21. National Agricultural Innovation Project

The objective of the National Agricultural Innovation Project (NAIP) is to contribute to the sustainable transformation of Indian agriculture from an orientation of primarily food self-sufficiency to the one in which market orientation is equally important for poverty alleviation and income generation. The specific objective is to accelerate collaborative development and application of agricultural innovations among public research organizations, NGOs, farmers, private sector and other stakeholders. The project is supporting a number of policy and institutional changes, and financing investments in 185 sub-projects under four components. Besides, three sub-projects under Component-3 are funded by the additional financing grant from the Global Environment Facility (GEF) Trust Fund of the World Bank.

ICAR as the catalyzing agent for management of change in the Indian NARS

This component with 40 sub-projects aims at creation of an enabling environment for the management of change for the Indian National Agricultural Research System (NARS). Some of the important achievements include operationalization of an e-publishing system for ICAR research journals and development of a knowledge management platform–Agropedia—for aggregation and dissemination of information, and rice knowledge management portal for providing complete rice information from a single portal. Meta data and abstracts of 7,332 and full texts of 5,759 Ph. D. theses, 2,900 international journals and group catalog 'AgriCat' (http://www.agricat.worldcat.org) of 12 major libraries are now available for online access by the researchers and students in the ICAR institutes and SAUs in the country.

Twenty websites of the ICAR and its institutes have been redesigned using latest IT tools and uniform guidelines which are attracting increased number of visitors (3.3 lakh visitors per month). About 150 e-courses are being developed for six degree programmes in offline mode.

The process of digitization of documents at IARI with the help of high resolution scanners

By subscribing to general purpose advanced statistical software package, the NAIP has enabled the NARS scientists to analyze voluminous research data on their desktops and publish their research in high impact international journals, and we are able to save about ₹7.5 crore each year. The ten Business Planning and Development (BPD) Units created in Agricultural Universities and ICAR Institutes have commercialized about 60 technologies in 18 months and have developed a model for their self sustenance after the project period by getting funding from other ministries and departments, and also have earned a revenue of ₹4 crore so far.

About 580 NARS scientists were trained internationally in 27 cutting-edge areas of agricultural sciences such as allele tuning, bioinformatics, nanotechnology. Twenty national trainings involving international experts have also been completed.

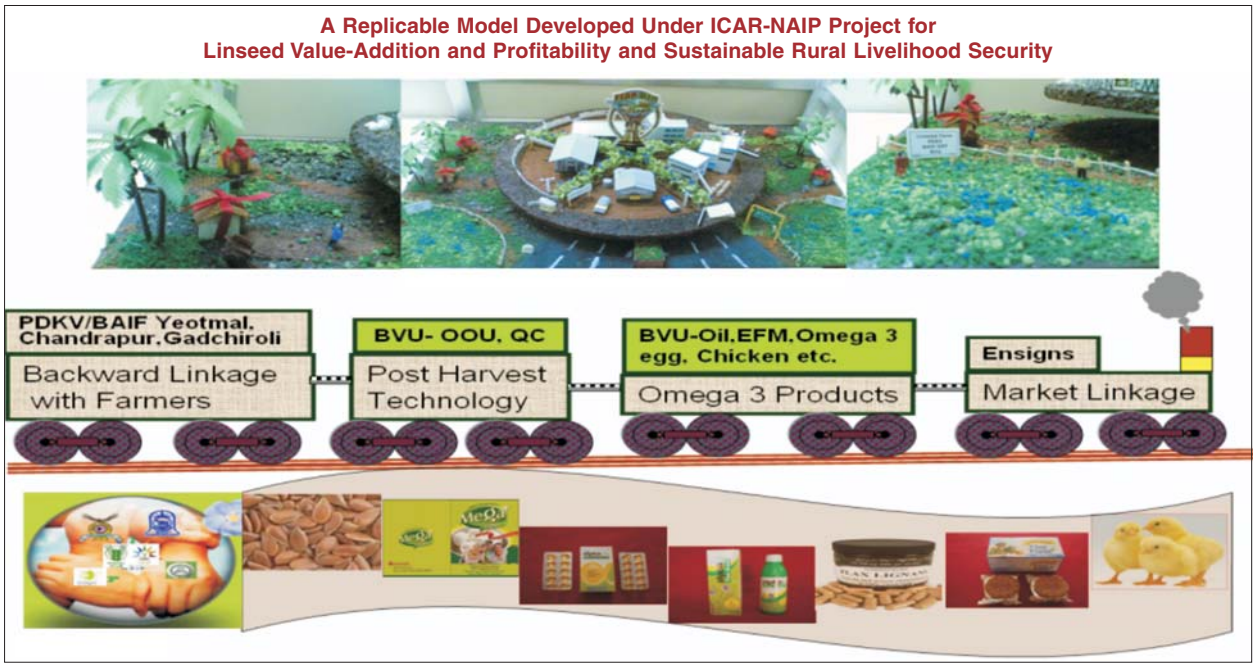
Research on production to consumption systems

This component has 51 consortia working across the sub-sectors of Indian agriculture with specific objective of establishment of market-oriented collaborative research alliances for sustainable improvement of selected agricultural production to consumption systems (PCS). Significant outputs of this component are:

Value-addition and promotion of linseed: The value-addition of linseed was developed for extracting Omega-3 and Lignan (SDG) catering market demand, providing remunerative price to farmers and thereby offering Omega-3 nutritional security to people.

The seed production of linseed variety NL 97 was 100 q/ha and 150 q/ha during 2007-08 and 2008-09 and of PKV-NL 260 was 150 q/ha and 600 q/ha during 2009-10 and 2010-11 respectively. The increased productivity under rainfed condition over baseline yield survey data (2006-07) was 63, 74 and 146% during 2007-08, 2008-09 and 2009-10, respectively, whereas under irrigated condition it was 325%. The net returns were ₹16,000 and ₹30,000/ha under rainfed and irrigated conditions, respectively, during 2009-10.

Omega-3 fatty acids from linseed were commercially used through 'Linseed Biovillage' concept. The PDKV, Nagpur and BAIF have undertaken the linseed seed production. A processing unit to extract omega-3 oil and omega-3 enriched poultry feed has been established in Sangamner by BVU. Another omega-3 oil extraction unit is being set up by PDKV and BAIF at Wagholi, Pune. Ensign Diet Care (EDC) has set up a pilot scale unit at their Wagholi campus to produce Omega-3



Omega-3 from linseed

fortifier (alphalite fortifier) to enrich Indian sweets, jam, bakery, dairy products including milk. Omega-3 eggs (Mega + egg) are produced at the Yojna Poultry Farm, Pune. Implementation of Linseed Bio-village project is going to give very rich dividends to our next generation and will be an important step in building a healthy nation.

Case study

Preventing deforestation through lac cultivation

Jamtara is one of the disadvantaged districts of Jharkhand blessed with *palas* (*Butea monosperma*) forest. The villagers of Baramajhadih village of Narayanpur block; Dahartola, Charedih, Rupaidih, Sarumundu and Sinjotola of Jamtara block have successfully produced and marketed broodlac from their *palas* trees within one year of implementation of the NAIP project. Ten farmers of village Baramajhladih (block Narayanpur), who were earlier unaware of lac, produced 399 kg broodlac from *palas* trees and earned ₹ 20,000 for the first time. Mr Baladeo Marandi and Mr Nirmal Marandi earned ₹ 7,000 each from summer season lac crop. Now, ten farmers formed a group named *Lac Utpadan Samooh,* Baramjhladih. Besides, these group members also preserved broodlac (lac seed) for their own requirement to produce next crop. Twelve farmers of village Dahartola, Charedih, Rupaidih, Saurumundu and Sinjotola have also successfully produced 354 kg broodlac and earned ₹ 17,700 in the same way. Mr Subodh Hembrom of village Charedih and Mr Bodi Nath of Saurimundu are the farmers who earned ₹ 3,600 and 3,500 respectively. These farmers now formed a group named *Khusiali lac Utpadan Samooh,* Rupaidih. First time intervention in these villages resulted in enhanced income from *palas* trees by introducing lac production. Now, farmers are able to produce broodlac for further propagating this venture, utilizing their own trees, set example for other farmers to follow it and utilize other unexploited trees. The farmers of this village stopped cutting naturally available *palas*, rather preserving these, for better environment and exploiting it rationally for income enhancement without any adverse effect on trees for lac production.

Fibre and value-added products from banana pseudostem: Navsari Agricultural University in association with the Central Institute for Research on Cotton Technology modified the raspador unit, standardized the process of fibre extraction and provided the trainings to banana growers.

After attending training followed by hands-on training in the field at Rajpipla village, one farmer Mr Upendrasinh Patel started fibre extraction from banana pseudostem using a raspador unit. After encouraging results he extended this activity to small-scale cottage industry in Gujarat Industrial Development Corporation, Rajpipla and installed 20 raspador units. With this facility, he extracted 7,400 kg banana fibre and could generate employment for 2,960 man-days worth ₹ 207,200, whereas his net profit was ₹ 347,800 from the sale of banana fibre.

Besides fibre extraction, the university standardized processes of pulp and paper making from pseudostem, fibres and scutching waste. Also standardized processes for extracting textile grade fibres from pseudostem and preparing home furnishings. A technology was developed for preparing candy, RTS and pickles from tender core of pseudostem.

The gross income of products (fibre, vermicompost and sap) developed from banana pseudostem was ₹ 124,895 and net income ₹ 64,478. It generated employment for 183 man-days/ha. The cost of production of candy (10 kg) from central core was ₹ 948 which fetched ₹ 1,800 through its sale, and there was net profit of ₹ 852.

Value-chains in horticultural crops: In Kadambur hills (Tamil Nadu), the area under marigold cultivation is 34.4 ha and improved livelihood of farmers who

were traditionally involved in millet cultivation. Initially, the net return through millet cultivation was ₹ 10,000/ha, which increased to ₹ 15,000-17,500/ha through conventional methods of marigold cultivation and has reached ₹ 25,000-35,000/ha with improved marigold production and post-production technologies. Significant increase in xanthophyll content from 1.40 to 1.75 g/kg in flowers has helped increase profit to the company by approximately 10-15% which prompted it to hike price of flowers paid to farmers from ₹ 2.30/kg in 2008 to ₹ 2.75/kg in 2009 and to ₹ 3.75/kg in 2010.

For improving keeping quality and export potential of jasmine flowers, innovative export packaging technology was developed and refined. It helped keeping flowers fresh for 72 hr with negligible damage, and the flowers could be exported to the USA markets also, besides Dubai flower market. Jasmine export volume of the Consortium Partner M/s Vanguard Exports of the project increased from 192 tonnes/year to 217 tonnes/year. Adoption of the packaging technology increased export volume of jasmine to Dubai market from 600 kg/day to 900 kg/day and to the US market from 500 kg to 1,000 kg/week.

Integrated management methods in carnation comprising pre-planting fumigation of greenhouse with Dazomet at 30 g/m^2, followed by treatment of rooted cuttings of carnation with biological control agent *Pseudomonas fluorescens* at 0.5% reduced *Fusarium* wilt incidence from 30-40% to 20%. The management method for calyx split involving spraying of 0.1% borax at fortnightly intervals reduced yield losses from 20-30% to 15%. This technology helped in obtaining a higher proportion of superior quality 'A' grade flowers and lower proportion of 'B' grade flowers with no 'C' grade flowers.

Casuarina-based pulp wood industrial agroforestry: The casuarina clone-based agroforestry model resulted in a net profit ranging between ₹ 43,075 (farm forestry) and ₹ 73,241 (agroforestry) compared to ₹ 26,700 (blackgram) and ₹ 36,400 (groundnut) on per hectare basis. Casuarina clone-based industrial agroforestry plantation is profitable compared to existing cropping system besides creating significant socio, economic and environmental changes.

Research on sustainable rural livelihood security

The major objective of this component is to improve livelihood security of the rural people living in selected disadvantaged regions through technology-led innovation systems. The 33 sub-projects approved are operating in 91 backward districts. Besides these, three sub-projects, covering 11 districts are also approved under GEF funding. Integrated farming system approach is implemented for sustainable livelihood improvement. The various interventions were planned, implemented and data analyzed for productivity and cost economics.

SRI method of paddy cultivation—a great success in Dhalai, Tripura and South Garo Hills, Meghalaya: Average productivity of local variety of rice in South Garo Hills district was 1.5 tonnes/ha and in Dhalai district it was 2.1 tonnes/ha. After introduction of Ranjeet variety through SRI, average productivity went up to 4.8 tonnes/ha in South Garo hills, whereas in Dhalai (Tripura) after the introduction of Naveen variety through SRI, the productivity enhanced to 3.7 tonnes/ha. At both the sites, the average enhancement in income/ha/year owing to the introduction of HYV rice and SRI technology was ₹ 6,700/ha/year.

SRI in Garo Hills and Dhalai

Crop diversification—a boon to marginal farmers for sustainable livelihood: Shri Ratan Uttam Bhoye from Laghadwal village with seven other tribal farmers cultivated onion during summer season of 2010-11. Varieties N 2-4-1 and Agri Found Light Red were cultivated with recommended technology in 7.20 ha of eight farmers' fields. The average productivity of onion was 200.1 q/ha with gross income of ₹ 125,302/ha during the first year of crop introduction. From this income, some of the farmers constructed onion storage structures. The farmer earned more than ₹ 90,000 from a single crop.

Success story

Enhanced rice productivity through appropriate technology

Shokham Gaon in Bordoloni Block of Dhemaji district (under the cluster of low-lying area) is affected by recurring floods every year. Winter paddy could not be grown there due to floods. Local deep water paddy is the only option. In 2010-11, 11 beneficiaries were selected for cultivation of summer rice. To escape flood, farmers raised seedlings in the later part of November. To overcome the problem of stunting due to severe cold in December-January, poly tunnel technology of raising seedlings was introduced. The temperature inside the poly tunnel was 5°C more than the ambient temperature. Excellent germination percentage and very good growth of seedlings inside the poly tunnel was observed. Transplanting of rice seedlings was done at the end of December 2010. All the inputs were supplied and as a result beneficiaries harvested rice with average yield 54 q/ha before flood. On the other hand, their local deep water paddy was completely damaged due to the flood in June and August 2011 with huge amount of sand deposition.

Success story

Household nutritional security and supplementary income through backyard poultry

The project "Sustainable livelihood through freshwater aquaculture, horticulture and livestock development in Keonjhar, Mayurbhanj and Sambalpur districts of Odisha" under NAIP (Component-3) was initiated to improve the livelihood of 3,000 farm families belonging to Keonjhar, Mayurbhanj and Sambalpur districts of Odisha through freshwater aquaculture, horticulture and livestock development. Regional centre, CARI imparted training for nutritional security to the infants, old, pregnant women and entire family. Farmers were sensitized through meetings and audio-visual aids. Trainings were also imparted on brooding, management, health coverage, production and marketing etc. Day-old CARI Devendra chicks (20), 10 kg of initial chick mash, one feeder and one drinker were supplied to each unit of backyard poultry. Vaccination with 'Lasota' nasal drop (within 7 days) and R_2B at 3 months of age was carried out. Poultry houses were constructed by the farmers with the technological support The birds started laying eggs within 5–6 months. Egg production performances were recorded and economic status of the unit was calculated. The whole process was named as CARI Model of Backyard Poultry Farming.

Year-round-production of high-value vegetables in North Sikkim: Year-round cultivation of high-value vegetables, namely tomato, capsicum, cauliflower, broccoli, under polyhouse has tremendously increased the income of the farmers in North Sikkim. More than 10 SHGs of Lingdong, Passingdang, Heegyathang, Tinvong and Samdong are engaged in the cultivation of vegetables. Under this project, 29 low-cost polyhouses were constructed, more than one lakh seedlings were distributed. The area under protected cultivation was increased to 0.5 ha from 0.02 ha.

Zero tillage in toria—a success in Tamenglong, Manipur: Toria M 27 was introduced in 50 ha area through zero tillage technique in the three selected villages. Higher productivity (0.84 tonne/ha) was obtained under zero tillage than local practice (0.54 tonne/ha). Farmers are also extracting oil from seeds with the oil expeller provided under the sub-project. The zero tillage cultivation of toria is gaining popularity in the adjacent districts also. The advantages of zero tillage in toria are timely sowing in October-November, conserving soil moisture, saving tillage cost, protecting soil erosion and reducing organic matter depletion.

Success story

Protecting hybrid chilli plantation

Mr Rajib Tait of Mersapori village developed a technique to save his hybrid chilli plantation from field cricket and grass hoppers. He covered each seedling with a disposable plastic glass after removing the bottom and managed to save chilli seedlings. From 0.133 ha of land, he earned ₹ 20,048 as net profit.

Desilting of minor irrigation tanks for increasing storage and improving soil fertility: In an effort to improve water storage, seven minor irrigation tanks were desilted in B. Y. Gudi cluster of Kadapa district. A total of 202 farmers participated in this programme by contributing to lifting of the tank silt and applying the same to their fields. About 18,800 tonnes of silt material dug out from the seven tanks was transported in 9,374 tractor loads to the farmers' fields. Many of the farmers used the silt to level their undulated fields while some of them added 30 cm of additional soil in their fields. They are expecting good harvest for the next three consecutive years.

Combination of vermicompost and gobargas: Nagaveni, a woman farmer from Vadddikere, Hiriyur, improved her income and family health status by effective use of vermicompost and gobargas. She saved on an average ₹ 50 to 70 per day on fuel. Unit cost given from the sub-project was ₹ 10,000 and generation of gobargas is 2 m^3/day, which is sufficient to cook food to a household/day. Thus by investing ₹ 20,000 (Zilla-Panchyat provided subsidy for construction of gobargas too) on the biogas, she could save on the fuel in the range of ₹ 1,500-2,100/month besides improvement in health and environment; and the slurry being effectively utilized for vermicompost preparation. Apart from saving on firewood, she also earns income by selling worms (₹ 150 to 200/kg) and compost (₹ 3/kg).

Replacement of *Lantana* with bamboo: *Lantana,* a perennial weed in Kandi area, reduced the cultivable land significantly. Under NAIP sub-project, bamboo plants were provided to Smt. Bachni Devi of village Alera (Talwara) @ ₹ 3/plant in 2009. Around 1.2 ha of land infested with *Lantana* was cleared and 500 bamboo saplings were planted. These plants got matured in two years and achieved a height of 10.7-12.2 m. The income has started this year (2011). Mature bamboo plants in good condition were sold @ ₹ 25/plant. This yielded a total amount of ₹ 15,000 from 1.2 ha plot of bamboos.

Bamboo leaves were used as animal feed during winter from October to March. The average yield was 1-2 kg/bamboo/month. The income will increase 2-3 times every alternate year, as new saplings (usually three in number) will mature into adult bamboos after two years. In the village Alera alone, five beneficiary families have planted bamboo in 8 ha of land.

Infertility accounts for major economic losses in livestock: In cattle about 60-70% lactations are affected by reproductive disorders and infertility. Implementation of the infertility control technologies, namely improved feeding, breeding, etc., has increased the milk production and also reduced the inter-calving period in cattle and buffaloes. Cumulatively, about 3,491 animals were diagnosed as infertility cases and 48.15% were brought to pregnancy. There was a significant reduction in the inter-calving period from 714 days to 438 days.

Success story

Herbal extracts for resistant ticks infesting cattle

Herbal extracts with high anti-tick activity were developed at IVRI, Izatnagar and National Botanical Research Institute, Lucknow in a collaborative NAIP research project. The extracts showed promising results when applied on crossbred calves experimentally infested with ticks, which were not amenable to organophosphate and synthetic pyrethroid groups of chemical acaricides due to resistance development. The patents have been filed.

The shelf-life of this extract was highly satisfactory up to 105 days and repeat *in vivo* application on cattle was recommended in 15 days intervals as aqueous solution. No adverse reaction was recorded in rabbit model when applied topically with five time higher dose. Presently, the herbal extract is undergoing field testing.

Mini rice mill: a community enterprise in a remote tribal village: A mini rice mill plant of 500 kg/h processing capacity with polishing facilities and 67% recovery was installed in Laghadwal village of Dhule district of Maharashtra in December 2010. Adequate training was imparted on operation and maintenance of the mill. A cluster level committee was formulated for maintenance and market linkages. The charges of processing were fixed at ₹ 30/bag of 60 kg (with retention of husk). From December 2010 to April 2011, 40 tonnes paddy was processed and an amount of ₹ 20,000 was collected as processing charges and ₹ 22,000 from sale of paddy husk to cattle industries. It also generated employment for six rural youths in operating the mill.

Sustainability of post project activities: A major emphasis of the Component-3 was on developing a mechanism of sustaining project activities beyond the project period. This is particularly important for the target vulnerable section of the society, viz. landless community, small and marginal farmers, which may need continued support for sustainable livelihood after completion of the project. Some of the efforts made in this direction are: Development of sustainability fund, Development of inclusive community based organization, Linkages with banks, insurance companies and other organizations, Marketing linkages, Need-based capacity building and creation of service providers, Building the chain, Revolving fund approach and Formation of village level commodity banks. An estimated a sum of ₹ 4.92 crore has been generated till 30 September 2011.

Basic and strategic research

This component has 61 consortia in frontier areas of agriculture. Following are the main research achievements/innovations.

- *Bioprospecting of genes:* Complete sequence of three genes [2-Cys peroxiredoxin (Prx2) and duplicated carbonic anhydrase (DCA1) from *Dunaliella viridis* and trehalose-6-phosphate synthase (TPS) from the microbes *D. viridis* and *Dictyosphaerium ehrenbergianum*] conferring tolerance to high salinity were obtained and functionally validated by expressing in *E. coli* system. Whole genome sequences of P43 (salinity tolerant) and P8 (salinity and temperature tolerant) strains of *Pseudomonas* were completed. Full length sequence of GPDH gene in fish that gave 16-fold higher expression at low temperature (4-5°C) for 96 hr in comparison to 15°C was cloned.
- *Taxonomy:* Taxonomic keys for 20 species of *Cucumis*, 11 species of *Abelmoschus* were defined and ambiguities in identity of *C. sativus* var. *hardwickii* vis-à-vis *C. trigonus, C. prophetarum* and *C. hystrix* were removed.
- Taxonomic ambiguities in freshwater bivalves in Western Ghats, including the species of *Parreysia* and *Lamellidens* were further resolved.
- A new record of a weevil, *Tanymecus pronceps* on non-*Bt* cotton feeding on leaves and flowers during off-season has been made. Four new species of parasitoids on cotton mealybug, *Phenacoccus solenopsis* were recorded, and two were identified as *Prochiloncurus albifuniculus* and *P. pulchellus*.
- *Nano-technology:* Eleven new fungal species were successfully deployed to produce 100% nanoparticles of Fe, Zn, Mg, P, Ag, Au and Ti within 96 hr. Gene sequences of nine efficient nanoparticle and polysaccharide-producing organisms were documented. Nano-induced polysaccharide powder from microbial sources was developed for soil aggregation, moisture retention and carbon build-up. Fungicidal efficacy of monoclinic sulfur nanoparticles on phytopathogenic fungi *Aspergillus tamari* and *Fusarium oxysporum* and entomotoxic bioefficacy on beetles and *Spodoptera litura* was observed. Nanocellulose used as filler in starch film, improved the tensile strength by 3.5 times and reduced water vapour transmission rate by 2 times. Biodegradability of starch nanocellulose composite film by native microbial population of garden soil in less than 21 days has been observed.
- *Disease forecast:* An artificial neural network model has been developed to forewarn first appearance and crop age at peak appearance of yellow stem-borer in rice using light trap catch data along with corresponding weather data of 1995 to 2010 from West Godavari district of Andhra Pradesh, and a crop-pest-weather database on CD covering rice and cotton crops was released.
- *Water harvesting and management:* Fabrications, developing anchoring mechanism and installation of two more rubber check-dams in field conditions at Chandeshwar in Khurda district of Odisha have been successfully completed.

- *Animal reproduction and health:* Isolated, sequenced, and characterized *NANOG* gene (another critical homeodomain transcription factor responsible for maintaining embryonic stem cell self-renewal and pluripotency) in buffalo Embryonic stem cell-like cells. Comparative expression profile of *PRM*1, *PRM*2, *Tnp*1 and *Tnp*2 genes showed that good quality semen producers expressed significantly higher level of PRM1 mRNA and PKM2 than the poor quality semen producing group; the differences in the expression of other genes were non-significant. Five Y chromosomal genes were cloned and *SRY* and *DDX3Y* genes sequenced in *Bos indicus* bull.
- A biochip capable of detecting mastitis-causing pathogens *S. aureus* and *Streptococcus* spp. (*S. agalactiae, S. dysgalactiae* and *S. uberis*) and *E. coli* and specific virulence genes has been developed.
- Resistance to *Peste des petitis ruminants virus* (PPRV) has been increased due to increased basal levels of TLR3 and TLR7 in indigenous breeds of goats (Kanni and Salem Black). Immunological superiority of Toda buffaloes was seen to be due to higher levels of TLRs.
- *Milk and dairy technology:* Spore-based bioassay on gold chip for detection of Aflatoxin M1 in milk has been optimized. A rapid colour based method developed earlier to detect labolene (0.02%) in milk has been validated. Sensorily acceptable levels of extracts of Indian herbs; *shatavari* (1%), *ashwagandha* (0.3%) and *vidharikand* (0.4%) into milk as nutraceuticals, were determined, and interaction effect of herb components with milk proteins resolved.

Infrastructure development

The major facilities like high-throughput genotyping using multiplexed microsatellite markers; phenotyping for drought tolerance under rainout shelter; facility for safe handling and disposal of microbes and hazardous chemicals like liquid handling system, EMCCD system; net house for commercial minituber production; mobile seed processing unit for seed spices; modification of vessel for enhanced deep sea fishing; ASRB online examination centres and *jowar* rath, etc. were created under the project.

Potato cultivation in net house for commercial minitubers