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A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Patch-budding in pomegranate – an easy *in-situ* budding technique

Pomegranate (*Punica granatum* Linn.) has occupied a remarkable position among the fruit-crops of the Deccan Plateau in India, especially in Maharashtra, Karnataka and Andhra Pradesh. It has mainly been propagated by air-layering and hardwood stem-cutting; and on a limited scale through tissue culture.

In the recent-past, some biotic and abiotic problems – bacterial blight, wilt, nematode, salinity and drought – have emerged in the crop. Their timely preventive measures are needed to sustain pomegranate industry in the Plateau. Therefore, a need arose to identify suitable rootstocks possessing resistance to biotic and abiotic stresses and also to standardize *in-situ* budding method. Since Western Himalayas is considered as one of the centres of origin of pomegranate, consistent efforts were made to collect maximum variability of wild types of pomegranate from Jammu and Kashmir, Himachal Pradesh and Uttarakhand to exploit them as rootstocks. Earlier wedge-grafting technique was standardized, but patch-budding technique has been found easy and better *in-situ* budding technique.

Patch-budding using 20 mm × 10 mm bud of cv. Bhagawa was done during February, which gave very high budding

Scion bud from cv. Bhagawa

Patch bud sprouts after budding on wild rootstock

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success (90-95%). In this method, bud sprouting took 25-40 days. Studies on different aspects of budding like compatibility, flowering, training, yield performance, tolerance to bacterial blight, wilt, internal breakdown, fruit cracking, salinity, drought are still to be done in the fields. Then this technique will be disseminated among growers.

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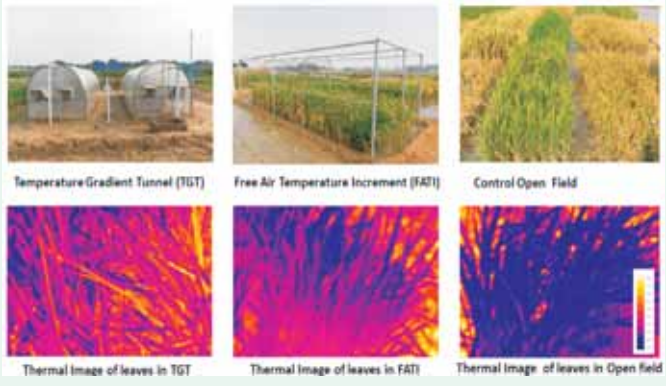
FATI technology to assess high temperature impact on rice-crop

Increases in the surface-air temperature at the end of the 21st century are predicted to be around 1.4–5.8°C, relative to temperatures of 1980-1999. Probably, there will be an increase in variability around this mean too. Thus, it becomes necessary to evaluate responses of crop-plants to high temperatures – estimate extent of effects on growth and yield of plants.



A Free Air Temperature Increment (FATI) technology has been developed to facilitate increase in canopy temperature in the fields. This technology does not involve any enclosures; it warms up the environment with infrared heaters in the open field conditions. All radiations below 800 nm are removed by selective cut-off filters to avoid undesirable photo-morphogenetic effects. By tracking ambient canopy temperature in a reference plot (unheated- control) with thermocouples using an electronic control circuit track, the radiant energy from the heater is modulated to produce a desired increment in the canopy temperature of an associated high-temperature stressed plot (with the options of continuous day and night or only in day or in night). This technology has been used for the first time to study high-temperature stress on the growth and the yield of rice-plants.

The effects were studied on twenty rice cultivars, grown under two different technologies – Free Air Temperature Increment (FATI) and Temperature Gradient Tunnel (TGT). These new technologies are necessary to characterize functioning of the plants in warmer climates.

The cultivars were exposed to 2°C above the ambient temperature. Rice-plants exposed to high temperature showed significant reductions in growth duration, Leaf Area Index (LAI), biomass, yield and Harvest Index (HI), along with substantial increases in spikelet sterility and membrane stability indices. Plants exposed under the FATI showed more decrease in LAI (15-20%) and plant height (15-22%), and lesser increases in spikelet sterility (14-18%) than those grown under the TGT technology.

These differences can be attributed to reduced light penetration, restricted air circulation and other associated changes in the microclimatic environment inside the TGT. Such changes are minimal or null in FATI technology; as is substantiated by the leaf temperature characterized by thermal images of the plant canopy.

This study clearly showed that without altering microclimate drastically, FATI can be used to study high temperature effects on the growth and yield of crop-plants. Nevertheless, further improvements are needed to warm plants for covering larger study area.

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In-vitro plantlets from endosperm to produce triploid seedless *mosambi*

In citrus-fruits, seedlessness is a desirable attribute, which determines their acceptability by consumers and by fruit-processing industry. Citrus triploids are potentially useful cultivars owing to their sterility and resultant seedlessness.

At present, *mosambi* is mainly consumed as a table-fruit, and only a little of its yield is being processed. Its seeds are the chief source of bitter principle, limonin; hence seedless cultivars are preferred by the processing industry. By regular breeding methods, development of seedless varieties is difficult due to long juvenility, incompatibility and high degree of apomixis.

Endosperm is a unique tissue of hybrid origin. Regeneration of triploids from hybrid endosperm can be a useful breeding tool in *Citrus*, a vegetatively propagated perennial fruit-crop, to overcome barriers of sexual hybridization.

A few promising trees of *Citrus sinensis* cv. *mosambi* were selected as a parent source to initiate experiments to standardize age/ stage of fruitlets (days after pollination) and to find out responsive endosperm for *in- vitro* culture. Around 1,500 fruitlets of *mosambi* were tagged during *mrig bahar* at the time of anthesis. Tagged open-pollinated fruits were harvested 70-100 days after anthesis for culture. Fruits were sterilized and fruitlets were dissected aseptically to excise seeds. The immature seeds were then washed, dried and peeled to excise endosperm.

Plantlet regeneration from hybrid

Callus formation was induced in endosperm in Murashige and Tucker (MT) medium. Maximum shoot bud and root differentiation was observed in MT along with $GA_{3.}$ *In-vitro* regenerated plants were transferred to liquid MS media with modified vitamins for strong rooting. The characteristics feature of the shoots of the endosperm origin is the presence of large number of multicellular glands/organ fasciations, where shoots appear to be fused. The experiments demonstrated feasibility of obtaining hybrid-plants via *in-vitro* somatic embryogenesis of endosperm-derived callus of *mosambi*.

The initial results from the study have indicated feasibility of plantlet regeneration from hybrid endosperm (natural triploid tissue) of *mosambi*; a single- step approach to triploid seedless *mosambi*.

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Compartmental bunding for rainfed black soils of the semi-arid tropics

Low yields of winter sorghum, chickpea, safflower and sunflower in the medium- to- deep black soils of the semi-arid dry region are attributed to low annual rainfall, i.e., around 500 mm and its poor distribution. This results in low soil-water availability in the soil profile from sowing to harvest. Nearly 10-20% of rainfall is also lost as runoff both prior to sowing and during the crop season.

Compartmental bunding

Generally bunds of 15-cm in height with compartment size of 10 m × 10 m in the cultivated lands with around 2% slope are formed after preliminary tillage operations during the second fortnight of June or the first fortnight of July for post-rainy (*rabi*) crops. Compartmental bunding increased yields of *kharif* (monsoon) and *rabi* (winter) crops by 5 to 35%, depending on the annual rainfall and its distribution at the Research farm of the CSWCRTI, Bellary.

The effect of bunding in increasing crop yields was higher during drought years as majority of the rainwater was conserved with the adoption of compartmental bunding as compared to the normal and above normal rainfall years. Its greater effect is observed in moisture-responsive crops/crop cultivars when they are cultivated during *rabi* season. In addition to higher yields, compartmental bunding also conserves top fertile soil. This low-cost compartmental bunding technology can be adopted by all farmers in the Vertisol (medium-to-deep black soils) regions of Akola and Sholapur districts in Maharashtra; Bijapur, Bagalkot, Gadag, Koppal, Haveri, Dharwad, Chitradurga and Bellary districts in Karnataka; Kurnool, Anantapur, Kadapa and Mehbubnagar districts in Andhra Pradesh and Dindigul district in Tamil Nadu, which fall under semi-arid region with <750 mm mean annual rainfall.

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Temperature-controlled phenotyping facility for developing wheat varieties under changing climate

Various studies are indicating an increased probability of losses in crop production in India due to anticipated rise in temperature by 2080-2110. Winter crops, like wheat, are more vulnerable, as temperature rise by one degree may bring down national wheat production by four million tonnes with the varieties grown at present. Hence, high temperature-resilient wheat varieties are important for research strategies to enhance adaption to changing climatic and ecological conditions. High temperature is one of the major stresses during grain-filling affecting wheat yield. Screening of thousands of wheat-germplasm is required for selecting high-temperature tolerant wheat-plants.

A novel facility has been designed that allows screening of several wheat-genotypes in a larger plot size (as in the fields) at a desired temperature at any stage of crop growth, while allowing plants to grow in the natural environment during the rest of the period. Motorized control units of this unique system allow roofs and walls to slide down to open structure during initial growth stages when weather usually is cool. It can serve as a perfect weather-controlled greenhouse during grain-growth phase with sliding roof and walls closed. With the focus on the desired growth stage of the wheat-plant, it exposes plant to natural environment during the rest of its life-cycle, thus minimizing cost of energy spent on controlling plant environment to the desired temperature. The size of the structure is approximately 100 feet by 35 feet, and two such structures are in operation at the Directorate of Wheat Research.

The temperature regulation in the structure is very precise and is linked to ambient temperature so that desired difference between the temperature inside and outside the structure is maintained in diurnal cycle during high-temperature treatment.

Lights and air-conditioners can be controlled either automatically or manually. Within 90 seconds, roof and windows can be automatically closed with a push button. It has a Programmable Logic Controller (PLC) for regulation of time of closing down of the roof and windows. Once the structure is closed, precise regulation of temperature, humidity and photoperiod is possible. Temperature of both the structures can be individually programmed from 0 to 10°C higher as compared to the ambient temperature.

Power supply for the structures is backed up by two separate electricity generators. Water-storage tank and heating system along with a housing facility for maintenance have been provided near the structures. The data logger system provides storage of temperature and humidity data, updated every 30 seconds, of both the structures and also of the ambient conditions. Archived data can be dis-played date-wise.

For increasing temperature, a boiler-based heating system has also been installed, in which warm water runs through network of pipelines hanging from roof with three inlets and outlets to avoid formation of temperature gradient. Inside structure is cooled through 16 air- conditioners, which are integrated and governed by the control panel. Mist system provides fine-water droplets to maintain required humidity level, and the drip system is for efficiently monitored irrigation.

Similar to closing, there is a mechanism to open the structures after the required temperature stress treatment is over. After the structure is open, the crop again is exposed to natural environment. This temperature controlled phenotyping facility would help identifying wheat-genotypes tolerant to abrupt temperature variations at different growth stages.

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Wealth from waste: Green Initiative

Worldwide consumption of paper has risen by 400% in the past 40 years, and 35% of the harvested trees are being used for paper manufacturing. The available data show that it takes 24 medium to large trees to make a tonne of paper. It has been estimated that by 2020 paper mills will produce almost 500,000,000 tonnes of paper and paperboard per year; hence efforts are required to ensure that the environment is protected during the production, use and recycling/disposal of this enormous volume of the material. Pulp and paper otherwise also is the third largest industrial polluter to air, water and land. Paper waste like other wastes have additional hazards of toxic inks, dyes and polymers that could potentially be carcinogenic when incinerated, or mixed with groundwater *via* traditional burial method such as modern landfills. Paper recycling may mitigate this impact, but not environmental and economic impacts of the energy consumed for manufacturing, transporting and burying and/ or reprocessing paper products.

Value-added products from recycled paper: To add value to the recycled paper from the recycling unit of the IARI further, a technology has been standardized to make petal-embedded paper from the used petals of rose, chrysanthemum, marigold and even mowed clippings of lawn-grass.

In addition, protocols for making different value-added products like photo-frames, greeting cards, carry- bags, file-covers and laminated dining table-mats have been standardized.

The technology is now integrated with dry-flower technology to make a number of value-added products. The petal-embedded paper is being supplied to farm-women identified in the four IARI -adopted villages in the NCR region to make different value-added products.

Training programmes on paper recycling and making of a number of products have been imparted to different stakeholders. The training programmes were organized through ZTM&BPD Unit of the IARI for the first generation entrepreneurs.

A paper recycling unit has been created at the IARI. Where used paper is torn and made into small pieces and soaked in water overnight. Wet paper is loaded into a motorized Hydrapulper (6 kg) for 20 min. to make paper as fine pulp. The pulp is then spread on to the mesh of Univat and distributed uniformly throughout. Then pulp is transferred on to a piece of wet muslin cloth by pressing mesh hard on the cloth surface. The sheets are placed one over the other to make a stack of at least 20-30 sheets. Such stacks are then placed under the Screw Press (Manual) to drain excess water from sheets and also to flatten them uniformly. The flattened sheets are dried under Sun/Shade for 12-24 hr depending on the season. The dried sheets of paper are passed through a motorized calendaring machine 2-3 times to flatten them completely. The rough edges are then trimmed with a manual cutter to give a perfect shape.

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Bycatch reduction device to reduce landings of hilsa juveniles in stationary bagnets

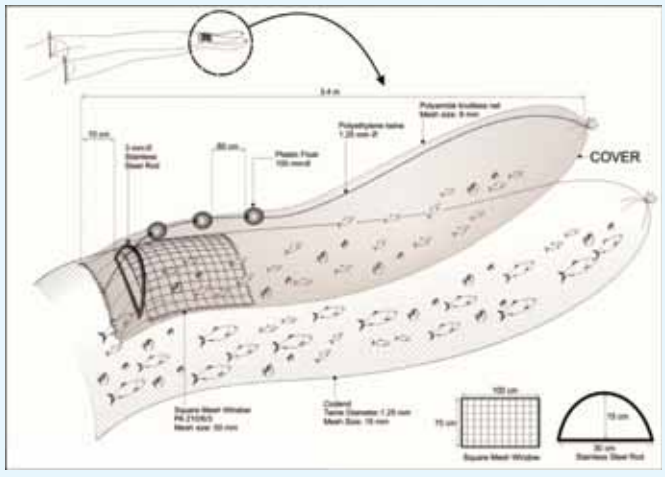
Hilsa shad, *Tenualosa ilisha*, is one of the costliest fishes in India, and was usually caught from sea and inland waters, mainly from the river Hooghly in West Bengal. It was also caught from the river Narmada in the south Gujarat. Stationary bagnets and Nylon monofilament gill-nets are the most popular fishing gears used for capturing hilsa along the inland waters.

There has been a decline in hilsa catches from West Bengal and Gujarat fishing grounds. As per the reports, decline in the overall rainfall or late arrival of rains, rise in sea level and increasing salinity are some of the climatic

shifts attributed for this reduced catches of hilsa.

Unregulated fishing practices, use of non-selective fishing gears and resulted mass destruction of juveniles, coupled with several other anthropogenic activities can adversely affect stocks. The estimated catch of hilsa juveniles from Hooghly estuary varied from 44.1 to 151.1 tonnes, averaging 85.1 tonnes per year with a size range of 6 to15.5 cm and weight 2.0 to 15.5 g. No management measures were being strictly followed for conservation of hilsa in India.

Stationary bagnets in Hooghly



Experimental bagnet (*Behundi Jaal*) with BRD

In view of this declining catches of hilsa, a study was undertaken to reduce capture of hilsa juveniles and of other commercially important fishes in the stationary bagnets.

A Bycatch Reduction Device (BRD) consisting of a square mesh window of 1m × 0.75m made of 50-mm mesh has been fixed near the cod- end of the bagnet as a technical measure to permit escapement of juveniles of hilsa and other commercially important species. Covers with very small mesh size are fixed over and on the top of the square mesh windows to retain and quantify juveniles escaping through window.

The experimental bagnets are under operation in Tribeni, Godakhali and Frasergunj in Hooghly river, West Bengal, and in Narmada river (Gujarat) at Bharbut, Bharuch, in a participatory mode. Results of the first round of experiments have showed encouraging results with good number of escapement of juveniles through the BRD. The experiment is in the preliminary stage and seasonal and temporal vari-ations in the catch and size classes need to be studied for optimizing mesh sizes and position of the BRD in the net for enhancing juvenile's escapement from bagnets.

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Off-season breeding of climbing perch, *Anabas testudineus*

Climbing perch, an air-breathing fish, has tremendous potential for farming in derelict and shallow water-bodies for enhancing fish production. The species, commonly known as Koi, is an organoleptically preferred fish, fetching high price (₹ 300-500/kg) in West Bengal, Tripura, Asom, Manipur, Nagaland, Jharkhand, Bihar and Kerala.

This fish has an added advantage to tolerate extremely unfavourable environment owing to its air-breathing ability, and can be a candidate species for aquaculture. It contains high available iron and easily digestible polyunsaturated fatty acids. It is considered a valuable item of diet for sick and convalescent people. However, non-availability of quantity and quality seed was the main bottleneck

This fish has been successfully bred in the first week of December 2012 with fertilization and hatching at 98% and 90%, respectively.

The off-season breeding of this species has lead to year-round production of its quality seed. Its off-season breeding technology is being standardized.

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Swarna Rituvar – a photo-insensitive lablab-bean

Off-season cultivation of vegetable-legume lablab/dolichos-bean during summer and rainy season is a traditional practice in the Eastern Plateau and Hill region as the produce (fresh pods) fetches higher market price (₹30 - 40 per kg). In addition, off-season lablab-bean requires lesser water, as it is mainly a rainfed crop.

But so far no improved varieties were available to farmers for off-season cultivation in the Eastern Plateau and Hill Region. So, nine diverse photo-insensitive germplasm of lablab-bean, which flower and bear pods during summer and rainy season (off-season) were collected from different parts of Jharkhand, Chhattisgarh, Karnataka and Tamil Nadu, and were purified. One creamy white-podded photo-insensitive line HADB 69 (IC 437165) was developed through individual plant selection from the maroon-podded germplasm line HADB 13. These 10 photo-insensitive lines were evaluated in total during the off-seasons (May-September) of 2005-09. Flat, fleshy and creamy white podded line HADB 69 (13.0 tonnes/ha) performed better than the local check variety (5.7 tonnes/ha) for fresh pods yield and quality and suitability for off-season cultivation. HADB 69 was also tested in 35 farmers' fields in eight districts of Jharkhand, Bihar, Chhattisgarh, Odisha and West Bengal, who accepted it as a remunerative off-season variety, and consumers also showed their preference for tender pods as cooked vegetable of this variety. On the basis of its superior performance, this photo-insensitive lablab-bean line HADB 69 has been released as **SWARNA RITUVAR** for off-season (rainy season) cultivation in Jharkhand, Bihar, Chhattisgarh, Odisha and West Bengal.

The seed multiplication has been done, and seeds are available to the farmers of the region.

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Orange-fleshed, carotenoid-rich cucumber

Cucumber (*Cucumis sativus* Linn.) is one of the most important vegetables, consumed throughout the world as salad, and in cooked and pickled forms. It is often regarded as a health food because of its low calorie content and its high vitamins and minerals content.

Common cucumber varieties have white to greenish mesocarp and are of low nutritional quality but orange-fleshed cucumber is rich in carotenoids. India, being the centre of origin for cucumbers, is known to be the treasure-house of cucumber diversity. Many diverse cucumber germplasm have been collected from all-over the country through planned explorations. Unique indigenous germplasm that have potential to enhance cucumber production and nutritional quality were not used in crop-improvement programmes due to lack of information about them.

IC 420405

IC 420422

Preliminary evaluation of cucumber germplasm resulted in identification of two unique accessions — IC 420405 and IC 420422; collected from Mamit district of Mizoram. They have yellow to orange mesocarp and endocarp; an extremely rare trait. Both accessions bear

fruits of average length of 16.8 and 14.6 cm, diameter of 7.0 and 5.9 cm and weight of 202.3 and 200.6 g, respectively. Both are comparatively late flowering types (60 days after sowing); start flowering with the onset of winter while other accessions flower early (40 days after sowing). Their fruits have rudimentary soft, sparse and white spines in contrast to others having hard and black spines.

Six more accessions having yellow to orange flesh have also been collected from Mizoram and Tripura. Their carotenoid content has been reported to be as high as 6.5 µg/100 g as compared to 1.17 µg/100 g in the best check variety Himangi.

Previously orange-flesh cucumber was reported to be derived from a landrace named Xishuangbanna Gourd (*Cucumis sativus* var. *xishuangbannaenensis*) from a Prefecture Xishuangbanna of the Yunnan Province in the South-west China, which is closer to north-eastern part of the India. Studies have indicated that orange-fleshed cucumber of China (Xishuangbanna Gourd) is closely related to Indian cucumber germplasm. This suggests that orange-fleshed Indian cucumber germplasm might have migrated to China from north-eastern parts of the country; which is the primary centre of its origin.

There is an urgent need to collect diversity from the north-eastern states through trait-specific collection programmes to develop carotenoid-rich cucumbers.

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Fallow lands cultivated through rainwater harvesting in village Gunia

The major climatic variability faced in the Gunia village *(*Baratpur, Jharkhand) during 2011-12 was less number of rainy days coupled with high intensity rainfall events. Before the implementation of the ***National Initiative on Climate Resilient Agriculture (NICRA)*** project, farmers of the adjoining villages of the KVK Gumla were compelled to follow monocropping due to scarce water resources.

After assessing available water resources in the area, the KVK mobilized villagers to store water by building a sandbag dam, locally called "*bora-bandi*", across the seasonal rivulet Mahsaria. This changed lives of Gunia villagers and opened-up opportunities for them for double and triple crops with the source for irrigation during *rabi* and summer.

In addition, 11 farm-ponds (*jalkund*) were constructed on the selected farmers' fields. Three existing farm-ponds were renovated by cleaning and plugging seepage losses. As a result, water storage capacity of the farm-ponds increased by 60% and seepage losses reduced by 80%.

Summer paddy cultivation was taken up in 10 hectares after *bora-bandi*. Necessary inputs including seeds of an improved rice variety 'Anjali' and fertilizers were made available by the KVK Gumla. Regular follow-up and advisory services were provided through training and farmer-scientist interaction. Grain yield of about 3-3.5 tonnes/ha was obtained, and net returns of ₹12,600 and benefit: cost ratio of 1.7 were recorded with paddy cultivation during summer.

Earlier farmers cultivated wheat in 2 - 3 hectares only. After *bora-bandi*, about 50 hectares have been brought under wheat cultivation. And after the creation of water resources, demonstrations for off-season vegetables cultivation were also conducted in 10 hectares involving 85 farmers. All vegetables were grown by ridge- and -furrow method that enhanced water-use efficiency.

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Fruit-based cropping systems for sustainable production

To mitigate risk of total crop failure, suitable crop combinations, involving perennial fruit-crops, seems to be a promising proposition to get multiple outputs for ensuring production and income generation in a sustainable manner.

In the cropping system, *aonla* (*Emblica officinalis*) is taken as a base crop; perennial crops are *ber* (*Ziziphus mauritiana*), *bael* (*Aegle marmelos*), *khejri* (*Prosopis cineraria*), drumstick (*Moringa oleifera*), *karonda* (*Carissa carandus*); and fodder crop, sewan grass (*Lasiurus sindicus*), is a component crop. Orchard interspaces are used to grow clusterbean and seed spices in *kharif* and *rabi*, respectively, to generate extra income, improve productivity, and to ameliorate ecological niche in a sustainable manner.

Systems comprised cropping models — *aonla-ber*-clusterbean-fennel, *aonla-bael*-clusterbean-coriander, *aonla-khejri*-clusterbean-*ajowain*, *aonla*-drumstick-clusterbean-dill and *aonla-khejri*-sewan grass. No negative allelopathic effects of the over storey crops (*aonla*, *ber*, *khejri*, *karonda* and drumstick) on the growth and production potential of the ground storey crops (*kharif* and *rabi* annuals) were observed. Besides, the yield of intercrops was found higher under multiple cropping systems than under the sole crop; probably, due to the synergistic interaction among the ground-storey and over-storey crops. The inclusion of the perennial fruit-crops improved soil fertility through litter fall. The physical and chemical properties of the soil under the canopy of the the perennial crops resulted in increased porosity and water-holding capacity of the soil, while soil bulk density decreased as compared to open sites. Available N, P and K contents in the soil under trees growing in diversified pattern of cropping were considerably higher than that under the sole cropping as well as in the bare field. Similarly, microbial population in soils also was noticed to be improved under fruit-trees. Additionally, *aonla*, grown in combination with other fruit-crops, was found to contain higher content of antioxidants than the sole crop. Canopy of perennial fruit-crops was also managed through regular pruning. Crop combinations such as *aonla-ber*-clusterbean-fennel, *aonla-bael*-clusterbean-coriander, *aonla-khejri*-clusterbean-*ajowain* were found sustainable and remunerative under the arid ecosystem.

Heavy fruiting in *aonla* under diversified cropping system (inset: *top left: ber*; *bottom left:* drumstick, *top right:* bael; *bottom right: Karonda*)

Average yield of over-storey and ground-storey crops in fruit- based cropping system

Fruit crops	Sole crop (tonnes/ha)	Multi-species (tonnes/ha)
Over-storey perennial crops		
Aonla	6.8	7.4
Ber	7.9	9.5
Bael	1.6	1.9
Khejri	0.3	0.6
Drumstick	7.6	8.3
Karonda	6.1	9.4
Ground-storey crops		
Fennel	1.4	1.5
Coriander	1.4	1.7
Ajowain	3.3	3.8
Dill	2.6	2.9
Mustard	5.8	7.1
Clusterbean	6.0	6.2
Sewan grass	-	15.7

Microbial population under different fruit-trees

Fruit-crops	Microbial population		
	Bacteria	Fungi	Actinomycetes
Aonla	1,543 / ml x 10^{-6}	8.6 / ml x 10^{-3}	74 / ml x 10^{-5}
Ber	2,020 / ml x 10^{-6}	11.33 / ml x 10^{-3}	69.6 / ml x 10^{-5}
Bael	1,290/ ml x 10^{-6}	7.7/ ml x 10^{-3}	178/ ml x 10^{-5}
Khejri	1,691 / ml x10^{-6}	10.3 / ml x 10^{-3}	181/ ml x 10^{-5}
Drumstick	1,115 / ml x 10^{-6}	11.33 / ml x 10^{-3}	107 / ml x 10^{-5}
Karonda	1,745 / ml x 10^{-6}	11 / ml x 10^{-3}	125 / ml x 10^{-5}
Bare soil	973/ ml x 10^{-6}	6.6 / ml x 10^{-3}	62 / ml x 10^{-5}

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Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora

Enhancing productivity and ecological sustainability of hill agriculture through niche-based diversification

Vivekananda Parvatiya Krishi Anusandhan Sansthan is a premier hill agriculture research institution located in the North-Western Himalayan region of India. It is more popularly known with its original name 'Vivekananda Laboratory', established by Padam Bhusan Late Professor Boshi Sen, on 4 July 1924 at 8, Bosipura Lane in north Calcutta(presently, Kolkata). Being a dedicated follower of Swami Vivekananda, he named the Laboratory after him**,** and addressed a letter to Swami Vivekananda.

"Swamiji Maharaj, I have dared to associate your name with this undertaking. You know what I can do and cannot do. My prayer to you, the blessed and beloved of my Guru, is that I may not discredit your good name. Please destroy me before that. They say you are the friend of the destitute and suffer fools gladly. Befriend me in this undertaking. May I have love for Thee and thine, and Faith, is the prayer which you have taught. Pranams and sashtanga" — Boshi, 1924

Later, in 1936**,** Professor Sen permanently shifted this laboratory to Almora to work on the fundamental plant physiology. The holocaust of Great Bengal Famine in 1943 made a profound impression on Professor Sen's mind; consequently he rededicated himself to agricultural research. In the beginning, the laboratory depended for its support on the private donations**;** later on from the small grants from the ICAR and Uttar Pradesh Government. While working at the Vivekananda Laboratory, Almora, Professor Sen was in close contact with the then Prime Minister Pt Jawahar Lal Nehru. On his request, he established an Agricultural Research Unit at Leh in 1961, which is presently a separate institute known as the Defence Agricultural Research Laboratory under the DRDO.

MANDATE

- Basic and strategic research
  - for improving productivity and quality of important hill crops.
  - on conservation and efficient utilization of natural resources.
- Development of ecologically sound and economically viable agro-production, protection and post-harvest processing technologies for different growing conditions of hills.
- Transfer of technology, research on extension methodology, organization of specialized training programmes and consultancy on hill agriculture.

In 1952, the Vivekananda Laboratory was allotted about 15 acres of land at Hawalbagh. To ensure continuation and expansion of the work, the Laboratory was transferred to Uttar Pradesh Government in 1959.

On 1 October 1974, the Indian Council of Agricultural Research took over the Laboratory. Since then, it has worked under the aegis of the ICAR with a mission to improve crop productivity of hills of Uttar Pradesh (now Uttarakhand), Himachal Pradesh and Jammu and Kashmir.

INFRASTRUCTURE

The Institute's Headquarters is located at Almora in Uttarakhand at an altitude of 1,600 m amsl. The Research Farm is located at Hawalbagh, 13- km away

Experimental Farm, Hawalbagh

'In July 1968, Indira Gandhi released a stamp titled 'Wheat Revolution'. I then wrote to Boshi Sen that his blessings in April 1964 had provided the spiritual force behind the wheat revolution. Dr Anderson and I also called on him to express our gratitude.' – M.S. Swaminathan (*In: Nearer heaven than earth* by Grish N. Mehra)

from Almora at an altitude of 1,250 m amsl (latitude – 29° 56' N, longitude - 79° 40' E). Being a multi-crop and multi-disciplinary research Institute, the research work is carried out under four divisions/sections— **Crop Improvement, Crop Production, Crop Protection and Social Science.** There are two field laboratories at Experimental Farm— Boshi Sen Field Laboratory and Diamond Jubilee Laboratory. These laboratories are equipped with routine laboratory works. For sophisticated works, the laboratories are at Almora. Boshi Sen Field Laboratory houses a medium-term germplasm storage module also.

Inside of the museum

The library has about 4,000 books, 6,000 journal and 2,000 miscellaneous publication accessions. Institute's museum is the repository of the classical instruments used by Prof. Boshi Sen, and of progress of research, salient technologies and outreach activities and human resource development.

The *Firsts* from the Institute

- Maize hybrid (VL Makka 54)
- Onion hybrid (VL Piaz 67)
- QPM hybrid (Vivek QPM 9) through MAS
- Dual-purpose (grain-cum-fodder) wheat (VL *Gehun* 616)
- Growing of fodder grasses under pine forest
- Two pronged strategy for (use of light traps and formulation of the BCA *Bacillus cereus* strain WGPSB 2) management of white-grubs
- Vivek thresher-cum-pearler for fingermillet/ barnyard millet and low-weight iron plough (VL *Syahi hal*)

SALIENT ACHIEVEMENTS

The Institute, in the last 89 years of service to the nation has several achievements to its credit.

- Developed varieties — VL Gehun 829, VL Gehun 832, VL Gehun 892 and VL Gehun 907 of **wheat**; VL Dhan 62, VL Dhan 65, VL Dhan 82 and VL Dhan 85 of **rice**; Vivek QPM 9, Vivek Maize Hybrid 45, Vivek Sankul Makka 35 and Vivek Sankul Makka 37 of **maize**; VL Mandua 324, VL Mandua 347 of **ragi**; VL Madira 207 in **barnyard millet**; VL Soya 65 of **soybean**, VL Masoor 133 of **lentil** and VL Matar 11 of **garden- pea**— resistant to major disease/s to reduce use of fungicides.

Latest Released Varieties

VL Gehun 892

Upland rice VL Dhan 206

VL Mandua 315

Quality protein maize, Vivek QPM 9

VL Arhar 1

VL Tamatar 4

- Reduced pesticides load through— improved light-trap for trapping adult beetles and talc-based bacterial biological control agent *Bacillus cereus* strain WGPSB 2 formulation for control of white-grub; identified effective local isolates of *Trichoderma harzianum,* fungal antagonist, against major soil-borne pathogens like *Sclerotinia sclerociorum, Sclerotium rolfsii, Rhizoctonia* and *Fusarium* species (one strain Tr-28 commercialized); use of botanicals like Batain *(Melia azedarach)* seed kernel extract (BSKE); soil incorporation of *Lantana camera* and *Parthenium hysterophorus* against insect-pests and soil-borne diseases like root-rot; and seed soaking for 48 hr in the extract of *Oxalis* for reducing hill bunt in wheat and stripe disease in barley; inclusion of preventive measures such as crop rotation, soil preparation, varietal resistance, use of biocontrol agents to break infection chain of diseases or life-cycle of pests; and prudent use of pesticides in the IPM modules.
- The potential carbon sequestration/carbon emission reduction per year from the implementation of the project interventions estimated is 2,012 kg CO_2/year, where carbon sequestration, due to planting of fruit and oak trees, contributed to maximum of 1,778 kg CO_2/year.
- The CO_2 emission reduction with the application of farmyard manure at 20 tonnes/ha was up to 1,838 and 1,337 kg/ha/year as compared to the recommended NPK- and INM-treated plots, respectively, through gain in soil organic carbon stock and preparation/manufacturing of nutrient source for the respective plots in garden-pea-Frenchbean cropping system. Pod yield in six years on FYM plots was more sustainable than that with the application of recommended NPK and INM.
- Developed cold-tolerant 'P' solubilizing and cold-alleviating microbial inoculants/consortia to alleviate cold stress and enhance 'P' uptake in hill-crops leading to reduced use of inorganic fertilizers to maintain soil fertility.
- Developed light weight (11 kg) mild- steel plough (VL *Syahi hal*) to replace traditional wooden plough, and thus saved forest trees.
- Enhanced spring water discharge almost twice (from 942.3 m^3 in 2006 to 1,874.7 m^3 in 2012) in six years by planting Utis (*Alnus nepalensis)* and roof-water harvesting in trenches in the spring catchment area.
- Runoff water harvested from 1,200 m^2 upper catchments in 150 m^3 tanks can support vegetables for 2,000 m^2 in *kharif* and 200 m^2 vegetables and 1,800 m^2 cereals during *rabi*.
- Developed farm tools and implements to reduce drudgery.
- Grew fodder grasses on slopy lands to enhance fodder availability and checked soil erosion (Hybrid Napier produced highest green forage yield of 5 to 8 tonnes/ha during initial year and 30 to 50 tonnes/ha from second year onwards).

Impact-making initiatives

- **Farmers' clubs and SHGs.** To disseminate technologies through farmers' groups, farmers were organized into four farmers' club and seven SHGs in Almora and Nanital districts.
- **Protected cultivation.** The advantage of protected cultivation are: **Higher yield** –tomato grown under protected condition gave 70-243% higher yield during 2007-08 to 2012-13 compared to that grown in open; **Stability of yield** – A comparison of yields of tomato (2007-08 to 2012-13) in open and protected condition showed that yield under protected environment is far more stable than under open conditions, as was indicated by coefficient of variation, which was around three times under open conditions as much as under protected cultivation (31.9 versus 10.9%); **Better quality and higher price** – The average price per kilogram fetched by the tomatoes grown under polyhouse was ₹2 more than that grown in the open fields; **Reduced cost of pest management** – Because of closed environment, the efficacy of the chemical can be realized to a far greater extent.
- During last five years, breeder seed indent increased from155.59 q to 229.67 q; resulting in 47.6% increase in breeder seed replacement rate. The breeder seed production increased from 230.7 q to 246.63 q with 6.9% increase.
- Adoption of IPM in rice resulted in an increase in yield up to 26.5% in local rice variety and up to 7.5 % in improved rice varieties at the farmers' fields. Besides, installation of insect traps and application of *B. cereus* WGPSB2 formulations in villages resulted in 70-90% reduction in white-grub populations over the years.
- Planned honeybee pollination of cross-pollinated crops resulted in an increase of 8 to 25% in yield of radish, coriander, *toria*, fenugreek and onion over natural pollinated crops. Farmers have adopted button and oyster mushroom cultivation, bee-keeping with higher economic returns.
- A single cross QPM hybrid Vivek QPM 9 has been developed through MAS. The seeds of this variety are in great demand.

Polyhouse in farmer's field

Polylank for water conservation

- More than 10,000 native and exotic accessions of wheat, rice, maize, small millets, pulses, oilseeds and vegetables are being maintained at the Institute.
- Cropping sequences, spring rice–wheat–fingermillet–toria could attain 200% cropping intensity against 150% of the traditional spring rice–wheat–fingermillet–fallow sequence in two- year cropping system; and soybean–lentil, maize–pea, maize–wheat, rajmash-Frenchbean-*toria*, pigeonpea-wheat, colocasia-coriander-tomato, soybean–pea and soybean–wheat among one- year crop sequences were found remunerative. Intercropping of soybean or groundnut in maize, soybean in fingermillet and pea, lentil or *toria* in wheat were found more profitable than pure crops.
- Long-term fertility management, being studied since 1973, revealed that use of FYM (10 tonnes/ha) along with the recommended doses of inorganic fertilizers was capable of alleviating nutritional problems of crops and also deterioration of soil physical condition. Under fodder and grassland management, suitable agro-forestry systems, species of grasses (including winter grasses), fodder legumes, and grass composition under pine and deodar trees were identified.
- Technologies for production of grasses on risers, steep slopes, degraded and marshy land have also been developed.
- Low-cost polyhouse technology has been developed for protected cultivation. Package and practices for growing vegetables under low- cost polyhouses have been developed and standardized.
- Low-cost LDPE film-lined storage tank, conveyance system and drip irrigation system have been developed for growing off-season high-value vegetables.
- Survey of Kumaon and Garhwal regions showed prevalence of yellow and brown rusts, loose smut, powdery mildew and hill bunt in wheat; stripe and covered smut in barley; blast, brown spot and false smut in rice; neck and finger blast in fingermillet; turcicum leaf blight in maize; powdery mildew and white rot in pea; buck-eye rot in tomato, root rot and anthracnose in bean; root rot and wilt in lentil, and frog-eye leaf spot and anthracnose in soybean as major diseases. Fuscous blight of Frenchbean/rajmash and zonate leaf spot of maize have been reported for the first time from this region. Viral diagnosis, based on symptomatology, showed presence of nearly 50 viral diseases affecting different crops.
- Indigenous *Trichoderma* strains were isolated from the N-W Himalayan region and have been found effective against soil-borne pathogens.
- More than 75 species of white-grub have been recorded from Uttarakhand. In addition, stem borer and leaf folder in rice and small millets, hairy caterpillar and sucking bug in soybean, leaf miner in garden- pea and pod borer in pea and gram, fruit borer in tomato, blister beetle in beans and pigeonpea are other major pests.
- Management technologies have been evolved for major diseases and insects in important crops. The technology of insect trap and the entomopathogenic *Bacillus cereus* have potential to manage white-grubs
- Agricultural database for N-W Himalayas is updated regularly.

THRUST AREAS FOR XII PLAN

- Development of high-yielding varieties tolerant to biotic and abiotic stresses and with quality traits through conventional and biotechnological approaches with matching production technologies.
- Development of nutritionally-rich traditional crops (fingermillet and barnyard millet, horsegram, bhat) and their popularization under rainfed conditions of hills.
- Diversification of hill crops for enhancing profitability as agroforestry and off-season vegetables cultivation.
- Efficient water and soil conservation and their proper utilization; protected cultivation and fodder production from marginal and wastelands and utilization of efficient microbes.
- Development of farmers' friendly small tools, which would be particularly helpful in reducing women drudgery.
- Capacity building, need assessment and skill development.
- Research on effective extension methodology.

Flagship Projects

- Development of iron rich Quality Protein Maize (QPM) composites and hybrids for the North-West Hills.
- Exploitation of plant growth promoting bacteria (PGPB) for enhancing crop productivity in hills under abiotic stress.
- Mechanization of hill agriculture through development of suitable farm equipment and machineries.

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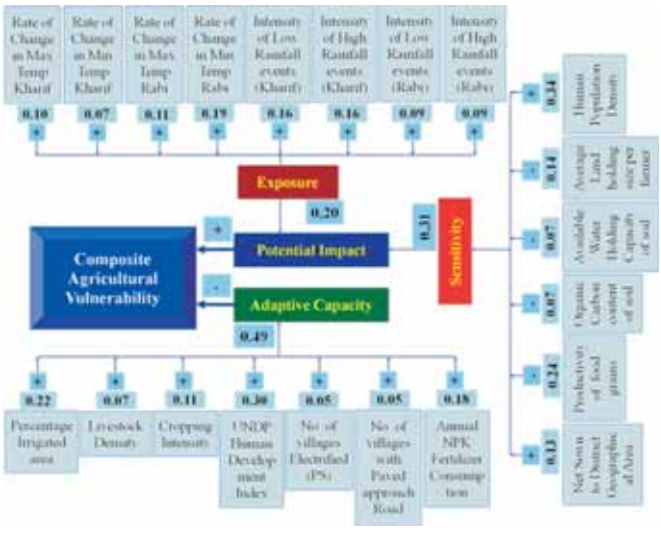
Agricultural vulnerability to climate change in Indo-Gangetic Plains

A study was undertaken with the use of Geographic Information System to demonstrate a comprehensive methodology to assess and map at the district level composite vulnerability of agriculture in the Indo-Gangetic Plains of India to climate variability and change.

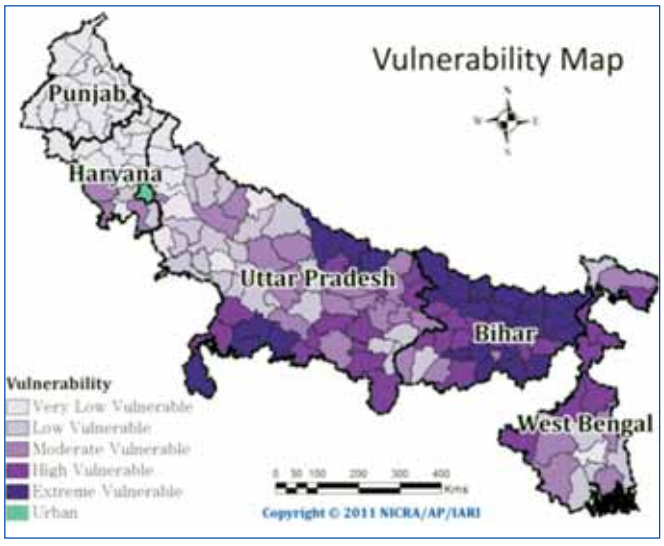
The vulnerability was determined using three core components—(i) exposure to hazards, (ii) sensitivity to climate change – the amount of damage expected to be caused by a particular event, and (iii) adaptive capacity to recover from stress.

This study emphasized climatic, physical and socio-economic factors together to arrive at the vulnerability rating. A total of 8 indicators were computed using



Methodology flowchart showing factors and their weightage

grided meteorological data of 1951-2009 for exposure. Sensitivity was computed from 6 indicators, based on the crop and soil characteristics; and adaptive capacity



Map showing vulnerability rating of agriculture to climate change

was based on the socio-economic indicators of the agricultural technology and infrastructure and human development. These spatial datasets of key factors contributing to vulnerability were generated for 164 districts, ranked, estimated weights of each factor using multi-criteria decision- making techniques like Analytic Hierarchal Process and then ranking maps were generated for vulnerability on a five- point scale. Bihar, some districts of Uttar Pradesh and West Bengal have been found most vulnerable; however, Punjab and Haryana showed higher adaptive capacity to recover from stress, and thus they were less vulnerable. This study may benefit planners and policy- makers in better management of resources towards implementing adaptation programmes for climate change.

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Protein-fortified *aonla* and beetroot lite-crackers

Technology has been developed for preparing protein-enriched nutritious crackers containing quality protein maize, chickpea-flour, whey-protein concentrate, *aonla*/ beetroot and oil. These sweet-salty crackers provide a wholesome alternative to commercial biscuits. They contain 60% less fat as compared to commercial biscuits, besides providing antioxidants and flavonoids and meeting 10% of RDA (Recommended Dietary Allowance) for protein in a single serving.

Aonla crackers Beetroot crackers

Nutritional status of the crackers

	Aonla Crackers			Beetroot Crackers		
	per 100 g	per serving (30 g)	% RDA	per 100 g	per serving (30 g)	% RDA
Energy (kcal)	403.25	120.98	6.05	392.7	117.81	5.89
Fat (kcal)	61.83	18.55		75.78	22.734	
Protein (g)	16.70	5.01	10.02	16.7	5.01	10.02
Carbohydrates (g)	68.66	20.60	6.87	62.53	18.759	6.25
Fat (oil) (g)	6.87	2.06	3.17	8.42	2.526	12.95
Fibre (g)	1.78	0.53	7.10	6.35	1.905	7.62
Vitamin C (mg/100g)	33.16	9.95	16.58			

Aonla crackers are mainly rich in antioxidants (ABTS assay: 117.32 µmol Trolox equivalent per gram), being richer than even pomegranate (18-20 µmol) and guava (22-38 µmol). They are also rich in flavonoids (116.74 mg per serving). Generally, foods providing more than 50 mg / 100 g flavonoids are considered rich sources of flavonoids. In addition to this, *aonla* crackers provide approximately 25 mg ascorbic acid even after three months of storage in nitrogen-pack of metallized polyethylene. The beetroot crackers have a pleasant pinkish-purple tinge. They also provide 7.9 µmol per gram trolox equivalent antioxidants (ABTS assay) and 14.53 mg of flavonoids per serving.

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Coconut-sap sugar for managing diabetes

Coconut sugar (also known as coconut-palm sugar, coco-sugar or coco-sap sugar) is a sugar prepared from the inflorescence sap of coconut-palm. It is truly a perfect and healthier substitute for artificial sweeteners, which are toxic to one's health as well as is a better alternative to other natural sugarcane-based sweeteners such as refined white sugar, brown sugar, molasses and others.

It is a by-product of coconut, which is devoid of any anti-nutritional factors. It is prepared from 100% pure sweet watery sap that drips from tapped coconut inflorescences. Sap is collected in an aseptic condition in the specially designed container without adding any artificial chemicals like lime. To get sugar with good quality and texture, the *p*H of the inflorescence sap should be above 7.5.

Comparative studies on biochemical and minerals constituents were performed for sap sugar and refined cane sugar, and it was found that there is a significant difference between sap sugar and cane sugar. The total sugar content was lesser in coconut-sap sugar (91.57 g/100 g) than cane sugar (97.7 g). The protein content was nearly 9 times higher in coconut- sap sugar (2.6 g) compared to cane sugar (0.31g).

The glycemic index of the coconut sugar is low, and ranges between 35 and 54 GI per serving as compared to other sugars such as refined white sugar and molasses that have a range of 65 to 100 GI per serving. By helping to maintain lower blood sugar and insulin levels, a low-GI coconut sugar may be useful in preventing and treating a variety of health problems. Thus, it can be a better substitute for synthetic sugars.

Coconut-sap sugar is considered to be one of the best natural sweeteners. Several factors make it a viable sugar substitute. It has high mineral contents. It is a rich source of potassium, magnesium, zinc and iron. In addition to this, it contains all essential amino acids required for protein synthesis, and is rich in B complex vitamin like B_1, B_2, B_3 and B_6.

It is a conventional food and may not have adverse effects in comparison to synthetic sugars. Thus, an immediate intervention is needed to create awareness among people, especially for diabetes, regarding the health benefits of coconut sugar.

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Single plant soybean thresher

In India, soybean productivity (1.12 tonnes/ha) is lower compared to world's average productivity (2.5 tonnes/ha). For this, genetic enhancement of yield potential is desirable to improve soybean productivity. As breeders need to screen a large number of single-plant population (in hundreds, sometimes in thousands) of each cross combination, each single plant needs to be threshed separately. Through manual threshing one can thresh 40-60 plants in a day, but with this modified single-plant thresher, 150-180 plants can be threshed in a day, thus cutting down on human drudgery.

Domestic-scale mixer/grinder has been modified into a single plant thresher for soybean. Grinding/mixing part of the mixer has been replaced with a circular plate of 2- mm thickness and 101- mm diameter. On this circular plate, bolts of 50- mm length and 4.55- mm diameter have been fixed. Top portion of the bolts is covered with hard but smooth tube to save seeds from mechanical damage. The rotation speed of the circular plate is found critical; it could be regulated using variac. A rotational speed of 10,000 rpm has been found optimum for threshing in two passes without any visible seed breakage.

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CIAE Millet Mill — Eco-friendly and women-friendly

India has a rich diversity of millets, and their small grains have a remarkable ability to survive under severe drought. Until recently, minor millets in India were considered food of the poor. But at present owing to their nutritional superiority, millets are increasingly sought by urban and elite sections of the population.

Owing to the absence of suitable primary processing, semi-processed raw materials and appropriate value-addition technologies, the production and the consumption of millets are constrained. Though machines with tangential abrasive dehulling device (TADD) concept exist for dehusking of millets, their demand for high energy and more quantity of millet-grains to process, restrict their operation in the production catchments. Aiming to eliminate drudgery involved during millets processing and to increase capacity in production catchments, initiatives were undertaken for mechanization of production and processing of millets to find and develop pathways for profitable uses of millets.

An energy-efficient continuous- type CIAE-Millet mill has been design and developed. It has a dehusking capacity of

100-110 kg of millet-grains at 10-12 % moisture content per hour. It operates with one horse- power single-phase electric motor. It can process a kilogram of mille grains in a single pass. The separation of the husk is simultaneous with suction arrangement and cyclone separator. It is suitable for all minor millets — foxtail millet, little millet, kodo millet, proso millet and barnyard millets. The mill has provisions to adjust clearance between dehusking surfaces to suit different sizes of minor millets. The dehusking efficiency of the machine is 95%. The machine costs ₹40,000. This machine is eco-friendly as its processing zone is compact, and it is attached with a cyclone separator, thus it does not allow dehusking mass escaping to environment directly; husk is gently trapped and collected. Besides, air and noise pollution is under control during its operation. It does not require any hard labour and, therefore, is women-friendly.

The CIAE-Millet Mill can be installed as an enterprise in the prevailing situation in decentralized manner of millets production under rainfed conditions and tribal areas with a payback period of only three months. This millet-processing machine may help promote successful commercialization of millet-based health foods.

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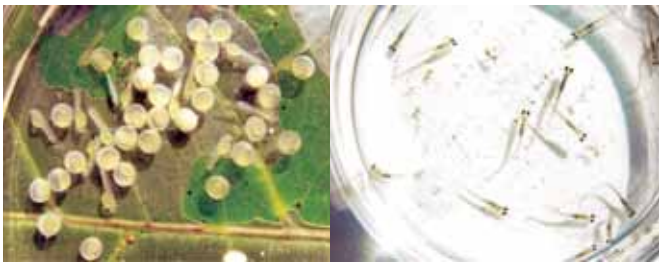
Induced breeding of *Puntius carnaticus*

Puntius carnaticus, the state fish of Karnataka, endemic to Western Ghats region, was successfully induced bred for the first time at the Regional Research Centre, Bengaluru, in November 2012. A female with a swollen belly (0.725 kg) and two readily milting males (0.575 and 0.425 kg) were injected with Ovaprim @ 0.5 ml/kg body weight. After 24 hr, the female was stripped and eggs were mixed with the milt obtained from the males. After 10 min, eggs were repeatedly washed with freshwater, and fertilized eggs were transferred to hatchery. Hatchlings were obtained from orange-coloured eggs between 56 and 72 hr. Then heavily yolk-laden larvae were transferred to an aquarium with aeration for further development. Forty days old hatchlings measured 158 mm in length and 56.65 mg in weight.



Hatchlings (Day 3) Larvae (12 days after hatchling)

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Pig bristles for innovative value-addition

An in-house methodology for bristle processing has been developed to remove dirt, epithelial scales and wax, to destroy microbes and parasitic eggs and for bleaching to soften and for colour removal before dyeing. After processing, different products could be developed manually using pig bristles. Pig bristles are natural, more durable, stable, and flexible as compared to synthetic bristles thus different high-quality end-products can be made from bristles. Pig bristles being flexible, structurally hard and densely packed in the brush/comb, ensure faster and better removal of dirt and dust, even in the deep or zigzag corners, which

There is a huge potential for production of high-quality pig bristles, leading to alternate employment opportunities. A total of 15.35 lakh pigs are slaughtered per year in the organized sector in north-eastern region, besides the number of unorganized pig slaughter at the block as well as at the village level; that number is not yet known. On an average 300-400g of bristles/ pig are obtained, so 10-12 thousand quintal of pig bristles can be produced/year from slaughter-houses in the region from the organized sector alone. The indigenous local pigs yield high- quality bristles in greater quantities; it is an added advantage in the region. The bristles are very hard, flexible coarse fibres with diameter of 210-320 µm. The tensile strength of the bristle is 4-5 times higher as compared to human hair and other animal fibres. Local indigenous pigs have long (5-7 inch) and dense (150-188/cm square of skin) bristles with special mechanical property, as compared to exotic pigs; and this is one of the unique traits of indigenous pigs for protection against extreme cold in this region.

Pig bristles from different breeds

with synthetic bristles may not be possible. Long, flexible with "flagged end" (split end) bristles in dusting brushes are effective for cleaning tables, computers, printers, equipment etc.

It is also a better choice in washing brushes, as they are stable and remarkably resistant to hard soaps. The bristle hair brush/comb are densely packed, it removes debris, dust and scales effectively from hair. Therefore, pig bristle brushes/combs are more expensive than other brushes in western countries.

Pig husbandry is an important component of farming system practised in the north-eastern region of India. Almost every rural household rears 2 – 3 pigs in their backyard. The number of pigs available per 100 person is very high (18) in the region against the national average (4). Pig population and consumption have increased consistently with the increment in human population in the region. Almost all parts of the pig are generally used for human consumption, excepting hair, hides and teeth. The pig hairs, called "bristles" are unutilized and are burned during conventional slaughter process (singeing) or dumped as slaughter-waste on the ground and thus results in environmental pollution, as it is highly stable keratinized protein; it takes longer time in bio-degradation.

Since the property of the bristles varies depending on the breed, parts of the body in which bristle are collected, parts of bristle (base, middle and tip), and accordingly different products are made for different purposes. For example a) moderately flexible middle part bristles obtained from the abdominal region of pig are used for shoe brush, b) medium stiffness with flexible bristles obtained from back and loin region are used for carpet cleaning brush and c) thicker hard and stronger base of bristles obtained from the neck and shoulder region of local indigenous pig are used for hair comb/brush. Shaving brush and different cosmetic brushes can be made from thin, soft and flexible bristles after bleaching and dyeing. The primary supplier of pig bristles worldwide is China. Therefore, the bristles have a tremendous export potential, if suitably utilized.

Coat and jacket cleaning brush

Cloth washing brush

Shoe brush

Soft-carpet cleaning brush

Hard carpet cleaning brush

Furniture dusting brush

Hair comb

Hair comb for pet dog

The bristle requirement for each product varies depending on the size of the products (small comb/ brush: 20-30g, medium brush: 50-70g and large size brush: 100-120g). Similarly cost of production also varies with size (small size brush: ₹80, medium brush: ₹100 and large size brush: ₹150). **For the first time in India, the institute has developed a methodology for clipping bristles from live-pigs without affecting growth performance.**

Since the manual method of processing was time-consuming, labour cost was the major investment in the production cost. A trained person could make 4-5 medium size brushes/day using manual method. The production cost can be reduced drastically with engineered automatic method.

Effective utilization of bristles would prevent environmental pollution and create a value-chain.

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Dairy co-operatives role in enhancing milk production

Dairy development in India has been acclaimed as one of the most successful development programmes in the world. Much of the success of the 'White Revolution' in India has been attributed to co-operative framework of dairy development strategies. The network of dairy co-operatives expanded considerably especially after the launch of the Operation Flood in 1970. In 2010-11, more than 14 million dairy-farmers got associated with dairy co-operatives. Integration with co-operatives has benefited farmers, and indeed has served as a catalyst for linking Indian dairy smallholders to markets – domestic as well as global.

Nonetheless, the potential of dairy co-operatives in the context of emerging and globalizing markets is often questioned. The emergence of several integrated marketing models backed-up by giant multinationals is posing shift competition to co-operative models of milk marketing. However, the earlier studies in India suggested that farmers' participation in dairy co-operatives resulted in a significant increase in milk production and productivity and reduction in per unit cost of milk production. The Government has been supporting milk co-operatives for strengthening infrastructure for quantity and clean milk production. Therefore, this study aimed to empirically examine the impact of co-operatives on the performance of dairy farmers pertaining to production and quality of milk, based on the primary data collected at the farm levels in three states of India – Bihar, Punjab, and Uttar Pradesh in 2007.

Are the co-operatives significantly better off compared to non-member farmers in terms of the different indicators? The co-operative farmers have relatively bigger herd size and also composition of their herd size is qualitatively better than their counterparts. The average herd size of co-operative dairy farmer is 5.6 Standard Animal Units (SAUs), as compared to 3.6 SAUs for non-cooperative farmers. Similarly, on an average, 54% of bovine-milch animals of co-operative dairy farmers were of improved breeds, while only 40% were of non-cooperative dairy farmers. The herd size of co-operative dairy farmers in Bihar was about 68% bigger than their non-co-operative counterparts. Similarly, level of adoption of improved breeds on dairy co-operatives farms in Bihar was almost three times higher than the independent farms.

The average co-operative farmer contributes to about 14 litres of milk per day and his herd's productivity is 6 litres per milch animal per day. On the other hand, the average independent farmer contributes only 8 litres with a productivity of 5.3 litres. In Bihar, household milk production by the co-operative dairy farmers was more than three times of the independent dairy farmers.

Performance of co-operative farmers and independent dairy farmers

	Co-operative Farmers	Independent Farmers
Herd size (no.)	5.6	3.6
Adoption of improved/cross-bred animals (%)	53.8	39.8
Milk production (litres/day)	13.9	8.0
Milk yield (litres/animal/day)	6.4	5.3
Margin (₹per litre)	2.6	0.3
Food safety Index	0.52	0.43
Cost of compliance with food safety (₹/litre)	0.41	0.50

Source: Author's calculations based on the field survey

On an average, co-operative dairy farmers fetch an operating profit of ₹2.6 per litre as compared to only 0.60 per litre by the independent farmers.

In conclusion, co-operatives have a positive impact on herd size and its composition, milk production, productivity and profitability. It also has a positive impact on the adoption of milk safety measures. Further expansion of co-operatives can induce an increase in milk production and productivity as well as improvement in the quality of milk. The integration of dairy farmers with the co-operative would also enhance dairy farmers' competitiveness.

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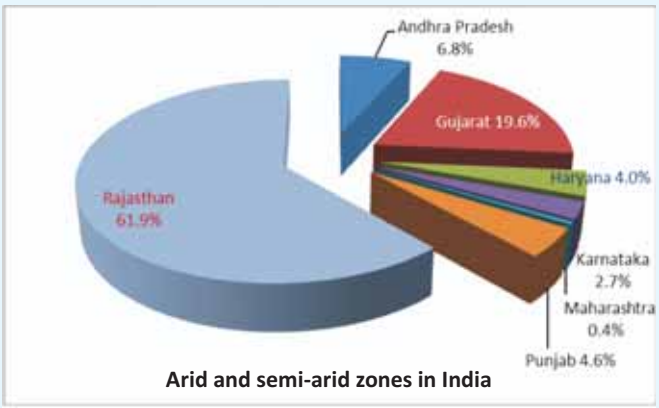
WAY FORWARD

IN India, hot arid areas cover about 3.2 lakh km^2 spread over Rajasthan, Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra and Punjab and cold arid areas 70,000 km^2 in Leh-Ladakh of Jammu and Kashmir. Large tracts of hot arid zone, ironically are endowed with many useful species of plants and domestic animals that provide sustenance to the rural economy. For development of agriculture in the arid regions, water is the key constraint. Therefore, its conservation, storage and judicious use is of paramount importance. And high perceived risk of crop failure due to drought is also identified as another constraint for adoption of improved agro-techniques. Soils of the regions are generally sandy and are prone to erosion, narrowing down further the choice of crops for cultivation.



Arid and semi-arid zones in India

Water-use efficient crops and cropping systems warrant mitigating extreme dry weather. Adoption of simple tillage methods like contour bunding, ridge and furrow have proved beneficial in field preparation, and drip irrigation has increased yields of many crops as compared to flood irrigation practice. In conjunction with these, use of suitable varieties, micro-dosing of fertilizers, timely weeding, disease and pest control measures will definitely boost crop production and also farmers' confidence for adopting improved agro-techniques.

In the arid areas, livestock have constituted an integral component of agriculture since ages. Thus comprehensive programme is necessary that specifically raises capability of the rural-poor to derive sustainable income by rearing animals. Interventions like introduction of fodder grasses, range legumes, trees and shrubs of browse value in unutilized wastelands and village commons will certainly raise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carrying capacity of the land for profitable livestock-rearing. Since arid regions face severe fodder shortage during drought periods, creation of fodder banks, popularization of fodder varieties and their cultivation also need to be given high priority. Experimental results on the supplemental feeding were positive, and so there is a need to undertake more research work on developing area-specific mineral mixtures for livestock. Given the appropriate technological backstopping, arid areas can be a milk and meat basket of the country. Popularization of livestock-based silvipasture, agroforestry or agro-horticultural systems can enhance agricultural sustainability. There also exists a large untapped and under-developed industrial potential in the agriculture/horticulture sector in the regions.

Arid areas have the advantage of ample sunshine. Technologies to tap solar energy for cooking, heating water and drying fruits and vegetables are available. A major technology dissemination programme with enabling policy support will help widespread use of solar energy for water-heating, cooking of food and feed, and thereby conserve sparse desert vegetation for recycling into soils, which are mostly low in organic matter content.

Given fragile environment as well certain climatic advantages, unique biodiversity and strong base of indigenous knowledge, agriculture in these difficult terrains has to be developed in a mission-mode way.

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