation for cucurbits in sandy loam soils of eastern plateau region	S.S. Mali Ranvir Singh M.K. Meena	2009	2012
5	ICAR-RCER/HARP/2008/56	Development of guava + pineapple based multistoried cropping system under irrigated conditions of eastern region plateau region.	B.R. Jana Bikash Das M.K. Meena	Jul. '08	Jun. '11
6	ICAR-RCER/RC Ranchi/2009/73	Evaluation of substrates & assessment of water requirement for commercial production of oyster mushroom	J.P. Sharma S.S. Mali	2009	2012
7	ICAR-RCER/RC Ranchi/2010/83	Genetics of bacterial wilt resistance in brinjal.	P. Bhavana A. K. Singh J. P. Sharma	2010	2014
8	ICAR-RCER/RC Ranchi/2010/86	Standardization of inter stock for induction of dwarfing in vigorous mango cultivars growing under eastern under eastern plateau and hill conditions.	Bikash Das B. R. Jana	Jul. '10	Jul. '12
9	ICAR-RCER/RC Ranchi/2010/87	Process development for production of dried products from selected fruits and vegetables.	K. Thakur R. Jana V. K. Gupta	Jul. '10	Dec. '12

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
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Division of Land and Water Management, Patna

10	ICAR-RCER/LWEERP/2008/55	Nutrient management in rice-lentil-cropping system.	A.K.Singh (Agronomy) M.K.Meena R.C.Bharti	Jul.'08	May '11
11	ICAR-RCER/LWEERP/2008/58	Design and development of a low pressure sprinkling nozzle.	A. Rahman A.K.Singh A. Upadhyaya	Aug.'08	Jul.'12
12	ICAR-RCER/LWEERP/2008/59	Characterization and classification of ground water quality of some parts of Maner block of Patna, of Bihar.	L.K. Prasad M.K.Meena Adlul Islam Ail.K.Singh	Jul.'08	Jul.'11
13	ICAR-RCER/LWEERP/2008/60	Enhancing and sustaining the land and water productivity through multiple uses of water. Assessment of land water productivity under multiple water use system in cannal command ii) Characterization of soil fertility and water quality under multiple use system iii) Monoculture and polyculture of high value shell fish under multiple water use systems	M.A.Khan Abdul Haris A. Upadhyaya Ujjwal Kumar M.K.Meena P.M.Sheery D.K.Kaushal A.Day	Jul.'08	Jun.'12
14	ICAR-RCER/LWEERP/2008/66	Assessment of soil quality in different agro eco system of South Bihar	K.Rajan Sanjeev Kr	Mar.'09	Mar.'12
15	ICAR-RCER/DLWM/2008/74	Development of drip irrigation practices in bhindi-potato-mentha system	S.K.Singh	Jul.'09	Jun.'12
16	ICAR-RCER/DLWM/2009/81	Formulation, development and assessment of pollen substitute meeting the nutritional needs of Indian honeybees (<i>Apis mellifera</i>)	Janardan Jee Md.Idris	Oct.'09	Sep.'10
17	ICAR-RCER/DLWM/2009/82	Performance evaluation of water users association in Bihar	A.Upadhyaya Abhay.Kumar	Jan.'10	Jun.'11

Division of Crop Research, Patna

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
18	ICAR-RCER/LWEERP/2007/41	Survey and surveillance of insect pest of rice and wheat cropping system of Patna district of Bihar	Mohd. Idris	2007	2008
19	ICAR-RCER/LWEERP/2008/49	Studies on irrigation and nutrient requirement of diversified cropping system in irrigated eco-system of Central Bihar.	R.D. Singh Shivani L.K. Prasad	Jul.'08	Jun.'13
20	ICAR-RCER /LWEERP/2008/52	Bionomics and integrated pest management of major crops of eastern India.	Md. Idris Janardan Jee Sanjeev Kr	Jul.'08	Jun.'11
21	ICAR-RCER/LWEERP/2008/53	Performance of transplanted maize under varying age of seedlings and method of nursery raising.	Sanjeev Kr M.K.Meena R.Elanchizian	Oct.'08	Jun.'11

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
22	ICAR-RCER/IWEERP/2008/62	Development of vegetable based IFS for marginal farmers for irrigated upland.	Shivani R.D.Singh K.Rajan P.K.Ray	Oct.'08	Sept.'12
23	ICAR-RCER/DCR/2009/72	Agricultural drought and flood risk assessment using satellite and meteorological indices over Eastern region of India	N. Subhash A. Abdul Haris	2009	2012
24	ICAR-RCER/DCR/2009/75	Effect of different type of organic matters on Soil Microbial Biomass Carbon (SMBC) on rice wheat system	Chunchun Kr T.K.Srivastava K.Rajan	Jun.'09	Jun.'12
25	ICAR-RCER/DCR/2009/80	Resource conservation ,soil health and carbon sequestration in relation to tillage and nutrient management in organic farming system	T.K.Srivastava A.R.Khan Chunchun Kr K.Rajan	Apr.'10	Oct.'13
26	ICAR-RCER/DCR/2010/84	Management of abiotic stress in rice through biotechnological approaches. a) Management of submergence tolerance through biotechnological approaches in rice grown in lowland ecosystem. b) Genetic variability analysis and development of mapping population for drought tolerance in rice.	R. lanchezhian Santosh Kr Chunchun Kr Sivani Santosh Kr R. lanchezhian Chunchun Kr S. S. Singh	Jul.'10	Jul.'14
27	ICAR-RCER/DCR/2010/85	Eco-biology and management of Rodent fauna of rice-wheat cropping system.	Md. Idris	Jul.'10	Jun.'13

Division of Livestock and Fishery Management, Patna

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
28	ICAR-RCER/LFIMP/2008/47	Improving the productivity of Black Bengal Goats by Selective Breeding	P.C. Chandran S.J. Pandian P.K. Ray	2008	2011
29	ICAR-RCER/LFIMP/2008/51	Formulation of poultry broiler and goat feed using Makhana by-products.	Dey BPS Yadav Janardan Jee P.K.Rai	Sept.'08	Aug.'10
30	ICAR-RCER/LFIMP/2008/54	Studies on reproductive diseases in cattle under field condition in Bihar.	S.J. Pandian P.K.Roy P.C.Chandran Manoj Kumar	Jul.'08	Jun.'10
31	ICAR-RCER/LFIMP/2008/64	Enhancement of land productivity through aquaculture based integrated farming system.	A.K. Jain P.K.Ray Janardan Jee N.Chandra	Feb.'09	Jan.'12
32	ICAR-RCER/LFIMP/2008/76	Peste des Petits Ruminants (PPR) and Blue Tongue (BT) in goat and sheep: Disease status in Bihar.	P.K.Ray J. Pandian S.Manoj kumar	Jun.'09	Jun.'12

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S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
33	ICAR-RCER/SEET/2008-09/69	Performance and status of SHGs in disadvantaged districts of Bihar	M.S. Meena P.K. Thakur Abhay Kumar Ujjwal Kumar	2008	2011
34	ICAR-RCER/SEET/2009-10/77	Training need assessment of farmers and field functionaries in different agro-climatic zones of Bihar	Kumar M.S. Meena U. Kumar K.M. Singh P.K. Thakur	Jul.'09	Jun.'12
35	ICAR-RCER/SEET/2009-10/78	Constraints and issues of water management in canal and tube well operated areas in Bihar	U. Kumar A. Kumar M.S. Meena K.M. Singh N. Chandra	Oct.'09	Sept.'12
36	ICAR-RCER/SEET/09-10/79	Value chain studies of selected commodities in case of milk and vegetable in Bihar	K.M. Singh N. Chandra M.S. Meena R.C. Bharti A. Kumar	Jan.'10	Dec.'12

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S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
37	ICAR-RCER/RCM/2008/65	Study on genetic diversity in Makhana	Lokendra Kr V.K. Gupta	Apr.'09	Mar.'11

Externally Funded Projects

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
1	ICAR-RCER/ICCW/2004/2	ICAR Network Project on climate change 'Impact, Adaptation and vulnerability of Indian Agriculture to climate change'	A Haris A Islam R. Elanchizian	2004	2012
2.	ICAR-RCER/ACIARFP/2006/5	Water harvesting and better cropping systems for the benefit of small farmers in watersheds of the East India plateau. (Australian Centre for International Agricultural Research funded Project).	S. Kumar S.S. Mali	1 Apr.'06	
3.	ICAR-RCER/Ext.Funded/NAIP/2008/8	Developing sustainable farming system models for prioritized micro watersheds in rainfed areas of Jharkhand	R.S. Pan B.R. Jana	2007-08	2012
4.	ICAR-RCER/HARP/BCKV/2008-09/9	NFBSRA funded project on "Epidemiology and forewarning system of downy mildew disease of cucurbits to develop appropriate IPM strategy"	S. Kumar (CCPI, HARP)	2008	2013
5.	ICAR-RCER/NAIP/2008-09/11	Sustainable livelihood improvement through need based integrated farming system Model in disadvantaged Districts of Bihar.	M.A. Khan P.K. Thakur B.K. Jha R.S. Sharma M.K. Jha R.P. Rai	2008	2012

S. No.	Project Code	Project Title	PI & Co-PI	Year of start	Year of completion
6.	ICAR-RCER/EFP/RCR/2008/14	Intensification of research on bael with special reference to medicinal value – funded by National Medicinal Plant Board.	B.R. Jana	2008	2011
7.	ICAR-RCER/EFP/LWM/2008/16	Scaling up of Water Productivity in agriculture for livelihoods through teaching-cum-demonstration, training of trainers and farmers	R.K. Batta A.K. Singh S.K. Singh K. Rajan Adlul Islam	Nov.'08	2001-12
8.	ICAR-RCER/EFP/RIU-DFID/18	Promoting sustainable livelihood development –(P 1064 Rojiroti)	M.A.Khan, S.S.Singh, Er.A.K. Singh U. Kumar	Nov.'08	Jun.'11
9.	ICAR-RCER/EFP/NAIP/2009/19	Modeling the performance of a new major cropping system in Eastern India in the light of projected climate change. (NAIP)	S.S. Singh N. Subash R.C. Bharti	Jan.'09	Mar.'12
10.	ICAR-RCER/EFP/2009/20	Capacity building of farmer's and field functionaries for scaling up of water productivity	M.S. Meena Abhay Kumar Ujjawal Kumar	2008	2012
11.	ICAR-RCER/EFP/RCR/2009/21	Development of Ultra-High Density Orcharding in Guava under Jharkhand Conditions	Bikash Das S.S. Mali B.R.Jana	2008	2011
12.	ICAR-RCER/EFP/CSISA/ 2009-10/22	Crop and resource management practices for sustainable future cereal-based systems.	M. A. Khan S. S. Singh A. R. Khan Md. Idris Er.A.K. Singh	Jul.'10	Jun.'12
13.	ICAR-RCER/E.F/CSISA/ 2009-10/23	Tracking change in rural poverty in village and household economics in south Asia.	K. M. Singh M.S.Meena Abhay Kumar Chunchun Kr. A.K. Jha R.K.P.Singh	2010	2014
14.	ICAR-RCER/EFP/CSISA/ 2009-10/24	Delivery & rolling out of conservation agriculture based RCTs – CSISA-I	A. R. Khan S. S. Singh T.K.Srivastava R.C.Bharti Ujjwal Kumar	2010	2012

Distinguish Visitors



Fig. 120. Foundation stone laying ceremony of farmers' hostel at ICAR-RCER, Patna by Secretary DARE and DG ICAR, Dr. S. Ayyappan



Fig. 121. Inauguration of Brain Storming Session on 2nd green revolution by Hon'ble Chief Minister, Govt. of Bihar, Shri Nitish Kumar and other dignitaries at ICAR-RCER, Patna



Fig. 122. Release of the publication of the institute by Hon'ble Chief Minister, Govt. of Bihar, Shri Nitish Kumar and other dignitaries at ICAR-RCER, Patna



Fig. 123. Sri M.O.H. Farook, His Excellency Governor of Jharkhand visiting to the experimental farm of the complex at Ranchi



Fig. 124. Dr. A. K. Singh, DDG, NRM discussing about on-going trials with the scientists at Ranchi



Fig. 125. Sri P.K. Basu, Secretary Agriculture and Cooperation, Govt. of India discussing about on-going experiments with the scientists at Ranchi

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Sh. Rajesh Kumar Rai, Driver
Sh. Sarfaraz Ahmad Khan, Driver

