

ACHIEVEMENT

- **Soils, land capability, classes and various land forms in Eastern Region:** Thematic maps of soil and land capability classification of the eastern region were developed in a GIS environment and Google maps were processed to identify different landforms of flood plains like *tal*, *chaur*, *maun* and *diaras*.
- **Development of web-enabled multimedia based crop information system:**
 - a) A data base has been designed for the storage of data regarding selected crops using MS-Access and MySQL software packages for developing user interactive web enabled multi-media based Crop Information System.
 - b) A web enabled crop information system has been developed for package of practices of cereal crops including rice, wheat and maize using PHP, Dreamweaver and MySQL software's.
 - c) A Web Enabled Multimedia based Crop Information System on package of practices for rice, what, maize, pigeon pea, lentil, gram and green have been developed.
- **Effect of Tiller and water Management practices on soil & crop under Rice-Wheat system of South Bihar:**
 - a) Deep summer ploughing done after three years was found better than alternate year and beneficial effect of Deep summer ploughing can be achieved especially under limited water supply.
 - b) Under evaluation of water management practices for rice-wheat cropping of south Bihar, it was observed that deep summer ploughing (DSP) treatments in rice were significantly superior to non-DSP treatments. The residual effect of DSP on subsequent wheat indicated that DSP every year produced higher grain yield of wheat over conventional method.
- **Comparative performance of system Rice – Intensification under different plant geometry and water regimes with conventional rice management:** Studies on system of Rice Intensification (SRI) technique in rice indicate that maximum grain and straw yields were obtained when paddy was transplanted at 25 x 25 cm spacing and 6 cm irrigation was applied 3 days after disappearance of ponded water.
- **Alternative Land Use System (Agri – Silvi Postural) for rain fed in Bihar:** Subabul when intercropped with guinea grass+ cowpea/field pea/cowpea during Kharif, rabi and summer respectively yielded maximum with a fodder and fuel wood yield of 44 and 4.8 t/ha/year respectively and 2 t/ha of pod yield of green field pea for human consumption.
- **Strategies for enhancing land and water productivity through multiple uses of water:** The economic analysis of 2 years data on different systems of multiple use of water indicates that integrating fish in rice-wheat system gave net income of Rs. 29,694/ha, 6% higher over the traditional rice-wheat system yielding Rs. 27,965/ha per year. Under seasonally waterlogged areas up to 1m depth, a system of fish trenches-cum-raised beds based horticulture + fish system generated a net income of Rs.80,951/ha/year, 189 per cent higher over traditional rice-wheat system. Under seepage-fed secondary reservoir supplemented with ground water, a system of horticulture on bunds + fish + duckery yielded net returns of Rs.1,32,590/ha/year, 374 per cent higher over traditional rice-wheat system. The results indicate tremendous increase in water

productivity by integrating fish + horticulture + duckery in permanently or seasonally waterlogged areas.

- **Low cost pressurized irrigation system:**

- a) The optimum pressure found for operating LEWA (Low Energy Water Application) device was in the range of 0.4 – 0.6 kg/cm². Christiansen Uniformity (CU) values for this range of operating pressure was found between 55 to 70 per cent (Row-to-row and nozzle - 6 m).
- b) The modified LEWA device has been tested and compared with a single nozzle sprinkler in the field on rice and wheat for water and energy saving. It has been observed that there is saving of over 50 per cent of water and over 60 per cent of energy (diesel) in case of rice while in case of wheat the water saving was 15 per cent against sprinkler, 50 per cent against surface methods of irrigation, and around 50 per cent of energy saved against sprinkler as well as surface method of irrigation.

- **Development of Decision Support System for design and layout of pressurized irrigation system for different crops:**

- a) A model for calculating all input materials, capacity of motor pump in horse power and how to minimize the capacity of motor pump of drip irrigation system has been developed in MS-EXCEL.
- b) A Graphic User Interface Decision Support System in Visual Basic was developed for design and layout of Pressurized Irrigation System to facilitate techno-economic decisions.

- **Physiological management for improvement of abiotic stress Tolerance in Rice:** Twelve HYVs of rice were grown in drought stress conditions and their crop growth characteristics were analyzed at different growth interval. Gas exchange parameters, proline content and protein profiles were measured in all the twelve rice varieties under drought stress conditions.

- **Development of farmers friendly Decision Support Tools, for Crop Planning and optimizing crop yield:** A Decision support tool was developed in Hindi and English employing Visual Basic platform. This model is capable of helping farmers in decision making about selection of crop and crop sequences considering three important indicators i.e. Benefit-cost ratio, land productivity and water productivity.

- **Development of fodder production strategies for rain fed and irrigated conditions of Bihar:**

- a) Fodder crops survived well with the help of rainfall. Rainfall significantly increased the green biomass and dry matter yields.
- b) Field experiments for round the year fodder production under rainfed and irrigated conditions were undertaken. Average fodder intake on fresh basis was 1.25 kg berseem / head / day, 0.885 kg mustard / head / day, 1.18 kg oat / head / day and 0.182 kg hybrid napier / head / day in goat. Yield of mustard fodder was 5.72 t /ha and yield of oat was 21.05 t / ha of land organically.

- **Setting of model organic form (development of organic farming Package of Practices):** Under organic farming system studies, it was observed that application of different organic sources helped to significantly increase the grain yield of rice over control. Incorporation of Vermicompost @ 6.66 t/ha applied in split doses, 50 % as basal and remaining half dose top dressed in two equal splits, at maximum tillering and panicle initiation produced 2.87 t/ha grain yield of rice, 137 % higher than control. Under organic farm fish based horticulture system and

polyculture of carp fishes were carried out by stocking 2-5 cm size fry of catla, silver carp, grass carp, mrigal, common carp and rohu in ratio of 1.5:1, 5:2, 0:2, 0:1, 1.5:1.5 at the rate of 20,000 fingerlings/ha.

- **Hybrid seed production of maize, variety Vivek QPM – 9:** Hybrid seed production of Vivek QPM – 9 on commercial scale can be undertaken in eastern region of Bihar after evaluation of optimum date of sowing for both the parents.
- **Survey and Surveillance of insect pest of rice and wheat cropping system of Patna District of Bihar:**
 - a) Twenty eight insect pests were identified in paddy crop. Flowering and milky stages attract more insects than vegetative and maturity. Intensity of insects during humid and rainy climate was recorded higher than sunny days.
 - b) In rice, gundhi bug population was recorded above ETL (2.7 bugs/hill) in Satyam variety in 1st week of September. The mealy bug (*Brevennia rehi*) infestation was observed at Sabajpura farm in pockets at the tune of 10-15%.
 - c) Survey of insect pests was carried out in different cultivars grown at CR farm and Sabajpura farm at 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 varieties trial plots at CR farm and Sabajpura farm respectively. The intensity of damage was recorded at the tune of 6.77% hill in BPT-5204 and 8.67% in aerobic rice varieties trial. The severity of mealy bug (*Brevennia rehi*) infestation was observed at vegetative stage in MTU-7029 at Sabajpura farm at the tune of 25.9%. The incidence of rice seed bug (*Leptocorisa oratorius*) was observed above ETL (1-2 bugs/hill) in Satyam (Avg.1.5bugs /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.
 - d) Two new Coleopteran beetles, *Haplochrus fasciatus* Fabricius, (family: Melyridae) and *Gonocephalum* sp (family: Tenebrionidae) were identified. *Haplochrus 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) has also been 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.
- **Evaluation of IPM Practices for hopper pest of Rice Crop under local condition:** A Study was carried out on evaluation of IPM practices to find environmentally safer, economically viable and effective technique to manage hopper pests. It is observed that like previous year, this year also long dry spell was experienced in July and August resulted in high temperature and low humidity. As 4-5 days continue rainfall and high humidity require for initiation of breeding activity in hoppers. Resultant, the brown plant hopper (*Nilaparvata lugens*) and white backed plant hopper (*Sogatella furcifera*) was not recorded during crop season in experimental plots. However, the incidence of green leafhopper (*Nephotettix virescens*) was recorded at milking stage of the crop in low number ranged 0.2-0.4 hopper/ hill and 2-3, hopper sweep in sweep net.

- **Characterization and classification of ground water quality of some parts of Maner Block of Patna District in Bihar:**

- a) Preliminary studies on characterization and classification of ground water quality of various parts of Maner block of Patna district indicates that ground water of shallow depth have more arsenic and iron compared to deeper depths.
- b) Characterization and classification of ground water quality in Maner block of Patna district showed that arsenic content increased from 1.65 ppm to 2.20 ppm with the depth of the soil and accumulated from 2.0 ppm to 5.0 ppm in vegetable and cereal crops. Spatial thematic maps were also developed for arsenic and iron distribution for this area.
- c) Under characterization and classification of ground water quality in various parts of Maner block to 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). Arsenic content was also estimated in congress grass, which was found widely as a major weed in the study area.
- d) 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 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.

- **Design and development of Low pressure sprinkling nozzles;**

- a) The optimum pressure found for operating LEWA (Low Energy Water Application) device was in the range of 0.4 – 0.6 kg/cm². Christiansen Uniformity (CU) values for this range of operating pressure was found between 55 to 70 per cent (Row-to-row and nozzle - 6 m).
- b) The modified LEWA device has been tested and compared with a single nozzle sprinkler in the field on rice and wheat for water and energy saving. It has been observed that there is saving of over 50 per cent of water and over 60 per cent of energy (diesel) in case of rice while in case of wheat the water saving was 15 per cent against sprinkler, 50 per cent against surface methods of irrigation, and around 50 per cent of energy saved against sprinkler as well as surface method of irrigation.
- c) Comparison of different multi-arm low sprinkling nozzle showed that the eight-arm prototype is the most appropriate and can be operated below 1.0 kg/cm² pressure with considerable throw distance and radial water distribution.
- d) 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.

- **Nutrient Management in Rice Lentil Cropping System:**
 - a) In rice-lentil cropping system highest rice yield of 8.60 t/ha was recorded under sulphur application @ 20 kg/ha. Highest rice yield of 8.53 t/ha was recorded due to application of zinc @ 6.0 kg/ha. The interaction effect of S and Zn was not noticed.
 - b) Nutrient management in rice- lentil cropping system showed maximum lentil seed yield of 963.8 kg/ha with 40 kg sulphur, whereas in rice, the minimum 6080 kg/ha and maximum 6602 kg/ha grain yield was obtained with 0 kg sulphur and 6 kg zinc, respectively
 - c) In case of rice maximum plant height 129.4 cm was recorded with application Zn @6kg whereas minimum was with S1 121.5 cm. Maximum leaf area index (7.855) was obtained with Zn @6kg and minimum LAI (6.35). Maximum panicle/M² was recorded with Zn @6kg (311.4). Maximum grains per panicle, was recorded with Zn @6kg (207.7). Minimum rice yield of 7.09 t/ha was recorded with no application of zinc and sulphur whereas corresponding maximum rice yield (7.72 t/ha) was recorded with combined application of 30 kg sulphur and 6 kg zinc. Whereas in case of lentil maximum and minimum plant height was recorded as 33.8 cm and 26.9.8 cm, respectively in case of 5 kg zinc and 0 kg level of zinc at harvest. Pod/plant were recorded maximum 51.7 in case of 40 kg of sulphur application and minimum value (38.9) with no sulphur treatment. S₄Zn₄ treatment combination (40 kg sulphur and 5 kg zinc) produces 1097.5 kg/ha lentil seeds. S₁Zn₁ treatment combination recorded minimum lentil seed yield (743 .4 kg/ha).

- **Water Saving Technology – FPARP Project Farmers Participatory Action Research Programme:** Under the Farmers Participatory Action Research Program for Demonstration of Water Harvesting Technology, demonstration on direct rainfall collection *Doba* (small water storage tanks) for horticulture establishment in uplands of eastern plateau region was given in 46 farmers fields. Six water saving technologies were demonstrated to 51 farmers in 28.5 acre land in Amarapura and Nisarpura village under Patna Main Canal in Sone command area.

- **Development of farmer family decision support tool for selection of beneficial integrated farming:** A Decision Support Tool (DST) developed is capable of facilitating farmers in selection of Integrated Farming System components keeping in view three performance indicators i.e. Benefit-Cost ratio, land productivity, and water productivity

- **Water Saving Technology under FPARP:** Four Water Saving Technologies under Farmers Participatory Action Research Programme where conducted for (a) Software demonstration for promotion of conjunctive use in canal command, (b) Zero tillage in wheat and surface seeding in lentil, (c) Balance use of nutrients, (d) Low Energy Water Application

- **Assessment of soil quality in different Agro – ecosystem of South Bihar;**
 - a) The soil quality and land use assessment in south Bihar (agro-ecological zone no. 9) shows that there are six major land use system (rice-wheat, maize-potato, red gram, sugarcane, mango orchards and agro-forestry). High soil compaction was observed in rice-wheat system. Soils of mango orchard contain highest organic carbon stock followed by agro-forestry, whereas lowest carbon stock is observed in sugarcane growing soil.
 - b) Relative soil quality index of four categories such as best, good, moderate and poor were established. 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.

- **Characterization of soil fertility and water quality under multiple use system:** Temporal water quality assessment under multiple uses of water indicated inverse relationship between oxygen saturation and temperature. Towards the end of the season nutrient concentration of nitrate, Phosphate and Potassium, respectively in all the water bodies.
- **Development of Drip irrigation practices in QKRA – Potato – Mentha System:** 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.
- **Formulation Development and Assessment of Pollen Substitute meeting the nutritional needs of Honey Bees (*Apis Mellifera*):**
 - a) Five treatments of pollen substitute made of local available food material (Wheat, Gram, Soya, Makhana, & Potato flours) in different combination were tried as artificial diet for Honey Bees (*Apis mellifera*). Diet made of Soya flour combination was most preferred over other combinations. A small experimental Bee keeping unit with four Bee boxes containing 8 frames each established in the Complex premises. Bee colony with healthy Queen Bee and workers introduced and acclimatized. Four treatments with one control (only sugar syrup) were tried for assessing the suitability of artificial diet of the honey bee (*Apis mellifera*). Pollen Substitute Combinations with Fatless soybean flour, Gram flour, Sorghum flour, Makhana flour and Potato flour and skimmed milk powder, defatted milk, yeast dried, honey and Sugar were prepared and given in the different proportion. September & October month is period of pollen scarcity. Honey Bee preferred the Soya bear flour over the other combination. Gur (Jaggery) is the most preferred rector substitute for the bees. More brood development was reported from soybean flour – sugar feeding colonies. Severe winter December 2009 and January 2010 was critical for survival of the bees, over 30% population lost due to continued low temperature.
 - b) The new five diets treatments 100g each were provided at weekly interval. Observations recorded for Brood area, Pollen stores, Honey stores and Bee population. Observation should that Gur (Jaggery) was the most preferred nectar substitute for the bees. Experimentation in Bee keeping unit with four Bee boxes containing 8 frames each continued in the Complex premises for the Formulation, Development and Assessment of a Pollen Substitute meeting the nutritional needs of Honey Bees (*Apis mellifera*).
- **Improving Livelihood security in Salt affected water sheds of Muzaffarpur and Sheohar District of Bihar:**
 - a) Socio-economic and bio-physical survey of Muzaffarpur and Sheohar districts of Bihar revealed that these areas are dominated by small and marginal farmers with rice based cropping system, with 25-50 per cent area being salt affected.
 - b) Muzafferpur 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). The area under mustard and vegetables got reduced in these salt affected areas due 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.

- **Scaling up of water productivity in Agriculture for Livelihood through teaching cum demonstration:** In vegetable-based-cropping system, crop yield of 5.0, 10.0 and 8 t/ha was recorded in okra, cauli-flower and chillies respectively with drip irrigation which was higher by 40, 32 and 28% over the surface irrigation. Water use efficiency was recorded to be 32, 22 and 27 kg/ha/mm, while water productivity under the drip irrigation system was recorded to be Rs.16, 22 and 108/m³ in okra, cauliflower and chillies respectively
- **Evaluation of Faba bean (*Vicia faba* L.):**
 - a) 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. 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 Sitamadhi districts of North Bihar.
 - b) Perusal of data 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. 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 of 58.9. In one of the accession (BP-14), four pods were found which was a unique character. In general, one to two pods are found in faba bean. Likewise, pod formation took place near the collar region in BP-23 whereas, pod formation in rest of the material was observed at 5-10 cm above the ground level.
- **Performance evaluation of water users association in Bihar:** Performance of Water users Associations have been studied and evaluated based on certain indicators. These indicators are helpful in pointing out the reasons of success or failure of irrigation system and all associated stakeholders. Comparative study shows the scope of improvement as well significant progress made in release, allocation, distribution and utilization of canal water
- For rice, Deep Summer Ploughing (DSP) once in 3 years was found most productive with significantly higher yield over non - DSP and at par closely followed by DSP once in 4 years. For wheat all DSP treatments have been found significantly superior for grain yield over non DSP. DSP every year produced highest grain yield.
- Zero Tillage (ZT) in wheat performed significantly superior over conventional tillage. In tillage combination of puddled transplanted rice in kharif and ZT wheat in Rabi, DSP once in 3 year has been found best to restore soil health & consistent higher yield.

- Seventeen HYVs of rice were grown in drought stress conditions and their crop growth and gas exchange characteristics were analyzed for identification of physiological traits. Photosynthesis rate, leaf area and grain wt. declined with more at stress during Panicle initiation and proline content was more with stress induction. TSS & Starch was found to be more in tolerant varieties with lesser decline in grain weight.
- Four rice varieties were grown under submergence stress and effect of anti GA on growth and physiological characters during submergence stress was analyzed. 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. It is also observed that proline, TSS & starch in the stem reserves may play a crucial role in the recovery process after submergence stress.
- Rice genotypes were screened for submergence stress imposed for 15 days during seedling establishment stage under simulated conditions and field conditions. Hybridization was made between varieties FR13A and IR64 and the F1 seeds collected. Molecular profiling of parents and F1 was done using molecular markers (SSR).
- Rice germplasm were screened for drought stress imposed at vegetative and reproductive stage for 13 and 17 days, respectively. Parents viz. IR55419-04 and IR64 were reared, pair crossing was made and the F1 seeds were collected. Molecular profiling of parents and F1 was attempted with microsatellite (SSR) markers.
- Under CSISA platform research, four Scenarios of cropping (Business as usual, Increasing food demand, Degrading natural resources, energy and labor crises and Food & nutritional security, Intensification and Diversification, farm profitability) with different CA practices, have been conducted in large plot size (1,900 m² each). Crop rotation of rice – wheat - cow pea Rice under zero till with residue has been found best productive and profitable system.
- Two IFS models a) 1 Acre – for irrigated uplands and b) 2 Acre – for irrigated lowland and upland situations have been developed for small and marginal farmers of eastern region. Under 1 acre IFS model enterprises like crop/horticulture/goat/poultry/mushroom /vermicompost have been integrated which has resulted in an annual net income of Rs. 1,35,418/yr. In addition to that 1.5 t vermicompost and 3.2 t of goat manure/yr. were also produced and were recycled within the system.
- Under 2 acre IFS model, enterprises enterprises like crop/horticulture/cattle (3)/ fishery/ duckery/ vermicompost have been integrated which has resulted in an annual net income of Rs.1,80,805/yr. In addition to that 2.2 t vermicompost and 22 t FYM/yr. were also produced and were recycled within the system.
- 1 acre and 2 acre IFS models have resulted in 2.5 times increase in the income over the conventional method of farming. The technology was accepted by Govt. of Bihar and 534 blocks of Bihar were selected for development of IFS modules and govt. is giving a subsidy of Rs. 10,000/- for adoption of at least one enterprise with crop.
- Transplanting of maize seedlings had solved the problem of low yields of winter maize due to late sowing of maize as harvesting of rice is delayed in the eastern India (November- December). 5 weeks older seedlings raised with sand culture and raised bed method were transplanted in the main field which had produced an yield of 66.59 and 63.89q/ha, respectively during rabi season

without any loss in yield over direct sown maize (mid October). Transplanting of maize seedlings had also curtailed the crop period by 20-25 days with saving of irrigation too.

- SMBC built up by FYM & GM application was found significant in rice-wheat cropping system. The highest paddy grain yield 7.48 ton/ha was recorded in green manure incorporation of *Sesbania* after 40 days followed by application of FYM@ 20 ton/ha. In subsequent wheat crop period maximum increase in microbial biomass C was observed with crop residue incorporation followed by application of FYM@ 20 ton/ha. During summer fallow the maximum increase in microbial biomass C over control occurred with FYM application @20 ton/ha. In terms of cropping season averages, in all treatments microbial biomass C increased from rice period to summer fallow through wheat period, excepting *Sesbania* treatment where a slight decrease was noticed during in wheat period.
- Boron application enhanced the seed setting in Berseem. In pot trial, boron applied @1.7 ppm has resulted in high root volume, vigorous crop, better flowering and seed setting.
- Study undertaken in Survey and Surveillance of Insect Pests of Rice-Wheat Cropping System of Patna District of Bihar revealed that low insect populations build up was observed because of high temperature and low humidity that inhibited the breeding of the hoppers in 2009 and 2010. However, in 2008 density of green leaf hopper population was recorded at rate 1.7hopper/hill in milking stage. Brown plant hopper population was recorded at the tune of 2.5 and 4.6/ hill at flowering and milky stage. Heavy infestation of ear cutting caterpillar (*Mythimna separata*) was observed at ICAR farm and Sabjpura farm to the tune of 40-60% in 2008 and 2010. Gujhia weevil (*Tanymecus indicus*) was noticed at nursery stage in 2009 and 2010. Termite (*Odontotermes* sp) infestation was observed in BPT- 5204 in 2009 and 2010.
- IPM practices for hopper insect pests of rice crop under local conditions were evaluated and it was observed that two consecutive sprays of neem oil and Beauveria within 15 days of interval suppressed the population of green leaf hopper and brown plant hopper at below injury level. Single spray with Imidacloprid insecticide also checked the hopper population effectively.
- Six rodent species – lesser bandicoot, *Bandicota bengalensis*, field mouse, *Mus booduga*, soft furred field rat, *Millardia meltada pallidior*, house rat, *Rattus rattus*, five striped squirrel, *Funambulus pennanti*, and white bellied rat, *Rattus niviventer* were collected from different cropping system. It was recorded that Bandicoot rat was predominant species (67.5%) followed by *Mus booduga* (23.5%) and *Millardia meltada* (9.0%). The bandicoot rat caused higher damage (14.73%) at maturity stage and moderate (3.86%) at vegetable stage in paddy crop. In wheat, maximum tiller damage was recorded at milking and dough stage (16.69%) followed by maturity (15.0%) and vegetable stage (11.0%). The efficacy aluminium phosphide was higher (87.7% mortality rate) followed by zinc phosphide (42.8%) and Bromadiolone (7.14%) against *B. bengalensis*.
- Analysis of extreme events indicated that rainy days increased in the winter season for different parts of the Bihar. The correlation between extreme rainfall indices during monsoon season and productivity anomaly index indicated that almost all the extreme rainfall indices contributed positively to rice productivity. The increase in maximum temperature during August and September adversely affected the rice crop by shortening the crop duration and thus by reducing the grain size, particularly in rainfed rice.
- Under OTC experiment, 25 % increased level of CO₂ has resulted increased in duration of rice and wheat and higher yield by 15% to 18%. Increased temperature by 1⁰C has reduce the yield as compared to normal condition. MTU 7029 produced higher yield with 25 % increase of CO₂. Least variability of yield has been noticed for Rajendra bhagavati and MTU 7029 under different OTC treatments and open field conditions. Swarna sub1 and MTU 7029 took more total duration under

control OTC and Rajashree and Rajendra Bhagavati took more duration under 25 % increase of CO₂ and 1 °C higher temperature conditions. Different varieties of wheat matured 3 days earlier in OTCs when compared to open field.

- Promoting sustainable livelihood development (Rojiroti) – (www.rojiroti.org), a project funded by the Research into Use Programme, a major initiative of DFID was operative in 11 districts of three states viz- Bihar, M.P. and eastern U.P. A total 4562 SHGs have been formed which cover 2300 villages and 50,880 beneficiaries in above three states. The project having major coverage area in Bihar and is particularly in Patna, Nalanda and Nawada district. More than 95% of Rojiroti SHG members are women, 76% are BPL, and 92% are members of disadvantaged groups.
- ICAR-RCER, Patna has tested KSKs (Kisan Soochana Kendra) as alternate sustainable institutional arrangement for quality information and input delivery through KSKs and its networking units Village Suchana Kendra. KSK's will be situated in peri-urban areas whereas VSK's in villages. KSK's will be source for accessing information by end-user through VSK's and also an outlet for quality agricultural inputs etc. Information to KSK's will be made available by National/State/ district/block level information hubs. All KSK's can be connected with each other whereas access to VSK's to other KSK's may be provided through their respective KSK's.

• **Strategies for enhancing land and water productivity through multiple uses of water**

(Fishery and Duckery components):

Four different systems namely i) Duck – fish farming, ii) Rice/ Wheat – fish farming, iii) Fish culture in service reservoir and iv) Fish culture in trenches were developed to increase productivity of land and water under multiple uses of water. Waterlogged areas having water stagnation 0.3 – 1.0 m were utilized for effective fish culture by further digging of the area in the form of trenches and raising a portion above highest flood level using excavated soil to cultivate vegetable or horticultural crops. Two types of fish trenches, 1) meandering type trench simulating river condition and 2) island type simulating pond conditions, were laid out. The fish yield to the tune of 1.97 t/ha was obtained by stocking fries @ 15000/ha. In service reservoir, composite fish culture along with duck farming yielded 5 - 6 t/ha of fish. Stocking of Khaki Campbell duck was done @ 300 /ha of water area. Fish culture with duck farming has beneficial effect as both are complementary to each other. A total of 43 thousand eggs were obtained per ha of water area per year in addition to 24 thousand kg fresh duck droppings as manure to the pond. Rearing of duck reduced the feed and manure cost by 25% while foraging in pond reduced the feed cost of duck by 20%.



- **Monoculture & Polyculture of prawn:** In ponds, fish trenches cum-raised bed under multiple water use system were undertaken. In monoculture, prawn yield was 610 kg/ha and survival rate was 50%. Polyculture yielded 730 kg/ha of prawn with survival rate of 69%, along with fish yield of 3321 kg/ ha. Prawns were cultured in the semi-intensive systems involving stocking of PL-20 at 4-20/m² in ponds. This adaptive research on monoculture and polyculture of scampi (*M. rosenbergii*) has paved way for its farming beyond December. The farmers and entrepreneurs will be highly benefited from the new approach of scampi farming in seasonally waterlogged areas of Bihar



- **Polyculture of carp fishes under organic farming:** The experiment was carried out by stocking 2-5 cm fries of catla, silver carp, grass carp, mrigal, common carp and rohu in ratio of 1.5:1.5:2.0:2.0:1.5: 1.5 @20,000/ha The growth studies revealed that silver carp



(*Hypophthalmichthys molitrix*), grass carp (*Cteopharyngodon idella*) catla (*Catla catla*), common carp (*Cyprinus carpio var specularis*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) attained average weight 900gm, 850gm, 450gm, 750gm, 400gm, 750gm per year and gave a production of 3263kg/ha/year.

- **Maximization of productivity of Makhana Ponds:** The productivity of Makhana based water bodies could be maximized by integrated aquaculture where yield potential of fishes ranged from 2 to 4 quintals/ha in a refuge covering 10% area of net water bodies.



- **Seed production of major carps:** Keeping in view of the constraints faced by farmers, breeding of major carps was done successfully for raising of fish seed.

- **Culture of Jayanti rohu:** Trials on the culture of Jayanti Rohu (*L. jayanti*) under polyculture systems in ponds have shown significantly higher growth of the species than that of rohu (*L. rohita*)



- **Enhancement of water productivity through multiple uses for livelihood of small holders (FPARP).** Following technologies were demonstrated:

- I. Fish culture in cages
- II. Fish culture in low land through pen culture & trenches
- III. Rice – fish culture in seasonal waterlogged areas
- IV. Multi- tier horticulture - vegetable and livestock production in fish pond system
- V. Establishing low cost eco-hatchery for raising fish seed

- The eco-hatchery operation demonstrated to farmers under FPARP lead to production of enormous spawn. This offers scope for its wider adoption in rural India. This will definitely enhance the fish seed availability *vis-à-vis* increase in fish production in Bihar.

- **Diseases in cattle**

- a) Foot-and-Mouth disease (FMD) is the most important livestock diseases followed by Hemorrhagic septicemia. Besides surra, anestrus, unexplained infertility, Degnala like disease, mastitis, nonspecific GI disorders, ecto and endo-parasitic infections etc. are also very common. Low milk yield, delayed maturity, repeat breeding, anestrus, poor veterinary services, inadequate market infrastructure for animal products, scarcity of green fodder specially during lean period (May to June and October to December), high cost of animal feeds are some of the constraints for animal production.
- b) The reproduction diseases in cattle indicated hair coat skin manifestations of worm infestation and micronutrient deficiency. The skin and hair coat changes were dull, rough, lusterless and alopecic coats in almost 90% of the animals with reproductive problems.
- c) In order to address the economic loss associated with infertility in cattle, a serological survey was conducted in Bihar for the presence of selected bacterial and viral diseases causing infertility using ELISA. Study revealed that Brucellosis, Leptospirosis, Infectious Bovine Rhinotracheitis (IBR) and Bovine Viral Diarrhoea (BVD) were prevalent in Bihar by 12.2%, 9.1%, 6.1%, and 6.2% respectively.

- **Diseases of sheep and goats:** The viral diseases of sheep and goats, Peste des Petits Ruminants (PPR) and Blue tongue (BT) have been studied for the prevalence in Bihar. The sera samples collected randomly from the small ruminants were tested by c-ELISA and the overall prevalence of PPR was found to be 36.65%.
- **Use of *Makhana* Bran as poultry feed ingredient:** *Makhana* processing by-product (bran+outer coat) was analyzed for its chemical composition which showed crude protein, carbohydrate & organic matter as 7.10, 86.64, 94.36 percents in *Makhana* bran where as corresponding value in outer coat were found as 4.75, 86.88 & 91.79 percents for its utilization in poultry and goat rations respectively. Study revealed that *Makhana* bran could be incorporated in the diet of poultry broiler up to 6% level without affecting growth and feed conversion efficiency. Dry matter intake and digestibility did not differ significantly up to 50% of replacement of rice bran.
 
- **Crop – livestock based farming system models:** Crop – livestock based farming system models were evaluated in irrigated & rainfed conditions for integration of dairy & goat species respectively. In intensified dairy based production system, 4 crossbred cows can be integrated in acre model with sparing of 40% area for fodder production. Lactation yield of crossbred cows was reported at 2200 kg.
- **Assessment of livestock water productivity:** Assessment of livestock water productivity has been initiated in Indo-Gangetic Plains, India. A baseline survey regarding resource availability, cropping pattern, livestock population & production and role of different institutions in crop-livestock-water nexus in all the villages have been studied. Assessment of livestock water productivity is being studied in the upper, middle and lower indo-gangetic plains, India. The study showed that for one litre of milk production, 800- 5000 liters of water required with variation in scale, breed etc. in Indo-Gangetic plains.
- **Value Chain Study of selected commodities – Case of milk and vegetables in Bihar:** It was observed that there were altogether 9 marketing channels with price spread ranging from zero in the shortest to 40 % in the longest marketing channel. The constraints to milk marketing experienced by milk producers were found to be costly feed, lack of capital and housing (animal shed), and problem of insurance and, conception and credit in that order. The milk retailers reported lack of capital as most important constraints followed by lack of storage and transport facility, and also unorganized market. The consumers faced two problems such as milk adulteration with water & milking of cow with injection, reducing the milk quality.
- **Development of a composite crop yield forecast system for rice and wheat in Bihar:** It was observed that the historical time series yield data fits the logistic model and auto-regressive integrated moving average model of the order 0,1,1. The step wise regression model based on weekly weather parameters and based on plant characters including farmers eye estimate about the likely crop yield, also fits the crop yield distribution. Secondly, it was found that the zone wise forecasting results better efficiency of forecasting. The composit estimate of these forecasted values (obtained using inverse of the variances of the estimates as their weights) resulted less than five percent forecast error in majority of the forecasting tests. However the forecast error exceed the limit while considering the whole Bihar for forecasting. Therefore, it is suggested to use agroclimatic zone wise forecasting by using a composit system of forecast consisting of various models. For the purpose the model parameters of logistic, ARIMA, Weather

based regression model and farmers appraisal model for rice and wheat crop yield in all the four agroclimatic zones of Bihar has been estimated.

- **Socio – economic analysis of access to farm credit in Patna and Vaishali district of Bihar:** Crop failure was found to be the most important reason for non/irregular repayment of borrowed fund, followed by low crop yield, lack of irrigation and low price of the produce. As regards constraints to borrowing expressed by respondents, it was observed that corruption, delaying tactics, non-cooperation by bankers, ignorance / illiteracy and unwillingness to borrow by farmers themselves were major constraints to borrowing. Constraints to lending in Patna (banker's perspective) were (1) borrower's enterprise is unclear, (2) borrower's intention is unclear, (3) loan – waiver scheme: the greatest hurdle in lending, (4) the project is not well prepared leading to its unviability, and (5) some borrowers are known for non-repayment (wilful defaulters). Suggestions to overcome access to credit problem in Patna were (1) bankers should be borrowers friendly i.e. they should help in making bankable projects for farmers, (2) bankers should be fair and transparent. They should not indulge in unfair practices, (3) banks should organize loan mela in villages sometimes, (4) loan-waiver scheme is not good for sincere and regular repayers. This discourages them to repay loans resulting into credit defaults, (5) farmers should be sensitized to banking, its procedures, importance of borrowing and timely repayment, adverse consequences of non-repayment, and also entrepreneurship, and (6) various formal / informal training institution can take initiative in this regard, banking personnel should also be involved in any capacity building programme for farmers.
- **Feedback assessment of agricultural training on farmers practices in Bihar:** Extent of and constraints to adoption of agricultural technologies taught in the training programmes were identified. It was observed that most of the trainee farmers felt satisfied with the delivery of almost all the training programmes. However, it was found that in order to improve the efficiency of farmers' agricultural training programmes in Bihar, the topic of farm training should be topical and need based, and the same should be organized preferably near the village site itself, before the crop season as far as possible, with more emphasis on field visits and practicals.
- **Socio-institutional parameters affecting makhana production and livelihood system of makhana:** It was revealed that cent percent makhana cultivation is done by *Sahni* community as main occupation in Darbhanga and Madhubani district. Whereas in Purnea, only 16 per cent and in Katihar only 18 percent cultivation of makhana is done by *Sahni* community. No ownership of ponds and lack of knowledge about the scientific method of makhana cultivation were ranked as first and second problem by the makhana growers of Katihar and Madhubani. Lack of scientific knowledge of makhana cultivation is top most problem realized by the farmers of Darbhanga and Purnea. Women play major role (more than male) in popping, preheating and frying during processing of makhana. Government leased out ponds/water bodies (*Jalkar*) to the Fishery Society and the society leased out to its members at generally 25% higher rate. Revenue received from members for leasing out is source of income of the society. Maintenance and renovation of water bodies is done by the members. Fishery Society helps in marketing and procurement of inputs for makhana cultivation. Leasing out by private pond owners also in practice and the lease term of private pond is generally for 3 yrs. annual rent vary from Rs 2000-Rs 3000/year/acre
- **Cost of production and input output relationship in makhana production:** It was found that makhana is produced in two different conditions. One is well managed system in which makhana is being cultivated in lowland rice fields during the months of March to September. After makhana boro/garma rice is taken up. In this system makhana is transplanted in the field after

field preparation. Makhana seedlings are collected from nearby natural water bodies. A water level of 1.5 to 2 feet is maintained in the field throughout the crop period. Farmers apply fertilizers and pesticides in this system. This type of cultivation is found in Purnea and Katihar districts. In the second situation makhana is grown in natural ponds. Makhana seedlings germinate from left out seeds of the previous season. No transplanting is done. Use of fertilizers and chemicals is not observed in this system. This type of cultivation is found in Madhubani and Darbhanga districts. Economics were worked out for both the situations (field as well as pond). Total cost was higher in field situation due to the more inputs when compared with pond situation but net return in field situation is more than pond situation. Human labour was the major cost component in both the situations.

- **Capacity building of farmers and field functionaries for scaling up of water productivity:** 50 farmers' trainings programmes of one week duration were conducted to develop the Participatory Water Management Skills among farmers. Nearly, 2500 farmers/women/youths were trained for scaling up of water productivity in agriculture. One trainers training programmes was also organized for 25 extension functionaries across the Bihar representing the distinguished departments. A knowledge test was developed to assess the impact of training in terms of increase in knowledge level due to training programmes. The Study further reveals that majority of trainees were male and belonged to Other Backward Class (OBC); however the age ranged from 21 to 44 years. The highly diversity in age shows the involvement of new generation in agriculture. The education level was above matric level and working experience in agriculture varied from 2-16 years. The participation in social activities was prominent as most of them were active members of social institutions like Kisan union, SHG etc. The newspaper, television and radio are the prominent source of farmers' information. A significant improvement in knowledge level was observed in water management aspects. Extension personnel gained a significant change in acquiring new knowledge, developed participatory skills, changed in their attitude and aspirations fulfilled toward scaling-up of water productivity. It is expected that the enhanced learning will be effectively transferred to their workplace for effective water management in agriculture. This systematic appraisal will also provide corrective measures to improve an on-going or future training program, consequently, justifying the training investment. As water resource development and management is imperative for sustainable agricultural, study reveals that few of them had experience in water related technologies. Hence, there is a great need to keep them up-to-date in technological advancement especially in water scarce area as they are playing catalytic role in adoption of agricultural technologies. The strong Information seeking pattern and wide experience can be effectively utilized through in research and extension activities through organization of need-based and skill-oriented training programs.
- **Status and Performance and Status of SHG in disadvantaged area of Bihar:** Majority of group members belonged to less than 43 years of age hence this category of members may be motivated for the income generating activities through capacity building. Marketing of produce are being done by the SHG member themselves in nearby city. Hence, there is utmost need to promote them through policy incentives hence the produce can be marketed in other states and even abroad. Progressive farmers are the prominent and reliable source of information. Hence they can be used as alternate extension agent as the ratio of extension agent and farmers are widening day by day. Being the member of SHG, a significant change in the attitude of SHG members in the areas namely Socio-economic upliftment; Educational and training; Marketing and entrepreneurship qualities; Technology adoption and participatory research, and Banking /credit aspect was observed. Therefore, it is recommended that the SHG can be used for speedy transfer of agricultural technologies in the region/state/country. Most of the members need short term loan for their activities hence there must be a provision for assured credit from NABARD of some other financing agency.

- Development of diversified cropping system for irrigated ecosystem in Bihar:** Four crop cycles for all the cropping systems have been completed. Pooled analysis of rice yield equivalence revealed that during all the year of experimentations, there were significant variations among cropping systems. Maximum yield equivalence was recorded in rice-tomato-bottle guard (40.20 t/ha) followed by rice-potato-onion (30.89 t/ha), rice-coriander-ladies finger (27.12 t/ha), rice-carrot-cowpea (25.33 t/ha) and rice-mustard-tomato (24.29 t/ha), respectively. The value of diversification index (DI) varies from zero to one. Higher value of DI represents higher level of crop diversification. It is evident from the results that DI varies from 0.299 on medium farm to 0.903 on small farm with an average DI of 0.643 among all categories of farmers. This seems to have reinforced the view that smaller the farm size; higher is the level of crop diversification. A perusal of crop diversification pattern of farmers further revealed that majority of farmers were high crop diversifiers (46.4 per cent), followed by medium 35.7 per cent) and low (17.8 per cent) levels of crop diversification.
- Studies on irrigation and nutrient requirement of diversified cropping system in irrigated eco-system of Central Bihar:** Two crop cycles for all diversified cropping systems has been completed and the yield of different crops was converted in terms of paddy. Results of paddy yield equivalence revealed that during both the 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 (40.49 t/ha) followed by rice-potato- onion (33.45 t/ha), rice-carrot-cowpea (21.91 t/ha), rice-coriander-ladies finger (19.73 t/ha) and rice-mustard-tomato (10.84 t/ha) and, respectively. Among levels of irrigation, maximum yield equivalence was recorded at optimum level (25.83 t/ha) followed by sub- optimum level (24.74 t/ha), respectively. Among levels of nutrient, maximum yield equivalence was recorded at recommended level (26.09 t/ha) followed by 50 % of recommended level of fertilizer.
- Development of vegetable based integrated farming system for marginal farmers of irrigated upland:** One acre of vegetable based integrated farming system has been developed in which vegetable crop was integrated with food crop, fodder crop, goatry and vermicompost. Among food crop rice-potato-greengram and among vegetable crop bittergourd-tomato-bottle gourd was recorded as the best cropping system. Cultivation of rice-potato-greengram as food crop and bittergourd-tomato-bottle gourd as vegetable crop in integrated manner with goatry and recycling of vermicompost gave a net return of Rs. 75,520 per acre along with 2.5 tonnes of goat manure and 0.7 tonnes of vermicompost.
- Climate change impact assessment on water resources availability in the Brahmani River Basin and Bhavani River basin under different climate change scenarios for developing adaptation plans.
- Development of Canal operation schedule for deciding the optimal release to different distributaries located between Ranitalab and Bikram gates (locks) of Sone Command.
- Calibration of IHACRES model for different sub-basins of Brahmani River basin and DVC Hazaribagh for development of regionalized parameters for water shed development plan.

- **Natural resource management- Characterization, classification, conservation and management:**

- a) Among different fruit crops, 180 mango genotypes, 42 litchi genotypes, 38 guava genotypes, 12 sapota genotypes and 10 bael genotypes have been characterized and conserved in the field gene bank.
- b) Improved lines of tomato, brinjal, cucumber, ridge gourd, pumpkin, sponge gourd, pointed gourd, chilli, bottle gourd, bitter gourd, garden pea, French bean, cowpea, dolichus bean, vegetable soybean were evaluated
- c) Promising germplasm of Amaranth, palak, methi, coriander, drumstick, Malabar night shade, Chinese cabbage, Chenopodium/Buthua, Ipomola/Kalimsas, Ivy gourd, spine gourd, cho-cho, Faba bean, winged bean, Lima bean, Sword bean, vegetable pigeon pea, yam bean were collected and maintained.
- d) Soil physiological characterization and classification of watersheds in Purulia have been done
- e) A model for enhancing land and water productivity through multiple uses of water under eastern plateau and hill conditions have been developed
- f) Water requirement for commercial production of oyster mushroom have been standardized
- g) Studies on gravity subsurface drip and fertigation for cucurbits indicated increased yield of cucumber due to subsurface placement of the laterals.
- h) Results of calibration and validation of IHACRES (Identification of unit Hydrograph) indicated that that IHACRES model performs reasonably well in all the four sub-catchments of Brahmani basin

- **Productivity and profitability enhancement:**

- a) Among the different vegetable crops, tomato hybrids, Swarna Vijaya and Swarna Dipti , one brinjal hybrid Swarna Neelima, pole type variety of cowpea Swarna Harita, snowpea line Swarna Tripti, vegetable soybean variety Swarna Vasundhara, Dolichos bean line HADB-3 and Swarna Rituvur, Cowpea line Swarna Mukut, Pointed gourd line Swarna Suruchi, French bean lines HAFB-3, HAPB-4 were identified for release .
- b) Feasibility of intercropping of mulberry under aonla based cropping system have been demonstrated successfully
- c) Under rainfed plateau conditions, mango based multitier cropping system having guava as filler crop with intercropping of French bean have been found to be most profitable and aonla based multitier cropping system with guava as filler plant, intercropping of ground nut have been found to be most profitable.
- d) Vegetable based cropping sequences with bottle gourd-cowpea-tomato have been found to be most profitable under the eastern plateau and hill conditions
- e) Technology on ultra-high density orcharding in guava under Jharkhand conditions have been standardized
- f) For cultivation of pointed gourd under eastern plateau and hill conditions, planting at a intra-row spacing of 50 cm, application of nitrogen @ 80 kg per ha, phosphorus @ 30 kg per hectare have been found to result in the maximum yield.
- g) In bottle gourd cv Arka Bahar, application of poultry manure at the rate of 2.5 t/ha plus 30 kg N, 20 kg P₂O₅ and 20 kg K₂O per hectare through chemical fertilisers recorded the highest yield of marketable fruit (183.33 q/ha)

- h) Treating the seeds with CaCl_2 10^{-6}M resulted in the maximum mean percentage of seed germination in onion cv. Arka Niketan,, whereas treating the seed with CaCl_2 10^{-4}M maximum mean percentage of seed germination in chilli cv KA-2.
- i) In mango cv. Amrapali, rejuvenation pruning at 1.5m with 120 cm length of primary shoot and 60 cm length of secondary shoot have been found promising with respect to canopy size, light penetration in side the canopy and yield.
- j) Pruning in 20th April to 50% canopy to a shoot length of 50 cm has been recommended for increasing the profitability of guava under eastern plateau and hill conditions.
- k) In pear, maximum flowering and yield was obtained from two time's spray of thio-urea 10%.
- l) In litchi cv. Shahi, harvesting of fruits with 50cm length of shoot was found to be most promising.
- m) Covering the litchi plants with shadenet (both 30% and 50% light transmission) resulted in maximum extension of harvesting time over that of control (23 days).
- n) Soil application of fungal antagonists like *Aspergillus niger* or *Trichoderma viride* or *Pseudomonas fluorescens* at the time of plating resulted in significant reduction in the incidence of guava wilt even after 10 years of planting.
- o) For integrated management of bacterial wilt in solanaceous vegetables, application of karanj cake or liming or PGPR resulted in significant reduction in the bacterial population.
- p) Seed dressing of tomato seeds with Captan and Carbendazim either alone or in combination have been found effective for control of externally seed borne pathogens.
- q) The milky mushroom (*Calocybe indica*) strain CI-1 (M1), Paddy straw mushroom (*Volvariella*, *volvacea*) strain VV-11 were found most suitable for cultivation in Jharkhand.
- r) For cultivation of oyster mushroom, Paddy straw was the most efficient agrowaste which has 110.8 & 117.0 % biological efficiency by chemical and boiling methods, respectively.
- s) For seed production of bitter gourd, isolation distances of 400m have been found to be most effective.
- t) Epidemiology of downy mildew of cucurbits has been understood.
- u) Conditions for storage of bael pulp have been standardized
- v) Process for producing dried instant mushroom soup-mix was developed.

- **Management strategies for maximization of productivity of water bodies through Makhana based integrated aquaculture farming system:**

- a) The makhana growing pond has resulted into improved fertility status of pond soil. The available nutrient status of pond soil was comparatively much higher than the non makhana pond soil.
- b) The biological characteristics of Makhana ponds indicated a rich diversity of phytoplankton, periphytons, zooplanktons and benthic organisms.
- c) The integration of fish culture with Makhana farming thus offers greater efficiency in resource utilization and provides additional food and enhances income to the Makhana growers.
- d) Fish species (38) were collected from local Baghmata River and Local fish market. Fish specimens were preserved and a fish gallery has been prepared at our Makhana Research Centre. It is important to note that African cat fish- *Clarias gariepinus* is prevalent in Darbhanga region. This fish species should not be cultured because this fish species is highly carnivorous.

- e) It is important to note that in one fishery pond *Daphnia lumnholtzi* is found in abundant amount. It has carapace. So it is suggested not to release fish larvae when this form is present in the water because it will choke the Buccopharynx of fish and the fish will die.

- **Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar”**

- a) In the Darbhanga Sadar Block Clusters, villages and households and their Base line survey completed. Identified the specific sites for different farming system models/technologies, i.e. Makhana cum Fish along with the horticultural components, vermi -composting, mushroom farming poultry and bee keeping, etc.
- b) Demonstration Model of Makhana cum Fish along with horticultural components, vermi-composting, bee keeping have been displayed and related works initiated at selected farmer’s sites in the Darbhanga Sadar Block.
- c) Intervention of poultry, vermin compost, duckery, poly house for nursery seedling raisings on makhana bunds and yield of seasonal vegetables on arches by utilizing vertical slopes and fruit crops like banana gave encouraging results for enhancing water productivity based on integrated makhana cum fish pond based farming system was done.

- **Study on genetic diversity in Makhana:**

- a) To find out the suitable parents for hybridation programme in Makhana, a study on genetic diversity was conducted during the year 2010-11. In this experiment a total number of 36 germplasm (29 from Manipur and 7 from Bihar) were evaluated in a field condition at RCM, Darbhanga. Apart from the specific results, from these experimental material, 4 elite individual plants having a good potential of seed yield (1325 g, 1112 g, 1027 g, and 926 g) were selected on the basis of individual plant performance.
- b) The result of this study reveals that 1.25 x 1.25m spacing is an ideal spacing for scientific cultivation of Makhana crop.
- c) The comparative performance of seed yield of (Pusa Basmati-1, Pusa Sugandha-5 and PNK-381) these varieties indicates on an average on 35% superiority over the control. It is clear from the experiment that cultivation of organic rice can be done successfully in Makhana-Rice cropping system.

S.N.	Name of Rice Variety	Seed yield of organic rice in makhana Post-Harvest field (q/ha)	Seed yield of organic rice in non makhana field (q/ha)	Superiority over control in %
1.	Pusa basmati –1	37.52	25.30	32.57%
2.	Pusa Sugandha-5	40.34	22.93	43.16%

- **Comparative performance of different rice varieties in Makhana based cropping system:**

- a) The result of this experiment indicates that the varieties PRH-10 is more suitable for rice cultivation in Makhana based cropping system.
- b) **Development of Makhana-Barseem cropping system:** In this experiment makhana was cultivated only at 0.3 m water depth. Makhana was transplanted on 20th April 2010 and harvested on 18th August 2010. Seed yield of Makhana was recorded to be

21.6 q/ha. In the same field berseem was sown on 1st November 2010 following the standard package and practices. From this plot a total fodder yield of 48q/ha was obtained.

- **Collection, characterization, descriptor, documentation, conservation, biochemical evaluation, value addition and utilization of Makhana and other aquatic crops:** Using the earlier available germplasm of Makhana at RCM, Darbhanga, 14 pure lines of Makhana were developed. A promising strain of Makhana (having a higher seed yield of 28.4 q/ha against the 15.6 q/ha of a local check) was identified. To know the actual performance of this strain on farmer's field, a quantity of 60 kg seed of this elite strain has been distributed among 5 advance farmers of Darbhanga and Madhubani districts.