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भारतीय कृषि अनुसंधान परिषद

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PROMISING TECHNOLOGIES

Aeroponics for potato-seed production

Availability of quality planting material has always been a limitation in vegetatively propagated crops. In India, potato was the first among all the vegetatively propagated crops where indigenous system of quality seed production was established way back in 1968. This system was based on tuber indexing for detection and for elimination of all prevalent potato viruses, followed by clonal multiplication in four successive generations. And the system had two inherent problems—slow multiplication rate and higher field exposure, thereby increasing chances of viral infection. Keeping this in view, a tissue-culture based system of quality seed production was perfected and upscaled. *In-vitro*

The potato-crop in the aeroponics

plantlets/microtubers were planted under insect-proof conditions for producing minitubers. However, rate of multiplication of minitubers from the plantlet was low, ranging from 8 to10 times. And consequently, large number of *in-vitro* plantlets under nethouse would be required to meet breeder seed requirement. The efficiency of the aeroponics system has been found 3-4 times higher than the normal tissue culture-based system also.

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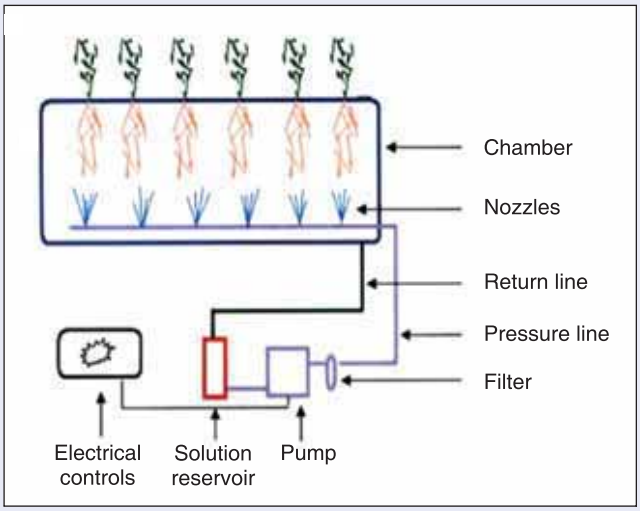
Aeroponics is the process of growing plants in an air-mist environment without soil or an aggregate medium. The basic principle of the aeroponics is to grow plants in a closed or semi-closed environment by spraying roots with a nutrient-rich solution. Since aeroponics technology is patented and not easily accessible, the CPRI Campus, Modipuram, undertook studies on developing all its components with the support from the CIP, Lima, Peru.

Advantages of aeroponics

- Three to four times more number of minitubers per plant as compared to the traditional tissue- culture system.
- Soilless cultivation, so less exposure to unfavourable soil conditions and freedom from diseases and pests.
- Reduced cost of production of minitubers through savings on *in-vitro* plantlets growing and nethouse space.

An aeroponic prototype was designed, constructed and tested with Kufri Bahar, Kufri Surya and Kufri Chipsona 3 potato varieties under nethouse conditions. This prototype consisted of an electrical unit, two light-proof growth chambers, a nutrient solution chamber, a high-pressure pump, a filter, and spray nozzles. All the essential nutrient elements required for plant growth were dissolved in the water in the solution chamber, and solution *p*H was maintained at the desired level throughout the crop period. This nutrient solution was compressed through nozzles by the high-pressure pump, forming a fine mist in the growth chambers. At the roof of the growth chambers, *in-vitro* propagated and hardened plantlets were planted in 20-mm diameter holes. Pump was automatically operated for 10-30 seconds after every 10-30 minutes interval with an electronic timer and a conductor. This way growth chambers were maintained at 100% relative humidity by misting nutrient solution round the clock. After a week, root systems started developing inside the growth chambers. Like in the soil system, stolon and tuber formations were initiated at different intervals depending upon the variety. Picking of the tubers was started after 60-65 days when some of the tubers attained 15-17 mm dia. Once the first flush was harvested, formation of additional tubers triggered resulting into more minitubers/plant. In this system, harvesting was done after every two weeks, and in total 4 flushes were taken. On an average 30-35 minitubers could be harvested from a single plant as against 8-10 minitubers under the nethouse.



Schematics of aeroponics

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Cold-shock protein gene (*cspA*) in pseudomonads

Type III class ice-nucleation activity (–6 to –12 log ice nuclei/cfu) at –10°C has been found in cold-tolerant pseudomonads, isolated from the Uttarakhand Himalayas. Major cold-shock protein gene (*cspA*) ~160bp was detected in all pseudomonads; *csp A* encodes cold-inducible protein, and the gene sequence showed more than 90% homology with the cold-shock protein of several *Bacillus* spp.

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High carotene pasta from orange-fleshed sweet-potato

Pasta with high carotene and protein content has been developed from an orange-fleshed sweet-potato cultivar ST 14; incorporating whey-protein concentrate at 10% level. The functional pasta has a high swelling index of 1.60 and has a smooth outer finish, and yields a non-sticky, resilient cooked product with carotene and protein contents of 10 mg/100g (dry weight) and 14 g/100g (dry weight), respectively.

Pasta from orange-fleshed sweet-potato

Slow starch digestibility over 2 hours, indicative of low glycaemic nature of the pasta, coupled with high carotene content makes it an ideal antioxidant rich food for diabetic and obese people.

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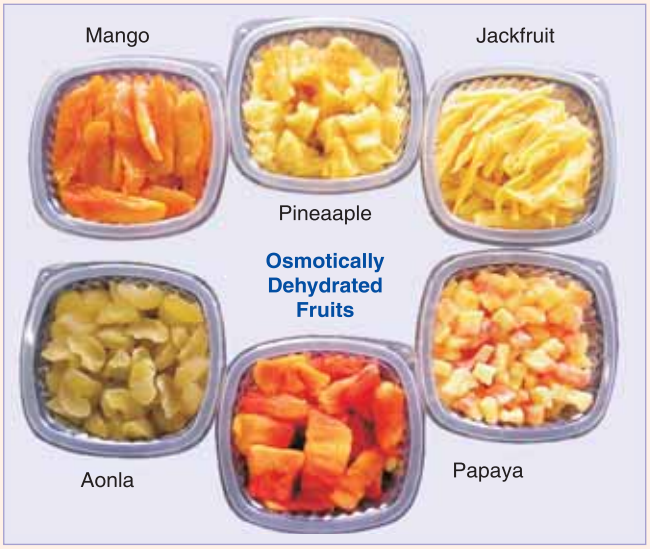
Osmotic dehydration of tropical fruit-slices

Osmotically dehydrated fruit products are shelf-stable, highly nutritious, and are with good natural colour, flavour and texture. Osmotically dehydrated mango is found nearer to fresh fruit with enhanced nutrients and taste.

Dehydration of tropical fruit-slices such as mango, pineapple, papaya, sapota, jackfruit, banana involves two phases. In the first phase, water is removed using sugar syrup (50-70° Brix) as an osmotic agent. In the second phase, dehydration of the osmosed slices is done in the hot-air drier at 50-60 °C temperature. The moisture content of the final product is brought down to 15%, and it is packed in the airtight pouches/ punnets/ containers.

In comparison to the single drying process, osmotic dehydration achieves a two-fold transformation of the food items, by decreasing water content and by incorporating a solute, which may result in weight reduction subsequently. Solute uptake during osmotic dehydration modifies composition and taste of the final product. Leaching of the natural acids out of the osmotically dehydrated fruit also affects taste; owing to changes in sugar: acid ratio. And partial dehydration and solute uptake protect fruit-slices against structural collapse during terminal drying.



These dehydrated products can be used alone as a dried fruit snack or as adjuvants with other dried fruits like dates, cashew, almond etc. And they can be used in ice-cream industry, confectionery, fruit salads, *kheer*, cakes and bakery products. These products will also be suitable for children, and mountaineers and defence forces in difficult areas where carrying and delivering bulky and perishable fresh fruits is difficult.

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The United Nations declared 2010 to be the International Year of Biodiversity. It is a celebration of life on earth and of the value of biodiversity for our lives. The world is invited to take action in 2010 to safeguard the variety of life on earth: biodiversity

Developed nutritious chicken-meat products blended with vegetables

The major cost factor in chicken-meat-based value-added products like fried-chicken, chicken-nuggets etc. is the cost of the raw meat, ingredients and imported equipment. And reduction in the cost of production of these products to an affordable level can be achieved by careful selection of ingredients, reformulations with use of unconventional food ingredients, and also by using indigenously available equipment.

Green vegetables are rich in dietary fibre, β-carotene, calcium and other phytochemicals that are natural antioxidants and possess health-improving properties. Huge amount of fresh fruits and vegetable are available in India all round the year. And efficient, inexpensive and environmentally-sound utilization of them and their products in the meat products can be done. This will reduce production cost, improve nutritional quality, and will provide an opportunity to formulate healthier and functional chicken-meat products.

Nutritious and tasty chicken-nuggets have been prepared utilizing indigenous equipment and reformulating their preparation. Chicken-nuggets with cauliflower, curry leaves and onion powder not only improved their texture and acceptability, but had favourable effect on their hydration level, emulsion stability and binding, and also reduced cost substantially (by 35 per cent). Their colour, chewiness and other textural properties were affected minimally by addition of vegetables. Further when they were tested by a panel of consumers, the acceptability of the nuggets was high. And above all, incorporation of vegetables increased dietary fibres in the products and decreased fat and calories levels. And natural phytochemicals in the vegetables increased shelf-life of chicken-nuggets.

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Fly-ash for managing surface cracks in medium-deep black soils

Dominance of swelling-and-shrinking smectite clay mineral in black cotton soils leads to cracking of surface on drying, which is one of the major soil management concerns in the Vertisol regions. These cracks damage soil conservation structures and also accelerate erosion and soil desiccation process.

Flyash application at 10 tonnes/ha prior to preparatory tillage for four years not only improved soil physical condition but also reduced crack development. There was 17 to 43% reduction in the crack volume owing to flyash application. In rainfed areas, grain yield from sorghum + pigeonpea intercropping system in these soils increased by 28% and net returns by about 43% over the untreated control plots.

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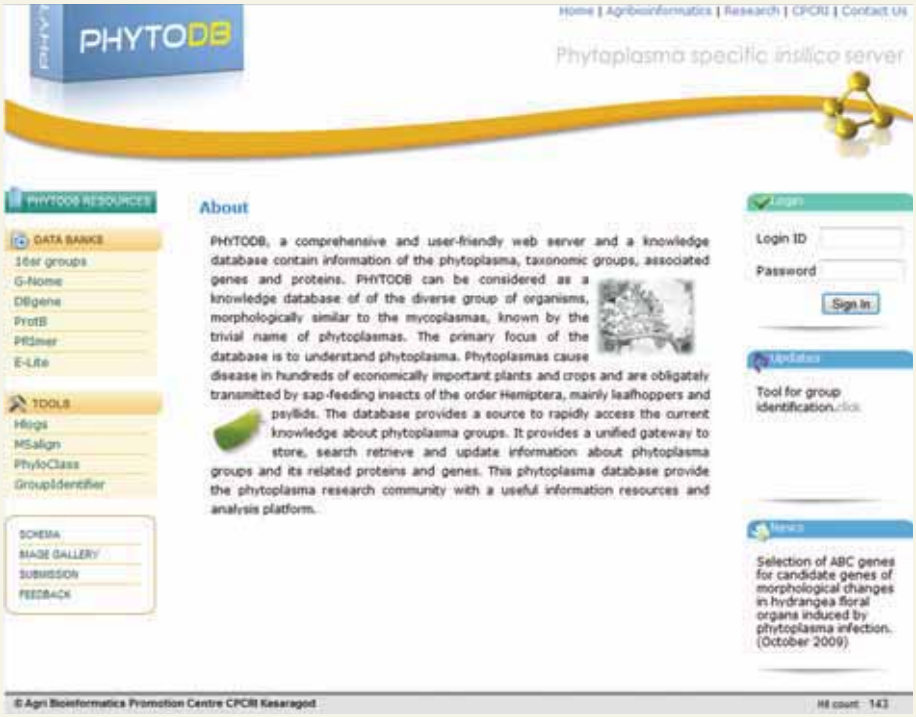
PHYTODB: Web server for phytoplasma

PHYTODB is a comprehensive and user-friendly web server and a knowledge-base devoted to plant- pathogen phytoplasma. It functions as the information system on the phytoplasma and holds extensive datasets for phytoplasma genomes, genes, proteins, different strains, and also research articles, which provide relevant information to scientific community. The primary focus of the database is to analyze and classify phytoplasmas and to rapidly access existing knowledge about them. The database resources are categorized into databanks and tools. The databanks serve as the reservoir of primary, curated data and whole genome sequences. Tools category comprises Hlogs, MSalign, GroupIdentifier and PhyloCass. Tools embedded are useful for homology search, multiple sequence alignment, phylogenetic analysis and 16S rRNA-based group identification of new phytoplasmas.



At present, PHYTODB contains 775 16S rDNA sequences, 1,514 genes and 2,102 proteins entries. The data have been modified especially for adding taxonomic group information to each entry in 16S group, manually curated genes and protein data to remove redundancies, and have been formatted for data access easiness.

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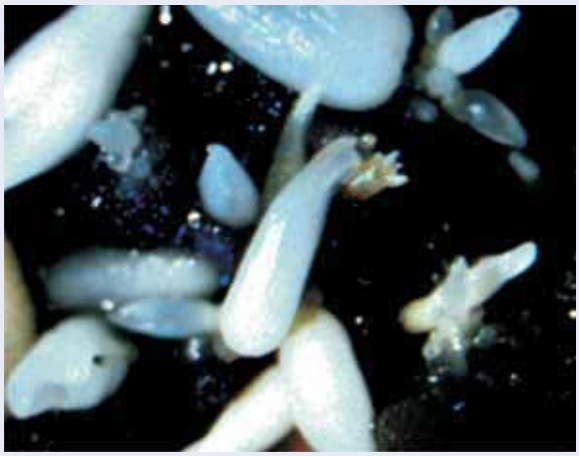
Somatic embryogenesis in guava

Zygotic embryos were isolated from fruits (60 DAP) of cv. Allahabad Safeda and were incubated in modified MS medium fortified with 2, 4-D, spermidine and glutamine. Higher rate of somatic embryogenesis was observed, and subsequently, somatic embryos were seen after 10 weeks in culture. Evaluation in stereomicroscope showed presence of globular somatic embryos at a low frequency after four weeks in culture. After five weeks, heart- and torpedo-shaped embryos were observed, leading to development of torpedo and cotyledonary somatic embryos in ten weeks. This protocol can be used for genetic transformation of guava, *in-vitro* selection for biotic and abiotic stresses and for rapid multiplication.



Somatic embryos

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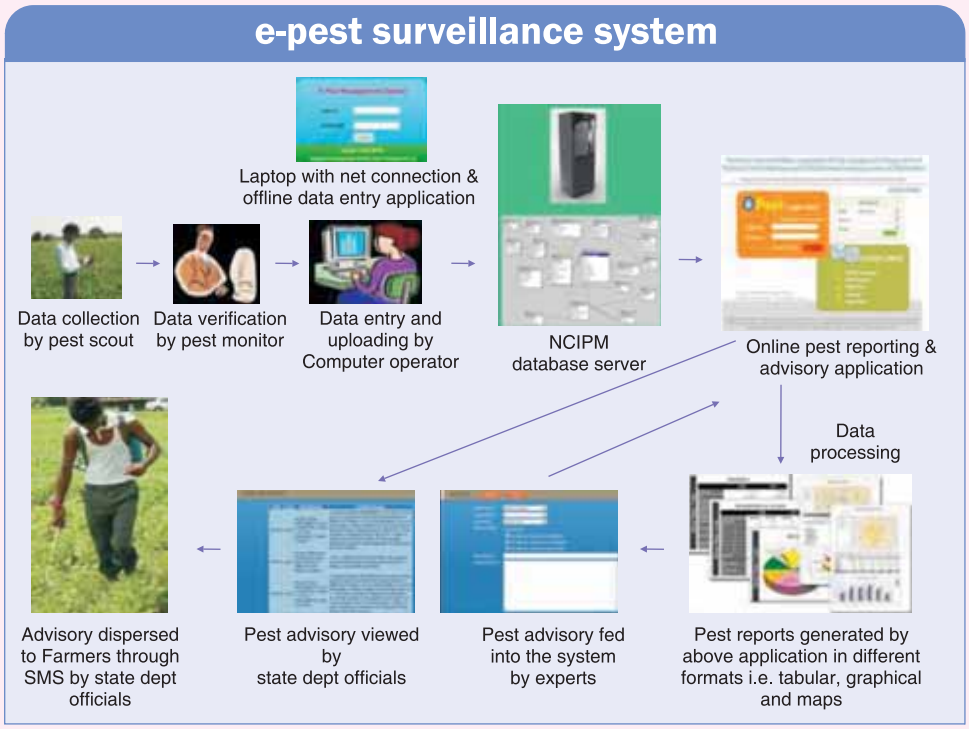
E-pest surveillance for cotton and soybean



Maharashtra, in general, and Vidharba region, in particular, witnessed an epidemic of *Spodoptera litura* coupled with *Helicoverpa armigera* and other leaf-eating caterpillars on soybean during 2008-09. Although sampling tools and pest management strategies for them were available; thus indicating the necessity for implementation of a strong pest monitoring and advisory mechanism. *"Awareness-cum-surveillance programme for management of major pests of soybean-cotton based cropping systems in Maharashtra"* was implemented in 2009-10 by eight stakeholders—State Department of Agriculture, Government of Maharashtra, State Agricultural Universities (Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola; Marathwada Agricultural University, Parbhani and Mahatma Phule Krishi Vidyapeeth, Rahuri) and ICAR institutes (National Centre for Integrated Pest Management, New Delhi; Central Institute for Cotton Research, Nagpur; Directorate of Soybean Research, Indore; Central Research Institute for Dryland Agriculture, Hyderabad). This programme consisted of two parts—awareness creation and pest monitoring-cum-surveillance based advisory system.

For regular-and-effective pest scouting, pest monitoring units were formed consisting of pest scouts, pest monitors and data-entry operators under the direct supervision of the State Department Agriculture Officers; and each unit was given a laptop computer with internet connection.

A web-based e-pest surveillance system was developed based on the three-tier architecture, consisting of a database, an offline data entry and uploads application and an online reporting and advisory application.

The database was developed using SQL server 2000 with options for storing all kinds of crop-pest information. An offline application was developed using ASP.NET 2.0 for data capturing, and XML format was used for transferring data into database through internet. This application has been bundled and loaded into laptops provided to the pest-monitoring units. Once data reaches database hosted on the NCIPM server, it is processed by the reporting application (developed using ASP.NET) and experts are able to view current and past pest situation of a location in diff report formats. And then these reports are interpreted by experts, and pest advisory is fed into the system, which is immediately available to the State Agriculture Department to spread it to farmers through its field staff as well as through SMSs to elite farmers, *gram panchayat* heads etc. A user-friendly graphical interface has also been designed for pest reporting and feeding advisory into the system.

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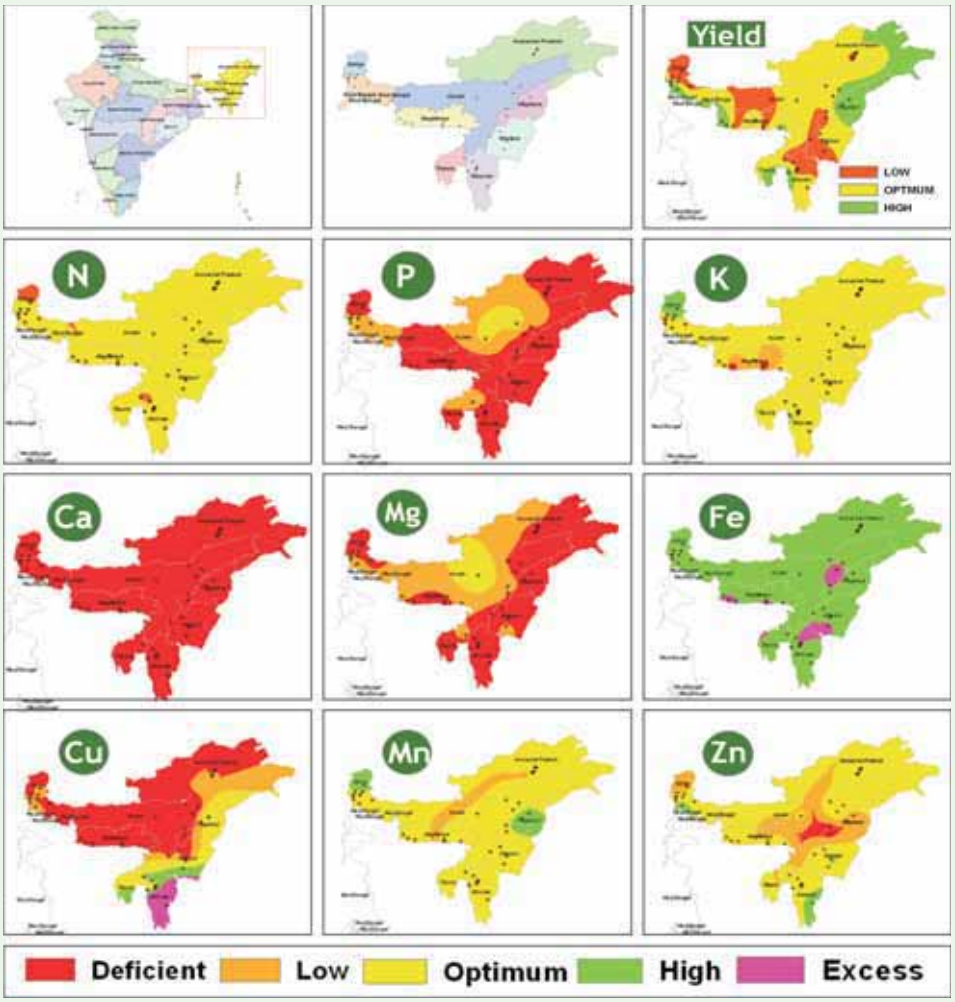
Citrus production zones for citrus industry

Precision citriculture success depends largely upon the correctness to which spatial variability in the soil fertility, a major production constraint, has been addressed to. An extensive exploration of Khasi mandarin (*Citrus reticulata* Blanco) (geo-graphical indicator) gro-wing belts across the seven sister states of the north-east India, Sikkim and West Bengal was carried out covering 108 orchards from 52 sites (grid points) of the different geographical origins. These grid sampling sites were georeferenced and digitized. And voluminous databank was generated for leaf nutrient composition (N, P, K, Ca, Mg, Fe, Mn, Cu and Zn) and fruit yields. The data, hence produced, were subjected to analysis through software-based decision support systems in two tiers of interpretations. These included: analysis through diagnosis and recommendation integrated system (DRIS) to determine leaf nutrient optima, and mapping of spatial variability in the nutrient constraints, nutrientwise and productionwise, using nutrient optima. The nutrient-wise maps produced were superimposed over one another to identify different production zones displaying high fruit yield and lowest frequency of nutrient constraint.



Spatial distribution of different nutrient constraints in 7 states of north-east India

Leaf nutrient optima was computed as : 1.97-2.56% N, 0.09-0.10% P, 0.99-1.93% K, 1.97-2.49% Ca, 0.24-0.48% Mg, 85-249 ppm Fe, 43-88 ppm Mn, 3-14 ppm Cu and 17-27 ppm Zn in relation to targeted fruit yield of 33-56 kg/tree using DRIS-based analysis. Based on these indices, spatial distribution map of each nutrient constraint was combined together to obtain three most productivity citrus zones. The zone with no deficiency of Zn-Mg-P-N as Zone I (26-27^0 8-25′ 13-43" N latitude; 92^{0}23-59′ 0.82-43"E longitude), with an orchard productivity of 69-104 kg/tree and represented by Navgaon (Asom) and Rangpara (Asom) was identified as the best production zone, followed by Zone II (26-27^0 25-26′ 36-51" N latitude; 93^{0}23-58′ 2-21" E longitude) having no deficiency of Zn-P-N with an orchard productivity of 52-68 kg/tree, represented by Golpara (Asom), Mirik (Kalimpong), Lisa hills (Darjeeling), and Zone III (26-27^0 6-44′ 20-56" N latitude; 91-92^0 33-57′ 6-17" E longitude) with no deficiency of Zn-P, having orchard productivity of 23-51 kg/tree, represented by Shergaon, (Arunachal Pradesh), Dirang (Arunachal Pradesh) and Tenga valley (Arunachal Pradesh). Such production zones will be of huge advantage for the performance-based development of citrus industry under any geographical unit.

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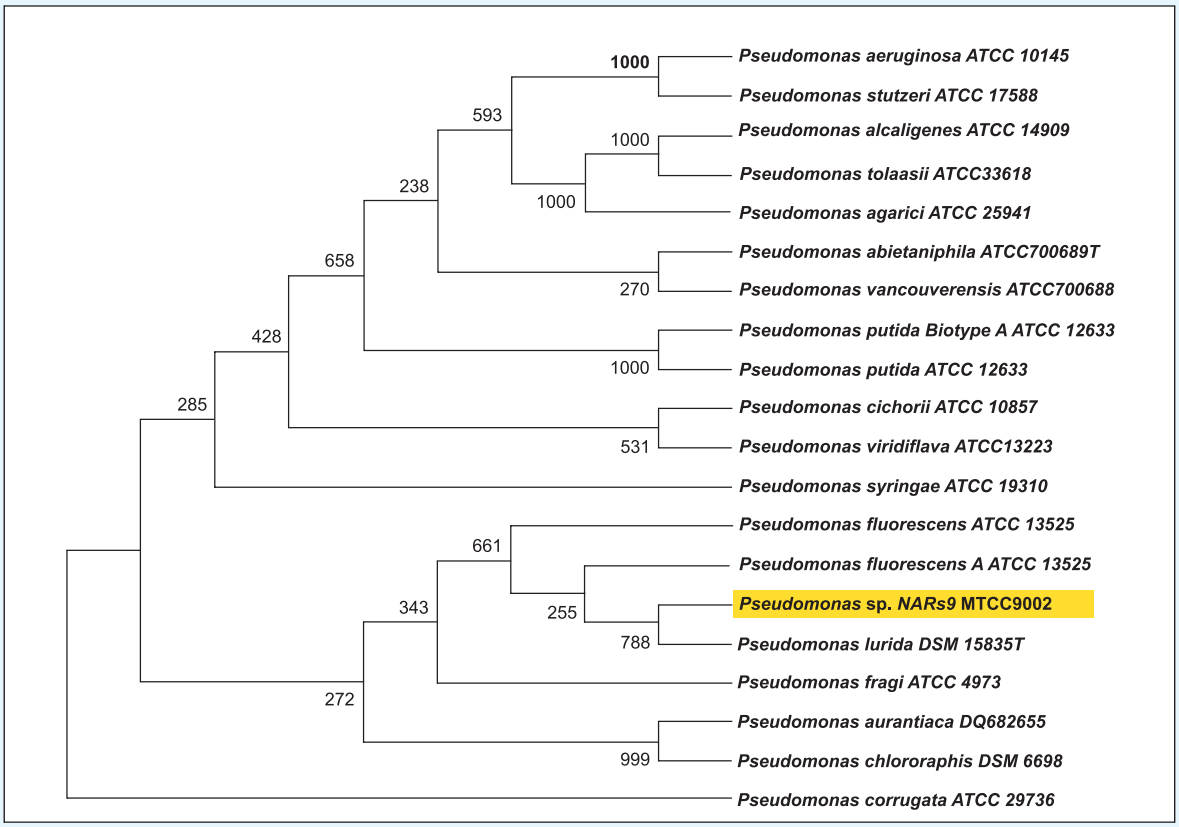
Novel cold-tolerant bacterium, *Pseudomonas lurida*-NARs9

A bacterium expressing plant-growth promotion traits was isolated from amaranth rhizosphere; cultivated at a high altitude of Uttarakhand in the North- Western Himalaya. This isolate has been found gram negative and its cells appear as rods (2.91µm x 0.71 µm). It grew at a temperature ranging from 4° to 30°C, with optimum growth at 28°C. It exhibited tolerance to a *p*H range of 5–10; optimum being 8.0, and salt concentration up to 6% (wt/vol). Although it was found sensitive to Rifampicin (R 20 µg/ml), Gentamicin (G 3 µg/ml), and Streptomycin (S 5 µg/ml), it showed resistance to higher concentrations of Ampicillin (A 500 µg/ml), Penicillin (P 300 µg/ml), Polymixin B sulphate (Pb 100 µg/ml) and Chloramphenicol (C 200 µg/ml). Its 16S rRNA sequence analysis revealed maximum identity with *Pseudomonas lurida*.



Phylogenetic tree showing relationship of *Pseudomonas lurida*-NARs 9 with other pseudomonads

Seed bacterization with this isolate enhanced germination, shoot length and root length of 30-day-old wheat seedlings by 19.2, 30.0 and 22.9% respectively, as compared to control.

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Germplasm collection of *Crotalaria*

Crotalaria shows largest diversity in tropical Africa, followed by South-east Asia and Central America. More than 113 taxa including 93 species occur in different eco-geographical regions of India. About 25 species are found economically important mainly for fibre and green manuring in the different parts of the country. Out of 50 species of Indian origin, 35 are endemic to peninsular region and temperate Himalaya; and 15 are reported rare and threatened.

The Bureau has collected over 400 accessions of cultivated and wild *Crotalaria* from different

phytogeographical regions of the country. Germplasm augmented through crop-specific and multi-crop explorations in areas of diversity mostly represent cultivars variability in plant morphology, period of maturity, resistance to diseases and pests and quality of fibre. Recent field surveys and exploratory studies undertaken were from parts of Uttar Pradesh, Punjab, Haryana and Bundelkhand (Madhya Pradesh).

C. tetragona

C. micans

C. spectabilis

Economically important *Crotalaria*

Species	Distribution (India; world)	Uses
C. alata Buch.-Ham. ex D. Don	North-western Himalaya to Khasi hills, southern peninsula; Indonesia (OC)	Green manure, animal feed, fence/hedge, medicinal
C. albida Heyne ex Roth.	Tropical India and Himalaya; Malaysia, China and Philippines	Green manure, root purgative
C. berteroana DC.	Karnataka, Maharashtra, Tamil Nadu; islands of Indian ocean; naturalized elsewhere (OC)	Ornamental
C. burhia Buch.-Ham.	NW India; Afghanistan, Sahara desert (OC)	Fibre, forage, medicinal
C. ferruginea Grah. ex Benth.	Asom; Philippines and Java	Forage, green manure
C. grahamiana W.& A.	Peninsular India (OC)	Cover crop on wavy ranges
C. incana L.	North-western Himalaya (Kumaon 3,500m); Sri Lanka, Malayan peninsula, tropical Africa and America (OC)	Green manure, cover crop, forage
C. juncea L. *	Widely grown throughout India; tropical Asia (widely cultivated)	Fibre, edible flower, forage/ animal feed
C. laburnifolia L.	Western peninsula; Sri Lanka, Philippines and Malaysia (OC)	Manure, ornamental, medicinal
C. leschenaultii DC.	Nilgiris and highest Ghats of Konkan	Fibre, green manure
C. medicaginea Lam.	Western Himalaya to Sri Lanka; China, Afghanistan and America (OC)	Forage
C. micans Link	North-eastern region (naturalized); tropical America (OC)	Green manure, animal feed/ forage, leaf edible
C. occulta R. Grah.	Khasi hills, Silhet (OC)	Ornamental
C. pallida Aiton*	Himalaya; tropical regions of Africa, America and Malayan Peninsula (OC)	Fibre, green manure, cover crop, seeds as coffee, black dye
C. prostrata Rottl. ex Willd.	Upper Gangetic Plains to peninsular India; Indonesia	Medicinal

(Continued)

Species	Distribution (India; world)	Uses
C. quinquefolia L.	Tropical Asia; Australia (OC)	Green manure, cover crop
*C. retusa** L.	Throughout tropical India, NW Himalaya; Malacca (OC)	Fibre, medicinal, green manure, cover crop, forage, leaf edible, fish poison
C. semperflorens Vent.	Tropical regions of peninsular India, Nilgiris; Indonesia (EC)	Green manure, soil binder
C. shevaroyensis Gamble	Endemic; Hills in Tamil Nadu (EC)	Ornamental
C. spectabilis Roth.*	Throughout tropical India, NW Himalaya; Malacca (OC)	Fibre, ornamental, green manure/ cover crop
C. subperfoliata Wight	Endemic; Andhra Pradesh, Kerala, Tamil Nadu (OC)	Green manure in paddy fields
C. tetragona Roxb. ex Andr.	Himalaya including foot hills; tropical Asia (OC)	Flower edible
C. trifoliastrum Willd.	Asom, Western peninsula	Forage, medicinal
C. triquetra Dalz.	Rajasthan, Western peninsula; Sri Lanka	Green manure, forage
C. verrucosa L.	North-western Himalaya; Sri Lanka; China; tropical Africa and America (OC)	Green manure, soil binder, medicinal
C. walkeri Arn.	Peninsular India; Sri Lanka (OC)	Soil binder

*,Species with commercial value; C, cultivated; W, wild; OC, occasionally cultivated; EC, experimental cultivation

On the basis of the analysis of the diversity distribution of *Crotalaria*, two regions, the Peninsular and the Eastern region, have been pinpointed. The priority areas for germplasm collection are parts of Bihar, Madhya Pradesh, Maharashtra, Rajasthan, Odisha and Uttar Pradesh for *C. juncea*; peninsular and north-eastern region for wild taxa (including endemic species); and Indus-plains and Deccan region for rare types in the cultivated taxa.

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Resource conservation in eroded Shiwaliks

To evolve sustainable, economically viable and eco-friendly organic farming systems, studies were undertaken with 2 crop rotations (soybean–wheat and Popcorn-tomato) using different combinations of compost, vermi-compost, biofertilizers and inorganic fertilizers. In soybean-wheat rotation, highest soybean yields of 0.7 tonne/ha was obtained under integrated nutrient management (compost/vermi-compost + fertilizers + biofertilizers) and 0.8 tonne/ha with 100% inorganic fertilizers in the first cropping year (2007-08). During the second year, soybean yields almost doubled with highest yields of 1.6 tonnes/ha under pure organic system (compost + biofertilizers), followed by integrated treatments (1.48 tonnes/ha). Overall root nodulation also improved significantly with the application of the inoculate in combination with compost or vermi-compost. Wheat yields were found highest in the integrated treatments during both the years.

In soybean-wheat, maximum moisture in the soil profile was found in compost or vermi-compost treatment; in deeper layers, there was better infiltration owing to improved soil structure. About 50% reduction in runoff and improved water retention were observed in vermi-compost treated plots as compared to control plots. Under popcorn-tomato rotation, even though such reductions in runoff and soil loss were not observed, but soil moisture retention was found maximum in compost and vermi-compost. These results indicate that proper combination of organic composts, biofertilizers and crop rotations can help in restoring soil fertility and productivity, and also in reducing erosion and improving soil-water balance to combat adverse effects of draught and climate change.

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Central Agricultural Research Institute: *in the Service of Island Farmers,* Port Blair

The Central Agricultural Research Institute was established on 23 June 1978 by merging different regional research stations of the Indian Council of Agricultural Research, situated at Andaman and Nicobar Islands. Since then, the CARI is working for the farming community of these Islands. The multidisciplinary Institute is well served by the dynamic young minds specialized in 22 disciplines of the agricultural research service.

In the last three years, scientists of the institute have attracted a large number of externally funded projects worth of Rs 120 million. The total annual budget of the externally funded projects amounts to over Rs 30 million, which is close to 27 % of the Institute's allocated (plan and non-plan) budget.

The average of publications of the scientists in the International and national journals is 0.5 and 0.6 per scientist, and for other publications is over 4 per scientist. And over 50 % of the articles published in the journals are with the NAAS rating of above 5.

Owing to the continued efforts of the multidisciplinary teams of scientists, some farmers have become entrepreneurs and are earning decent livelihood through agriculture and allied sectors. These farmers/ farm women have now become role-model for the unemployed youth of the area. *Institute's five success stories, out of a dozen, have been included in the Coffee Table Book "Harvest of Hope"* on the 101 Success Stories from all over the country, published by the Ministry of Agriculture, Government of India, New Delhi (*see* website (http://cari.res.in).

During the last five years, CARI scientists have received 6 National Awards; 11 Society Awards; 3 State Awards; 8 Other Awards; 8 Best Paper Awards and 8 Best Poster Awards.

REACHING-OUT TO FARMERS

- The CARI conducted demonstrations for broad-bed and furrow system, drip irrigation, tank-cum-well system and integrated farming system for twelve farmers each in the South Andaman, Neil Island, Havelock the Island and little Andaman.
- To reach farmers, an Out-Reach Centre funded by the NABARD was established at Diglipur. This centre

Field demonstrations under FPARP

Policy Development

A number of brainstorming sessions were organized on different aspects, and on the basis of the recommendations emerged out during these sessions, four policy papers were formulated for the Islands, which were given due weightage by the Andaman and Nicobar Administration also. These are: Water Policy for Union Territory of Andaman and Nicobar Islands; Status and Future Strategies for Horticulture Development in the Islands; Development of Island Fisheries; Biodiversity Conservation, and Environmental Biotechnology

Kisan mela

became operational from 15 July 2009. And one more at Campbell Bay is in progress.

- The ICAR has sanctioned one KVK in Nicobar district, and another KVK in the North and Middle Andaman district has been sanctioned in principle.
- The CARI has reoriented its fourteen technologies into **'Micro Business Module',** and has brought out a publication, which is being used by farmers for preparing project report to avail credit facilities from banks.
- The institute publishes 'KRISHI SANDESH' which guides impending farm activities of the month.
- The institute has prepared twelve video-films on different technologies.

MAJOR ACHIEVEMENTS

- Developed and released five varieties of medium-duration rice; out of which two are salt-tolerant; four varieties of coconut—specific for copra, coconut water and ornamental purposes; two varieties of sweet-potato.

New Initiatives

The Institute has taken up following new research initiatives.

- Assessment of impact of climate change on the Island ecosystem with special reference to Nicobar group of Islands.
- Estimation of carrying capacity of Islands under constraints of limited cultivable land resources and fragile ecology.
- Design of irrigation systems for various farming and topographic situations along with nutrient and water schedules for fruits and vegetables.
- Introduction of table purpose *rabi* groundnut along with seed production facility during *kharif* to facilitate a total livelihood chain.
- Evaluation of existing long-duration paddy varieties (160-170 days) as well as breeding programme for new strains to take advantage of long rainy season and adding fodder component in pre-and post- paddy period to enhance cropping intensity to 300% in rainfed areas.
- Germplasm collection of minor fruits—Rambutan, Durian, Mangostean, Wild Cashew, West Indian Cherry etc.
- Micropropagation of orchids, ferns and medicinal plants.
- Intensification of work on flowers, banana, papaya, pineapple, off-season mango and mushroom.
- Evaluation of tropical potato varieties, both TPS and tuber at Diglipur (North Andaman).
- Black pepper village with black pepper on *Gliricidia* and its value-addition through proper cleaning, grading and packaging.
- Cage cultivation of groupers and seabass in creeks and bays to enhance livelihood options.
- Introduction of buffaloes and management practices for indigenous cattle.

- Developed rainwater management technologies for water resource development in valleys, mid-hills and hill tops for irrigation and domestic purposes.
- Introduced Water User Association (WUA) to create and manage water resources in a participatory mode.
- Developed rice-based multiple cropping systems with maize, sorghum and pulses
- Identified *Morinda citrifolia* (Noni), a medicinal plant, suitable for tsunami-affected lands.
- Identified Nicobari fowl as most productive, disease-resistant indigenous poultry species, and developed its two genetically improved strains Nicorock and Nishibari that attain weight of 1 kg in 16 weeks and lay 150-170 eggs/ year.

Rice varieties

- Developed technology for crop diversification to grow vegetables, fish and fodder in lowland areas, using broad-bed furrow system.
- Soil map for Andaman district has been prepared.
- Developed cross-bred goat, by crossing Boer goat and local Andaman Black, which gave 30 % more body weight.
- Disease map of livestock and poultry has been prepared.
- Database on disease monitoring and forecasting system has been developed.
- Standardized technology for induced breeding of tiger prawns.
- Developed captive breeding technology for marine ornamental clown anemone fish.
- Generated information on mangrove biodiversity and ecology.
- Developed low-cost coconut de-husker, biomass fired dryer and solar dryer.
- Found 5 local strains of *Pseudomonas* species, which proved effective as biocontrol agents against pathogens of solanaceous vegetables.
- Documented diverse fishery resources of A&N Islands.

THRUST AREAS/VISION OF XI PLAN

The Islands economy has undergone a sea-change in the recent-past. From forest-based and government-job-based economy, it has shifted to tourism-based economy. This shift requires a rethinking to meet emerging challenges of inclusive growth and sustainable economy. And following are pointers to reorientation:

- As Island-level food security is not achievable, Panchayat-level food requirement should be estimated, and food production planning needs to be tailored to provide local-level food security; with town area being served by food imports from the mainland.
- Reorientation of agricultural production system to provide local-level food security and to meet demand of perishable products, *viz*. milk, egg, meat, fish, fruits, vegetables and flowers with specific reference to demand of booming tourism industry.
- Making isolation as the strength, conversion of spices cultivation to organic farming with a decoratively packaged Andaman brand organic spices.
- Development of suitable production to consumption level chain, involving SHGs and retailers / armed forces / processors.
- Biodiversity richness of the Islands is to be preserved and exploited for the national benefit.
- To develop proper rainwater management technology to create micro-level water resources to increase irrigated area from the 3% of the present.

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Weed-tolerant rice and groundnut

Rice ORS 102-4 in *kharif* and Ghanteswari in *rabi* recorded high tolerance to weed infestation. Similarly, groundnut TMV 2 recorded highest yield potential and weed tolerance. The threshold weed population limit for economic losses for groundnut was 125 and 25 weed-plants/m^2 at 30 days of crop in *kharif* and *rabi*. Women's participation in weeding, particularly in hilly areas, is as high as 83%, and they remain engaged in weeding for about 11 hours a day. Popularization of weed-tolerant varieties ORS 102-4 and Ghanteswari of rice and TMV 2 and Smruti of groundnut may reduce drudgery of farming women to a great extent.


Smruti groundnut

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Varietal Releases

VPKAS, Almora

Wheat VL Gehun 907

VL Gehun 907 (VW9365// PBW343), a nutritionally-rich high-yielding, disease-resistant variety with good chapati quality, has been notified by the Central Sub-Committee on Crop Standards, Notifications and Release of Varieties (CSCSNRV), New Delhi, for rainfed and irrigated timely sown conditions of hills of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Manipur and West Bengal.

VL Gehun 907 at physiological maturity

It has shown an overall yield superiority of 18.0, 24.2, 16.4% in rainfed and 15.9, 11.0, 5.9% in irrigated areas over checks HS 240, VL 738 and VL 804. It is found resistant to brown and yellow rusts, and possesses higher resistance against most virulent yellow rust pathotypes 46S119 and 78S84 under natural as well as artificial epiphytotic conditions.

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Horsegram VLG 19

This variety released by the CSCSNRV has recorded 14.39% yield superiority over the best check AK 42; 16.62% over PHG 9 and 25.98% over AK 21.

It has showed better digestibility (83.47%) than AK 42 (82.35%), PHG 9 (81.80%) and AK 21 (79.83%). VLG 19 is found resistant to anthracnose and root-rot; and moderately resistant to collar rot, powdery

VLG 19

mildew and leaf-spot.

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MPKV, Rahuri

Six new varieties have been released during the Joint Agricultural Research and Development Committee Meeting-2010 of the SAUs of the Maharashtra at the DBSKKV, Dapoli.

Rabi Sorghum Phule Revati

In irrigated areas, Phule Revati gave 4.6 tonnes/ha, which was 41.8% higher than CSV 18 (3.2 tonnes/ha),

21.4 % over Phule Yashoda (3.78 tonnes/ha.), 16.1% over Phule Vasudha (3.9 tonnes/ha), 35.2% over Maldandi (3.4 tonnes/ha), 19.8% over PKV Kranti (3.8 tonnes/ha) and 35.3% over Parbhani Moti (3.4 tonnes/ha). Its fodder yield in the areas was 115 tonnes/ha, which was 16.1% higher than CSV 18 (9.9 tonnes/ha), 15.9% over Phule Yashoda (9.9 tonnes/ha), 16.2% over Phule Vasudha (9.92 tonnes/ha), 20.6% over Maldandi (9.56 tonnes/ha), 16.5% over PKV Kranti (9.9 tonnes/ha) and 19.6% over Parbhani Moti (9.6 tonnes/ha).

It has bold grains of pearly-white colour, and has better chapati-making quality. It is recommended for cultivation in irrigated areas during *rabi* on deep-black soils of western Maharashtra.

Rabi Sorghum Phule Panchami

Sorghum Phule Panchami has been found superior in grain-popping quality (87.4 %) as compared to Khandesh Local 1 (14.2%) and Jabalpur Local 2 (54.4%).

It has superior, extra large, whitish and fully-opened pops as compared to other checks. It is found tolerant to shoot-fly and charcoal-rot. It is recommended for release during *rabi* in rainfed areas of Maharashtra.

Sesame JLT 408

It gave 787 kg of seeds/ha which was 29.9% higher than check JLT 7 (606 kg/ha) and 20.8% than JLT 26 (630 kg/ha) in rainfed areas. This variety has showed medium maturity (81-85 days) and has white bold seeds, with higher oil content (53.2%) compared with JLT 7 (49.7%) and JLT 26 (49.2%). It is recommended for release for *kharif* in assured rainfall zone of Khandesh and adjoining areas of Vidarbha and Marathwada.

Safflower SSF 708

It recorded highest seed yield under rainfed (1,376kg/ha) as well as under protective irrigation (2,275 kg/ha), and was found superior over check Phule Kusuma (1107;1,898 kg/ha) and Bhima (1,131; 1,631kg/ha) by 19.57, 22.44% and 19.85, 37.64%. It showed higher oil content of 29.1%. It is recommended for release under rainfed as well as protective irrigation in western Maharashtra.

Grain-Amaranth Phule Kartiki

This gave higher yields (1,056 and 1,621 kg/ha) during *kharif* and *rabi*; 33.11% and 36.46% higher than national check GA 1 (794 and 1,188 kg/ha), and by 10.89% and 42.83 % higher than Suvarna (953 and 1,135 kg/ha).

Grain-amaranth phule Kartiki

It is tall and erect growing variety with yellowish-green and straight inflorescence. It is recommended for *kharif* and *rabi* in western Maharashtra.

Phule Priya (RHRP 87)

It gave highest green pod yield (9.8 tonnes/ha) over checks, Arkel (5.3 tonnes/ha), pH 1 (6.7 tonnes/ha), NDVP 8 (6.6 tonnes/ha) and Swarna Mukti (7.2 tonnes/ha) by 85.55, 46.98, 49.58 and 37.19%, respectively. It is found tolerant to pod- eating caterpillar and powdery mildew. Its pods are green, attractive with 8-10 seeds in each pod that are sweet in taste. It is recommended for cultivation in western Maharashtra during *rabi*.

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Crop-logging models in banana Ney Poovan

In perennial crops like banana, with growth spread over months, several plant biometrical characters, apart from ecological variables, influence yield. Hence, identification of best yield indicators across different growth stages along with their required optimum values will help researchers to enhance crop productivity, and also to have streamlined control over crop growth. Such optimized best indicators, in turn, will boost crop productivity by targeting specific biometrical variables. A system of "crop-logging" models has been developed by employing statistical modelling. Primary sample surveys were conducted during December 2003 – February 2005 (I year database) and December 2006 – March 2008 (II year database) at the farmers' fields located at Kestur, Bengaluru.

The stochastic models developed with identically and independently distributed (i.i.d) white noise, revealed that 48 cm of leaf length and 37 cm of plant height at 71 days after planting (DAP) (after sucker emergence and before inflorescence), 64.5 cm of leaf length and 10 leaves at 144 DAP (initiation of male flower), 90 cm of leaf length and 36 cm of leaf breadth at 207 DAP (development of pulp), 13 leaves and 41 cm of leaf breadth at 260 DAP (starch accumulation in pulp), 42.5 cm of leaf breadth and 14 leaves at 326 DAP (degradation of chlorophyll molecule from fruit skin), 51cm of plant girth at 380 DAP (fruit development) are best indicators of crop yield. The prediction power of the crop-logging models has been worked out at 93.6% - 96%. Validation test based on the second year results revealed that 59 cm of leaf length and 25 cm of plant girth at 75 DAP; 74 cm of leaf length and 13 leaves at 150 DAP; 112 cm of leaf length, 36 cm of leaf breadth and 15 leaves at 240 DAP and 52 cm of plant girth and 18 leaves at 370 DAP were best indicators of crop yield. These models generated significant yield indicators of crop growth during their respective stages along with the computed optimum values would go a long-way in formulating suitable management strategies, not only to achieve sustainable crop production but also to enhance crop productivity. These results may also be useful as one of the effective inputs while framing management strategies for precision farming of the crop.

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Heap storage for coping market glut of potato

In northern plains, during potato harvesting in January-February, arrivals in market are huge, creating glut-like situation, and prices fetched for them turn out to be very low. Potato prices increase rapidly in April-May, and are almost double in June-July.

If the surplus potatoes can be stored on-farm itself for a short period, proper profits can be reaped.

An improved heap-storage technology has been developed with the use of sprout inhibitor CIPC (isopropyl N-(3-chlorophenyl) carbamate). With this, farmers can keep potatoes in heaps at farms for 3-4 months at a lower storage cost of Rs 150-200/tonne and can fetch 50-60% higher market rate than the rates when sold at harvesting. These prices are comparable to cold-stored potatoes. Normal cold storage rent varies from Rs 1,600-1,800/tonne of potatoes, besides farmer has to incur an additional expenditure on transportation of the produce.

Well sorted-out fully mature potatoes with proper skin are spread in thin layers on the ground under shade of trees, thatched sheds or high tin/asbestos shed. Perforated plastic pipes of 10-15 cm (4-6 inches) diameter are placed at the base and 40 ml of CIPC in 1 litre of commercial grade methanol is sprayed uniformly on one tonne of potatoes to cover exposed surface. Spraying process is repeated with each layer of tubers and after the treatment, the potatoes are collected in a conical heap and are then covered with 1.5-to 2-feet thick layer of rice straw (*pural*). Heap size can vary depending upon the quantity of potatoes stored but the height should not exceed 1.5 m.

Low temperature (below 30°C) and consistently high relative humidity (60-95%) inside the heap during

March-June help reducing losses in potatoes (outside maximum temperature is generally in the range of 40-44°C and humidity varies from 30 to 70% during this period). The CIPC-treated potatoes remain sprout-free and firm with reduced total losses (5-6%) up to first week of June, and untreated potatoes with multiple sprouts appear much shrivelled leading to higher losses (11-12%).

Potatoes stored in heaps are not sweet in taste due to low sugar content, and they fetch higher price owing to good taste. They are suitable for processing industry and farmers can also get higher prices by selling their produce to potato-processors. These potatoes are safe for human consumption as CIPC residues in peels of stored potatoes (2-4 ppm) are far below the permissible levels (10 ppm).

With this storage technology, potato-processing industries can also get suitable raw material up to 3-4 months after harvest at comparatively lower rates.

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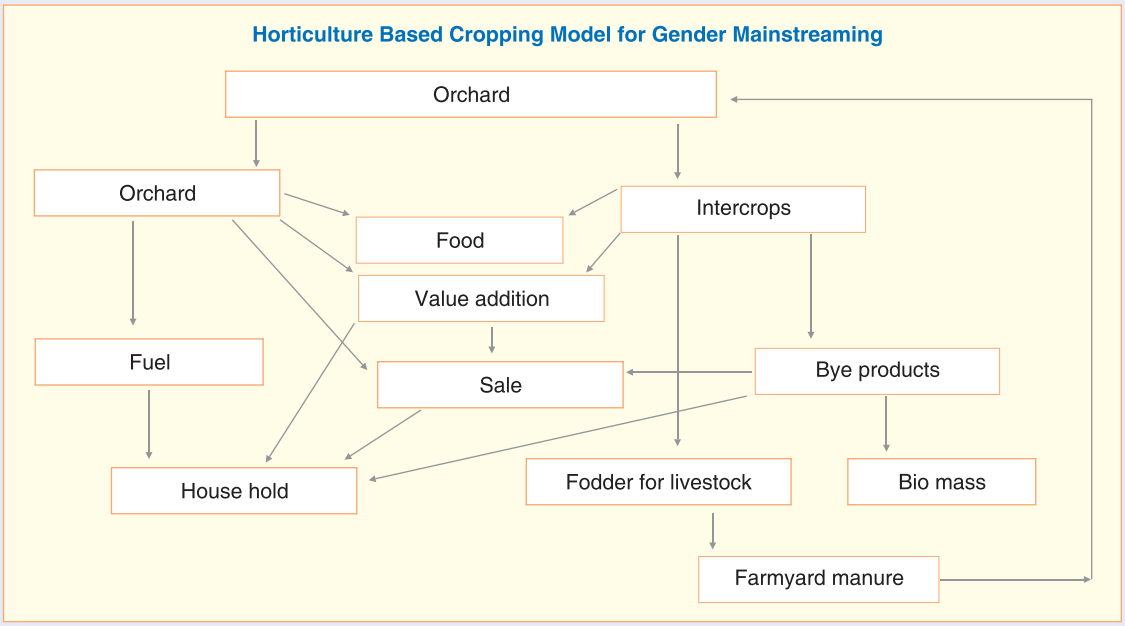
Six- F model for horticultural crops

Horticultural crops play an important role in revitalizing rural economy, as this can provide employment, as being labour-intensive, and can also contribute for the nutritional security, particularly of the miconutrients and vitamins. An integrated system with several crop combinations to maximize production of nutrient rich-food, fuel and fodder along with increased income and employment generation would ensure a sustainable development of farm-families and would also give additional opportunities to farmwomen. Considering this, various horticulture-based cropping models — mango-based, guava-based, minor fruits-based, coconut-based, cashew-based and horti-silvi postural models were laid out. More than 25 intercrops, including vegetables, short-duration fruit crops, flowers, aromatic plants, fodder crops and root crops were planted among these crops. Crop combinations were selected in such a manner that they could fulfill food, fuel, fodder, financial needs of a farm family. Initial evaluation of the models have revealed that fruits, vegetables, flower, fuel and fodder production in these models can provide employment and income generation through fresh sale as well as through value- addition. These models help in generating '6Fs' of sustainability—food, fodder, fuel, feed, fibre and finance.



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Chemical-free, hand-made paper from date-palm leaves

The total domestic demand for paper in India is 7.2 million tonnes and production is only 6.7 million tonnes. It is high time to think for a viable alternative for production of pulp and paper.

Date-palm leaf (sustainable agri-residue) is an excellent raw material for making pulp and paper of various grades, owing to the presence of high alpha cellulose (50-55%), hemicellulose (26-30%) and ultimate fibre-length (1.25 - 2.50 mm).

Paper by mechanical pulping: Leaves of date-palm were chopped to 1 – 1.5 cm and kept in plain-water for 24 hours at room temperature to soften them and clean them to reduce energy consumption in softening chips prior to beating operation; unlike thermo-mechanical (™) pulping from logs. Water was poured in the beater machine (electrically driven) till half of the tank (oval-cemented shape) filled with water. Ratio of liquid : raw material was maintained at 1 : 10. Small chips floated in water partly around the beater. Mechanical process to break down date-palm leaves chips into pulp required no chemicals; it happened owing to mechanical action of the fine-toothed saw between the base plate and rotating fine toothed saw around beater arms.

For recycling chips, foreign material inside the chips and lignin in the leaf cells were broken and partially removed. Since lignin was not fully removed, the yield of the pulp-exhibited was relatively high, about 90-95%. Pulp prepared by mechanical process is often used for making newspaper, carry-bag, fine-cover and other non-permanent goods, writing pad, greeting cards etc.

Fibres are hydrated mechanically during beating process. When beating proceeds, internal film structure loosens and fibres swell rapidly twice to the original diameter. Swollen hemicellulose on the fibres surface actively forms bonds between fibres in the paper sheet, acts as a glue. The more surface material swells and partly dissolves in water, the stronger is the surface tension force when drying and larger will be the area of contact between fibres

leading to formation of a strong-and-even surfaced sheet.

Sheet formation: Pulp slurry (after two hours of beating) is drained out through attached delivery pipe to another blow-tank made of cement where pulp mixture (if blending of pulp is required) is diluted further resulting in a very thin slurry. The slurry is drained through a fine wire-mesh screen to form fibrous web of a particular size and collected as the web-sheet on the nylon cloth and subsequently stacked over one another.

Pressure may be applied (manually) to remove additional water in a squeezing instrument. The paper may then be removed from the mould for further processing. Natural drying of sheets can be done either by clipping vertically or horizontally on the ground surface. Finally trimming and calendaring makes paper glossy and even surfaced.

Mechanical pulping process is cost-effective and is environment friendly. Main target is to gear-up hand-made paper technology for rural sectors. Also low capital investment is required to dispose of date-palm leaves available in most of the states of India.

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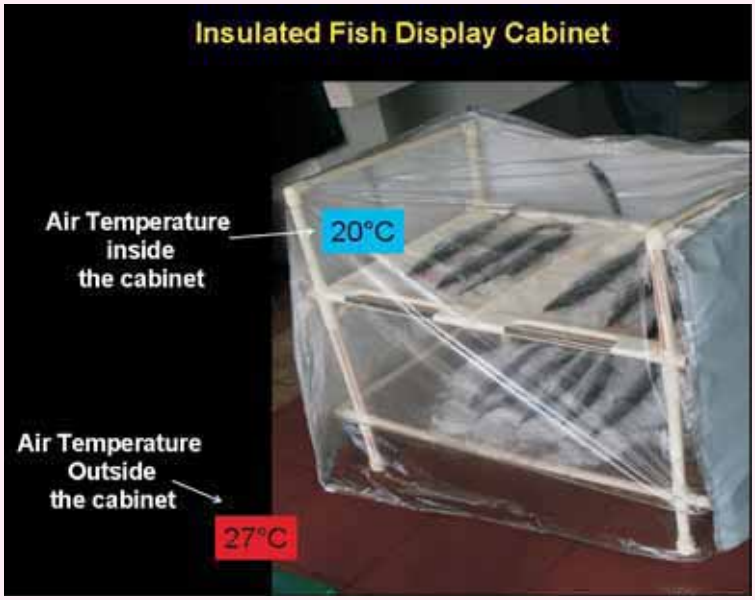
Insulated fish-display cabinet for fish-market

Improper handling of fish accounts for huge post-harvest losses. Temperature abuse is the single most important factor responsible for quality loss of fresh fishes. Generally, in urban retail markets fishes are displayed in planks, exposing them to dirt and flies. Moreover, ice used to prevent spoilage melts faster when exposed directly to outside air.



To address these problems, an insulated fish-display cabinet has been designed and fabricated. This display cabinet is a dismantable unit with 2 racks on which plastic trays can be placed for keeping fish and ice. The front portion of the display cabinet is made of transparent material. Sides are covered with three-layered insulation (outer cotton coated rexin, middle thermofoam and inner plastic sheet) to slow down melting of ice and also to prevent contamination from dust and flies. Air temperature inside the cabinet remains at 20°C, much lower than the room temperature (27-31°C). Use of these display cabinets in local fish markets by fisherwomen vendors will go a long way in improving sanitary and hygienic conditions in the fish-markets.

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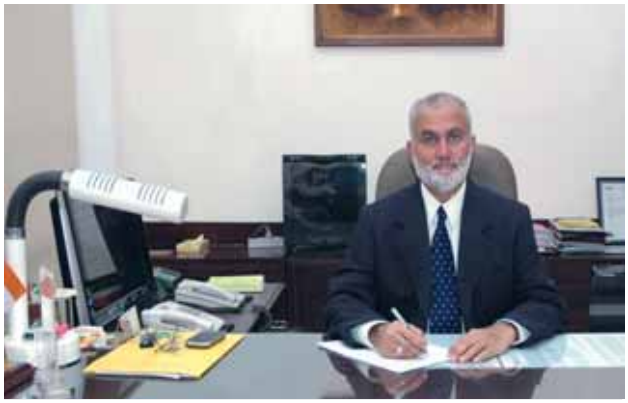
WAY FORWARD

Tropical root and tuber crops serve as the secondary or subsidiary staple for about one-fifth of world's population, and are the third important group of crops after cereals and pulses. Cassava, sweet-potato, aroids(taro, tannia), elephant-foot yam, yams (lesser yam, greater yam and African or white yam), country or Chinese potato and yam-bean are important ones among them. While cassava predominates in Tamil Nadu, Kerala and Andhra Pradesh, sweet-potato dominates in Odisha, followed by Bihar and Uttar Pradesh. Yams and aroids are grown as semi-commercial scale crops in various states. And elephant-foot yam, owing to its growing demand as a healthy vegetable, is gaining importance in most of the states. Cassava productivity in India is 30 tonnes/ha, the highest in the world. Sweet-potato yields only 9 tonnes/ha, compared to 15-18 tonnes ha of China, indicating need to improve its production and management practices.

In spite of increasing foodgrains production and availability, their net shortage of nearly 26 million tonnes is anticipated by 2020 in the country; equalling to about 80 tonnes of root and tuber crops. Tropical tuber crops are efficient converters of solar energy with cassava producing 250 x 10^3 kcal/ ha and sweet-potato producing 240 x 10^3 kcal/ha; higher than cereals, and hence they have significant role as the food security crops.

Besides starch, most tuber crops are rich in calcium and vitamins, and a computation of the Recommended Dietary Allowance has showed that cassava and sweet-potato supply more calcium and vitamin A than is required. Orange-fleshed sweet-potato cultivars, Sree Kanaka and ST14, with high β carotene content are cheap source of vitamin A, and their promotion in homestead gardening and for household utilization can improve vitamin A status of children and pregnant women. Sree Karthika is the latest selection (30 tonnes/ha) with compact tubers and good cooking quality. And Sree Kiran, the first genetically improved hybrid taro, has been released in India with longer shelf-life.

A wide variety of instant and ready-to-eat food products – fried snacks, incorporating cassava flour, extruded puffed snacks with very low fat content, cassava semolina, sweet-potato based *gulab-jamun* mix, sweet-potato jam, pickle, sauce can be prepared from these crops. Anticipating projected growth of functional food market to Rs 2,000 million in the next 2-3 years in India, a host of functional foods like protein and dietary-fibre-enriched pasta from sweet-potato and cassava, high protein mini-*papads*, and nutraceutically fortified extruded snacks have been developed. New products: low glycaemic noodles and spaghetti from sweet-potato; low calorie sago and sweeteners from cassava are also being formulated.



Dr S. Ayyappan, Secretary (DARE) and Director General (ICAR)

Earlier patented technology on bioethanol from cassava has been refined, making it cost-effective; new technology yields up to 680 litres of ethanol per tonne of cassava-starch. Industrial scope of tuber crops starches has been enhanced through development of gums, solid adhesives, superabsorbent polymers, cold-water miscible starches and edible biofilms.

Large coverage of cassava by high-yielding varieties,sustained demand of tubers by starch industries, and organized market support led to success of cassava cultivation in Tamil Nadu, and this model can be replicated in other states as well. Value-chain development will be an effective tool for integrating production, processing and marketing.

The impact projections suggest that these crops contribute to energy and nutrition requirement of over two billion people in the developing countries, and will continue to do so over the next two decades. To make this a reality, greater thrust is required in tuber crops research, by spreading their cultivation to non-traditional areas, projecting their nutritional and food security role, augmenting their utilization prospects by developing value-added functional foods, feed and industrial products and developing demand assessment strategies. Exploring hitherto under-explored areas like developing herbal products with medicinal effects, bio-insecticides, natural food colourants, low glycaemic and low calorie foods to combat life-style diseases like diabetes, obesity and cardiovascular problems would open up new avenues. There is also a need for developing high starch end-use specific cassava varieties and transgenic lines resistant to cassava mosaic disease. Nevertheless, the food security role of tuber crops, cassava and sweet-potato, either as a direct food source or indirectly through their use in animal, poultry and fish-rearing should not be overshadowed by their industrial importance; for tropical tuber crops are the right solution for food-deficit areas.

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