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ICAR NEWS

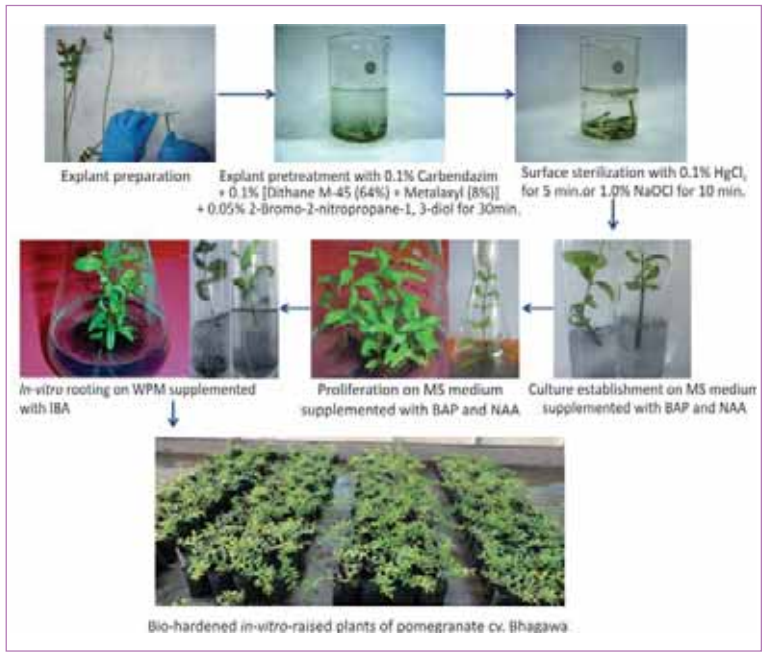
A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

In-vitro propagation and bio-hardening of pomegranate 'Bhagawa'

Pomegranate (*Punica granatum*) is one of the most emerging fruit-crops of India. In recent years, it has shown tremendous market potential due to its huge neutraceutical value, high demand of its fruits, its wide adaptability and diverse use and lesser resource demanding quality in comparison to other fruit-crops. Pomegranate cultivation has increased remarkably, by more than ten folds, within a short span of two decades; it touched an all-time high of 130 thousand hectares in 2014. Majority of the area under pomegranate cultivation is occupied by cultivar Bhagawa, which undoubtedly is the *numero uno* variety of pomegranate in India because of its deep-red rind and aril colour, optimum size and good yield. These



Stages of *in-vitro* propagation and bio-hardening of pomegranate-plants of cv. Bhagawa

Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001, India
www.icar.org.in

features have made 'Bhagawa' an ideal candidate for multiplication through tissue culture.

Intensification in pomegranate cultivation and its expansion in non-traditional areas have led to huge demand for its disease-free planting material of quality, particularly against bacterial blight of pomegranate; any negligence on the planting material may lead to spread of the pathogen to the newer areas of its cultivation.

Advantages

- Availability of elite, disease-free planting material in bulk
- Synchronized flowering and fruiting of *in-vitro* raised pomegranate-plants make them more suitable for mechanized cultivation
- *In-vitro* raised plants ensure high uniformity, precocity, better quality and yield as the mother-plant of proven horticultural traits is used as the explant source
- Disease-free elite planting material for expanding pomegranate in non-conventional areas

Protocol for *in-vitro* propagation of pomegranate cultivar Bhagawa has been standardized using green nodal segments of 2-2.5- cm length. This would ensure rapid and bulk production of disease-free planting material, and bio-hardening of *in-vitro* raised plants by placing formulations of plant beneficial microbes (arbuscular mycorrhizal fungi like *Glomus* spp. and *Aspergillus niger* strain AN 27) near the root zone at the time of secondary hardening would ascertain improved field performance of these plants. However, there is a need to develop package of practices and sanitation measures for *in-vitro* raised pomegranate orchards to realize full potential of the technology.

N.V. Singh and **R.K. Pal**
ICAR-National Research Centre on Pomegranate
Solapur (Maharashtra) 413 255
e-mail: nripendras72@gmail.com

A bioregulator – ortho silicic acid – a ray of hope after hailstorm in watermelon field

Heavy rains and hailstorms lashed at Marathwada, Vidarbha and western Maharashtra; affecting severely a dozen districts of the state. The hailstorm, initially thought of as one-off phenomenon, continued to batter places in Maharashtra for two weeks during mid-February. *Rabi* crops, wheat, cotton, *jowar*, summer onion and vegetables, all were lost; horticultural crops like papaya, sweet-lime, grapes were battered; and orchards, which took years to grow, had ridden to ground. For many farmers, the tragedy was unbearable as majority of their crops were about to be harvested.

A progressive farmer had planted watermelons in more than 10 acres of the land. It was disheartening to see severely damaged and rotted watermelons lying in the field, which would have fetched him a good market price in a week or two. To recover from the impact of hailstorm, he was guided for a follow-up crop of watermelon with promising bioregulators.

Accordingly, 30 days old seedlings, instead of 25 days, were transplanted. He was advised for using bio-regulator ortho-silicic acid (OSA) - based formulation for


Without treamant at 30 DAP


OSA treamant at 30 DAP


Without treatments (close view)


Ortho-silicic acid treatment (close view)


Without treamant at 70 DAP


OSA treamant at 70 DAP


Farmer acknowledging the technology intervention


Fruit size differences between treatments

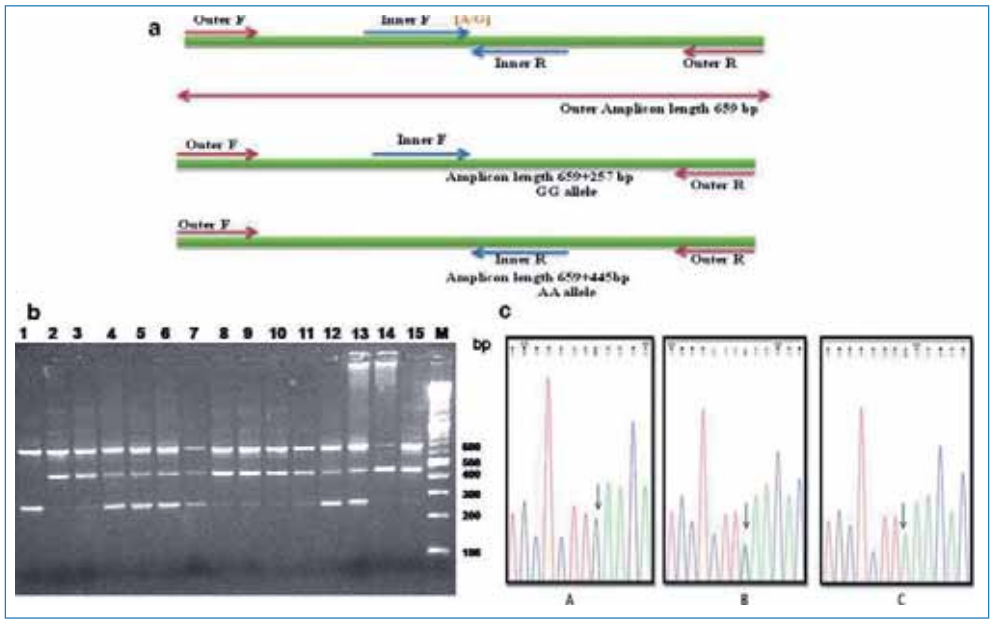
Effects of ortho-silicic acid on watermelon

stimulating crop growth, increasing greenness, number of flowers, shortening crop cycle and for increasing fruit size. He drenched the field with silixol after 20 days after transplanting (DAT) and with the foliar spray (4 ml/ L) of the same bioregulator after 60 DAP, which coincided with the initial fruiting stage. The vines drenched and sprayed with OSA produced bigger sized fruits (5 to 8.5 kg/ fruit) than the untreated (2.5 to 6 kg/ fruit) ones without compromising much on the number of fruits per vine. The plants treated with OSA showed one week advanced horticultural maturity than the untreated ones. Ultimately, the crop fetched the farmer a premium price; he earned more from the treated plot.

P. Ratnakumar, Yogeshwar Singh, P. Suresh Kumar, Kiran Bhagat, D.D. Nangare, P.B. Taware and **P.S. Minhas**
ICAR-National Institute of Abiotic Stress Management
Malegaon, Baramati, Pune (Maharashtra) 413 115
e-mail: pratnakumar@gmail.com

Single tube tetra ARMS PCR-based assay for genotyping FMD virus receptor in cattle

Foot-and-mouth disease virus (FMDV) exhibits a strong cellular tropism for bovine epithelial cells, and following a natural infec-tion, initial virus uptake and/or replication has been suspected to take place in pharynx and in soft palate. Two types of cell-surface receptors have been identified for FMDV – heparin sulphate proteoglycans (HSPGs), and most commonly, integrins. On the basis of the synthetic peptide inhibition studies, it has been reported that G-H loop of *VP1* gene contains a highly conserved arginine-glycine-aspartic acid (RGD) sequence that is implicated in the host receptor integrin binding, and is shown to mediate infection of the susceptible cells in *in-vitro*. Host heterogeneity has been indicated to play an important role in disease susceptibility. Understanding genetic basis of the host resistance, using advanced molecular tools, especially by identifying polymorphisms in the genes that determine specificity of the immune response and play a role in conferring resistance or susceptibility, would offer new alternatives for many disease-control programmes, especially for infectious diseases.



a. Schematic representation of the tetra-primer PCR assay for detecting polymorphism in the 5'UTR of the *ITGB 6 receptor* gene, **b.** Lane 1, GG genotype (659 and 257 bp); lanes 2, 3, 8, 9, 10, 11, 14 and 15, AA genotype (659 and 445 bp); lanes 4, 5, 6, 7, 12 and 13, GA genotype (659, 445 and 257 bp), **c.** Dendrogram analysis for different genotypes sequenced: A, GG (KJ847280); B, GA (KJ847281); and C, AA (KJ847282)

A single tube tetra ARMS PCR-based assay for rapid genotyping of the 5' UTR region of *bovine Integrin beta 6 receptor* gene, linked with FMDV host tropism, has been developed. Four sets of primers were employed: Outer Forward, Outer Reverse, Inner Forward and Inner Reverse. They were designed to amplify fragments of different sizes for each allele band; in the order to be easily resolved using agarose gel electrophoresis. To increase specificity of the reaction, a mismatch was introduced at the 3' end of each of the two allele-specific primers. Identified genotypes were subjected for their association with infected and non-infected animals, which were shown to be associated significantly with the FMDV susceptibility.

Rani Singh, Rajib Deb, Umesh Singh, Rani Alex, Sushil Kumar, Soumendu Chakraborti, Sheetal Sharma, Gyanendra Sengar, Rupali Singh and **Birham Prakash**
Molecular Genetics Laboratory
ICAR-Central Institute for Research on Cattle
Meerut (Uttar Pradesh) 250 001
e-mail: usinghas@gmail.com

Litchi in winter – A reality

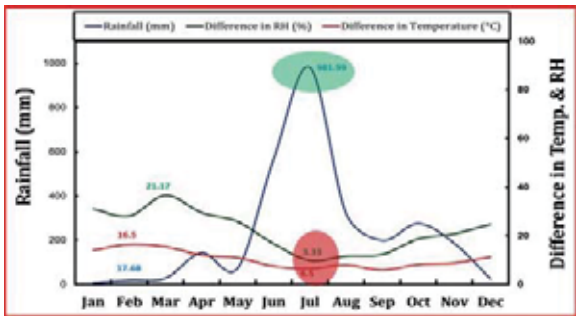
Main season of litchi in the northern parts of the country is April to July. Flowering occurs during February- March after a low temperature regime of three to four months (November-January). Low temperature triggers flower-bud differentiation. Unlike northern India, flowering in litchi in the southern parts, particularly places 900 amsl, takes place during August-September with a temperature of less than 20°C from June to August. Temperature difference of 3.53°C and humidity of 6.5 % coupled with high rainfall during pre-blooming period (June to August) triggers flowering in litchi-plants in the region.

Analysing climatic features, a survey in litchi-growing areas in southern India (Karnataka, Tamil Nadu and Kerala), at higher altitudes (>900 amsl) was carried out for three years consecutively in collaboration with the CHES (IIHR) Chettalli. This region has been identified as one with the potential for producing litchi-fruits at a par in quality with those from the northern India.

After visiting some of the litchi orchards in Kodagu, Kelpetta, Meppadi, Manandoadi, Wythiri, Ambalavayal, it has been observed that despite soil with low organic content, litchi-plants have done exceptionally well and have demonstrated possibility of further expansion in the areas in the southern region.

Some of the existing plantations in the region are producing regular fruits with lesser fruit-crack and sun-burn. However, some farmers' orchards had fruit drop during October. And some owning good plantation in the region, expressed concern regarding damage of fruits by birds and bats. A systematic technology demonstration in the region can boost litchi production.

Litchi cultivar China in full-bearing at the CHES, Chettalli



Wyanad and Chettalli climate favours litchi-plant to flower in August

Performance of litchi varieties in humid subtropics (Chettalli)

Variety	Panicle emergence	Fruit set (%)	Yield/tree (kg)	Fruit weight (g)	Pulp (%)	TSS (°Brix)	Acidity (%)
Dehradun	10 Aug.	35.25	28.3	18.43	72.91	17.3	0.98
Early Seedless	08 Aug.	29.9	21.0	15.2	73.89	16.3	1.04
Rose Scented	12 Aug.	8.50	13.2	13.3	69.50	13.5	1.07
Shahi	12 Aug.	34.60	26.0	19.2	71.30	16.2	1.04
Green	12 Aug.	33.9	20.0	15.2	71.23	15.8	0.67
Dehra Rose	12 Aug.	28.1	24.0	17.5	70.42	16.3	0.96

Vishal Nath, Amrendra Kumar, S.D. Pandey and *P.C. Tripathi
ICAR-National Research Centre on Litchi
Muzaffarpur (Bihar) 842 002
*Central Horticutlural Experimental Station (CHES) (IIHR), Chettalli
e-mail: nrclitchi@yahoo.co.in

Online access to Institutional Repository (IR) database

The University Central Library of the SKNAU was established in 2013, and its primary mission is to provide adequate support for teaching, research and extension programmes (by maximizing digital information resource for teachers, scientists, students, researchers, farmers, trainees, agricultural officers and other users of the University). The vision of the Library is to make a Digital Resource Learning Center (DRLC) for all constituents of the University. The Central Library is planning to develop a comprehensive collection of conventional documents and a digital learning environment with modern ICT infrastructural facilities – Laptop zone with Wi-Fi facility by establishing Online Public Access Catalog (OPAC), Internet Surfing, e journals, e theses and e catalogue (Webopac), e books (Open Access) , Digital Library Services and online-cum-CDROM databases facilities.

The University Central Library has started building its own Institutional Repositories (IR) to preserve, share and search teaching and research materials of the SKNAU. The digital resources would include annual reports, theses, e courses,

library periodicals' directory, reports, old question papers, research highlights, manuals, technical reports, e books, reprints, newsletters, advances and e journals' database of all units of the SKNAU. To make IR information accessible to online user community, it has to be stored as a Repository to create Institutional Database for further use and sharing among all unit libraries. A digital library portal has been created to bring digital collections and services of all libraries at one platform for speedy and prompt use of e resource collections. The digital library facilities have also been provided to all unit libraries of different teaching campuses of the University. More than 400 question papers, 40 manuals, 280 MSc /PhD theses,

newsletters, reports, Webopac are available online through weblink http://117.240.227.133/centrallibrary/and http://117.240.227.134/webopac/ on the university Website link. The online archiving e journals' database facility will be created by maintaining back-up files of the list of research contributions of faculty / scientists / students under the Institutional Repositories (IR) to serve as a meaningful indicator of the university's agriculture research contributions.

K.M. Krishna
Sri Karan Narendra Agriculture University
Jobner (Rajasthan) 303 329
e-mail: kmkskn@gmail.com

A promising 3-way cross for backyard poultry

Backyard poultry is for rearing birds with desirable plumage and high performance compared to local indigenous birds, with very little changes in husbandry practices, followed for indigenous fowl. Improvement in genetic make-up can be achieved either by pure-line selection or by crossbreeding to improve desirable traits through heterosis or combination of both. Different pure-lines are developed through selection and are crossed to develop crossbreds for backyard poultry farming. Higher shank length with moderate body weight helps birds to run faster; protecting themselves from predators.

3-way cross grower

Females in cages

One such line PD1 has been developed with higher shank length; to be used as a male parent for backyard poultry. PD1 was used for developing different 2 way crosses. However, there is a requirement of 3-way cross to supply easily parent stocks and for exploiting heterosis. Keeping this in view, a 3-way cross was produced using PD1 × IWI male and PD3 female. PD1 ×IWI × PD3 was evaluated for different traits under intensive system of rearing.

Body weight of male and female at 16 weeks of age was 1670±62 and 1096±14 g, respectively. Corresponding shank length was 122±2 and 99±0.5 mm. Weight at sexual maturity was 1702±20 g. Body weight recorded at 40 and 72 weeks of age was 1971±26 and 2182±33 g, respectively. The age at sexual maturity was 163±1 days. Egg production per bird up to 40, 64 and 72 weeks of age was 91.71±1.37, 204.48±2.50 and 233.28±3.18 eggs, respectively. The egg weight during early age was high, and at 28, 40 and 52 weeks of age was 51.25±0.37, 57.15±0.39 and 60.05±0.47 g, respectively. Eviscerated carcass yield (%) at 16 weeks of age for male was 66.12±0.36 %. The birds consumed on an average 120g feed per bird per day during the laying period. The performance of this cross has been very encouraging as it lays good number of eggs with high egg weight; indicating that this cross may be used as a potential egg-type backyard poultry variety. The multicolour plumage of this cross will be of great help for its popularization in the field. The male can be sold at 16 weeks of age for meat purpose. The higher body weight of the female at the end of a year cycle at 72 weeks of age may also fetch good price in the market for meat purpose. The brown colour of the eggs of this cross would be liked by farmers and consumers in the rural areas. Quality of eggs measured at different weeks of age indicated them of good quality. However, before large-scale supply of this cross, birds must be evaluated in the field under backyard system.

M.K. Padhi, R.N. Chatterjee and **M. Niranjan**
ICAR-Directorate of Poultry Research
Hyderabad (Telangana) 500 030
e-mail: rnch65@gmail.com

Popular rice landraces of Kashmir

The state is rich in rice culture from the ancient times, and has traditionally been known to grow aromatic and non-aromatic rice varieties. During the last five to six decades, a number of traditional varieties and landraces have been replaced by the modern high-yielding varieties.

An exploration and germplasm collection programme was organized in Khag area of Kashmir province, where just three decades ago 70 different types of paddy in the fields were claimed. Considerably high genetic erosion over the years has lead to loss of this tremendous genetic variability. Still some variability in the paddy fields in some remote and high altitude areas has been noticed, which is highly endangered. Therefore, these areas have been called as the 'last remnants of rice genetic diversity' in the state. During the exploration, 32 germplasm accessions of 15 rice landraces/traditional varieties from different areas of the province could be collected. These include landraces – Mushuq budij, Kamad, Baber, Kathwur – and some Zag(red rice) varieties – Gulzag, Mirzag and Tillazag. It is believed that more than 100 indigenous rice varieties were once grown in Kashmir. Aromatic rice Mushuq budij is the most popular landrace cultivated by many farmers in Budgam, Kokernag and Tangmarg areas of Kashmir. Next in importance is Kamad, yielding bold grained sticky rice.

Field of Mushuq budij(*right)* at Nunar Budgam and Kamad(*middle*) at Sagam, Kokernag, Anantnag

Mushuq budij has become a sought-after commodity on marriage ceremonies and special occasions, and can fetch ₹ 15,000-20,000 per quintal in the market as against ₹ 2,500 from ordinary Kashmir rice. Efforts are continuously being made by the SKUAST (K) for this landrace revival on a large scale to boost income of the farmers. An elderly farmer of village Nunar Budgam has revealed that he has been cultivating Mushuq budij since last six decades, and has always selected and maintained his own seed. According to the farmer its cultivation is comparatively labour-intensive and that nitrogen fertilizers and herbicides in this were never applied, even when there was decrease in yield. Weeding was done manually. Its crop generally matured in 130-145 days, giving a yield of 16 quintals/acre.

Sheikh M. Sultan
ICAR-NBPGR Regional Station
Srinagar (Jammu and Kashmir) 190 005
e-mail: sheikhmsultan@gmail.com

Badka – a new fig selection for Subtropical Himalayan Region

Frost is a major delimiting factor for growth of horticultural crops in the subtropical region in the north-western India, and there is also not much choice of crops and varieties in the region for diversification of horticulture. To assess the potential of fig cultivation in the lower Himalayan region, a survey was conducted in the subtropical region of Himachal Pradesh for the extent of variability in the local fig germplasm.

Common fig (*Ficus carica*) is one of the best options in frost, as it is basically a fruit of the warmer temperate regions well adapted to frost.

In India, it is largely grown in Pune and in a few sporadic plantations around Bengaluru, Sreeranghpattanum, Bellary and some isolated patches of Tamil Nadu and Andhra Pradesh. In north India, its cultivation is scattered over some parts of Uttar Pradesh, Uttarakhand and Punjab. In a study, entire subtropical region of the Himachal Pradesh was surveyed for fig germplasm diversity. There exist three distinct strains of local fig, initially named as BF-I, BF-II and BF-III. These strains were evaluated on-farm as well as off -farm for twelve years. BF-III has been found outstanding, and has been named 'Badka' (means Big Brother). Badka has been recommended for cultivation in zone-1 of Himachal Pradesh.

'Badka' selection bears nutritious large- sized bluish black fruits with an average weight of 36.8g and total soluble solid content of 14.8°B with low titerable acidity of 0.74%. The average yield of a full-grown tree is 37.6 kg. The fruits are quite gritty due to the presence of a large number of easily chewable seeds. The fruit-water content (72.7%) is comparatively lower than other strains of the region. Besides these, the tree of this selection is found to possess good degree of drought tolerance and with a fewer incidences of pests. No serious disease has been observed on this cultivar.

Bearing shoot of 'Badka' fig selection

Chip-budding in 'Badka' fig

'Ex-situ' establishment of 'Badka' fig mother-plants

Soil and climatic requirements: This cultivar has been found better on deep clay-loam soils. In the preliminary findings, it was observed that quality of 'Badka' fig was better during years when summers were prolonged than those with normal summers. In the areas where full Sun shines throughout the day, fruit physico-chemical characteristics were much better.

Propagation and planting: Leafless fully mature dormant hardwood cuttings of 1-2 cm thickness and 15-20 cm length are severed from mother-plants in December-January and are planted in nursery beds at a spacing of 15cm × 15 cm after callusing during mid to end of February. For callus formation, cuttings are kept in bundles of 50 to 100 in small pits for 1 to 2 months (January-February). The cuttings are ready for planting by July-August but for better field survival, the operation should preferably be carried out during winter. As 'Badka' is a vigorous cultivar, its planting can be at a spacing of 6m × 6m**.**

Top-working of local types: Top- working of 'Badka' fig may be done on the *desi* small fruited local figs through heading back of the primary branches in December. On the remaining stubs new shoots would emerge out in March. Three to four shoots per stub are retained and the rest are thinned out. These retained shoots attain bud-able size by mid of July. Chip-budding is generally practised for top-working of these new matured shoots.

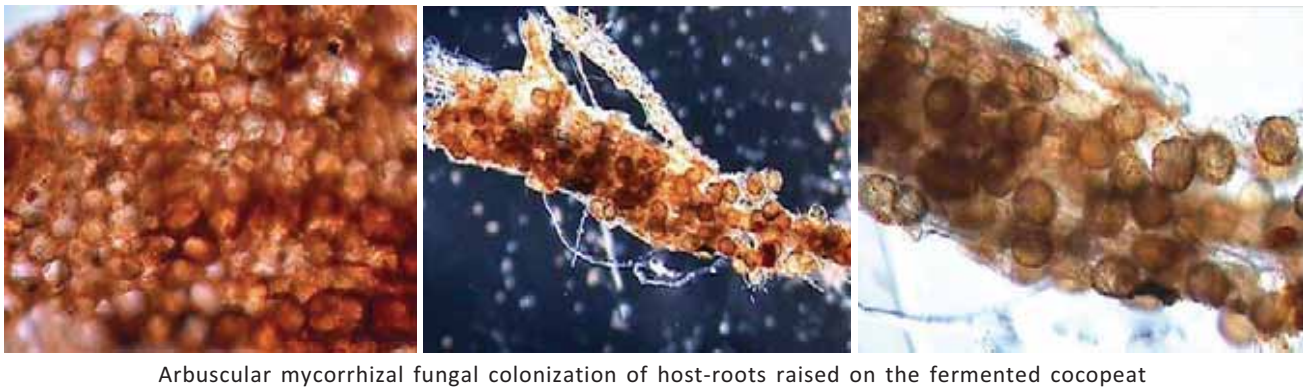
Training and pruning: Fig-trees are easy to manage when trained on fan system or bush system of tree training. Like other fig types, 'Badka' selection also bears on one to two years old wood and therefore tendency should be for encouraging this type of growth. Heading back of shoots generally to two buds should be practised.

Harvesting: This cultivar has a tendency to bear throughout the year but fruits attain maturity only in spring-season crop. The picked fruit are collected in wooden small-sized containers. One collection should not weigh more then 100-500g, otherwise whole lot gets spoiled. If large quantity is to be harvested then it is advised to harvest fruits in containers containing water, but such figs should not be allowed for more than 15 minutes in water and should be transported for further use as fresh consumption or for drying or processing.

Shashi K. Sharma
College of Horticulture and Forestry, Neri
(Dr Y.S. Parmar University of Horticulture and Forestry)
P.O. Khagal, Distt Hamirpur (Himachal Pradesh) 177 001
e-mail : shashi_uhf@yahoo.com

Soil-less arbuscular mycorrhizal fungal inoculum production technology

Arbuscular mycorrhizal (AM) fungi being obligate in nature cannot be multiplied in synthetic media. They usually multiply on the live-host plant roots grown on different substrates: sand and soil mixture, vermiculite, perlite, etc.



Arbuscular mycorrhizal fungal colonization of host-roots raised on the fermented cocopeat

Recently, AM fungal inoculants could be produced in *in-vitro* using modern technologies like root organ culture, aeroponic culture, etc, which facilitate host fibrous root proliferation in *in-vitro* conditions by providing suitable nutrient and growth conditions. Irrespective of the method followed, the host-plant root proliferation is the most important factor for getting desired AM fungal propagules in the final inoculum. To achieve this, a fermented cocopeat-based AM fungal inoculum production technology has been developed.

This technology utilizes sterile fermented cocopeat as the sole substrate for host-plant growth with the intervention of a beneficial bacterium (applied at 0.5 kg of carrier based inoculum per 1,000 kg fermented cocopeat substrate) for enhancing host-plant root growth, AM fungal colonization and proliferation within host-plant roots. The AM fungal inoculum so derived contains nearly five-fold higher number of infective propagules than the earlier substrate-based AM production methods, besides being free of any cross contamination. The entire process can be carried out in 45 to 60 days, either outdoors or in glasshouse. The fermented cocopeat-based AM fungal inoculum can be used as a bio-inoculant for raising vegetable, fruit, ornamental and plantation crops.

This technology also facilitates production of mycorrhizal colonized seedlings and planting materials, which is a prerequisite for successful horticultural crop production. A patent application (3817/CHE/2014) has been filed for this technology.

P. Panneerselvam, G. Selvakumar and
A.N. Ganeshamurthy
Division of Soil Science and Agricultural Chemistry
ICAR-Indian Institute of Horticultural Research
Bengaluru (Karnataka) 560 089

Indian tropical tasar silkworm on cashew plantations

In India, besides mulberry silkworm, tasar, muga and eri silkworms are other wild silk sources, which are lately being exploited. These three species were a good source of income since a long time for many farmers, especially of the North-Eastern region, tribal belt of Central and Eastern India and also of sub-Himalayan region. The Indian tasar silkworm (*Antheraea mylitta* Drury of Saturniidae : Lepidoptera) is a natural fauna of tropical India, represented by more than 40 eco-races. It feeds primarily on the following forest-tree species — *Terminalia tomentosa, T. arjuna, Shorea robusta*— and secondarily on *Lagerstroemia parviflora, Zizyphus mauritiana, Anogeissus latifolia, Syzigium cumini, Ricinus communis, Careya arborea* and *Hardwickia binata.*

Hatched larva and its chorion

4th instar larva

Damaged cashew-shoot

Cocoon of *A. mylitta*

Tasar cocoons are reported to be the largest among all silk-producing insects in the world with higher tensile strength, elongation and stress-relaxation value. These properties have made tasar silk as competent and as desirable as the mulberry silk.

In Odisha and Jharkand, *A. mylitta* was noticed to occur on cashew; rearing studies of *A. mylitta* were conducted on cashew-plants at the State Agricultural Department, Ranchi. At Gadjah Mada University (UGM) in Yogyakarta (Indonesia) also it was reported that silkworms eating leaves of cashew-trees produced high-quality silk. However, neither occurrence of *A. mylitta* nor utilization of cashew for its rearing was reported from any other part of India.

Interestingly, for the first time, during 2013 and 2014 in cashew plantations at Puttur (Karnataka), larvae of *A. mylitta* were noticed to damage repeatedly cashew-leaves. During June to August, silkworms were noticed on tender shoots of young cashew-plants. While during August to February, it occurred in a scattered manner on the young as well as medium aged cashew- plants. Oval eggs of about 2.5-2.8- mm size were seen mostly on the ventral surface of tender cashew-leaves. And at the same time, stout cruciform green larvae with hypognathous head were seen feeding voraciously on leaves of young cashew-shoots, leaving only the leaf-base of the midrib. Lots of faecal pellets were visible at the base of the plant. Larval

period lasted for 20-22 days. Cocoons with well formed dark- brown peduncle with a ring at the distal end were also seen on cashew-twigs. The cocoons were large, white and creamy-yellow. Females were bigger and yellowish orange, while males were brown. Presence of all life stages indicates suitability of cashew-plant for this silkworm. Rearing of this silkworm on cashew-shoots was successful in the laboratory also.

Subsequent surveys in other blocks of cashew plantations indicated that a maximum of two larvae or cocoons were noticed on a single cashew-plant but silkworm-fed-bearing trees yielded normally. The present report explores possibility of rearing *A. mylitta* on cashew. The obstacles in traditional outdoor rearing of *A. mylitta* on naturally grown forest trees can be overcome by adopting indoor rearing using suitable host-plant, probably cashew-shoots. This report is the first report of tasar silkworm occurrence in this region and throws light on the possible rearing of *A. mylitta* silkworm to derive additional revenue for cashew-farmers of coastal Karnataka. However, proper technology package for rearing of *A. mylitta* silkworm on cashew plantations both *in-situ* and *ex-situ* is yet to be developed.

K. Vanitha, P.L. Saroj and **P.S. Bhat**
ICAR-Directorate of Cashew Research
Puttur (Karnataka) 574 202

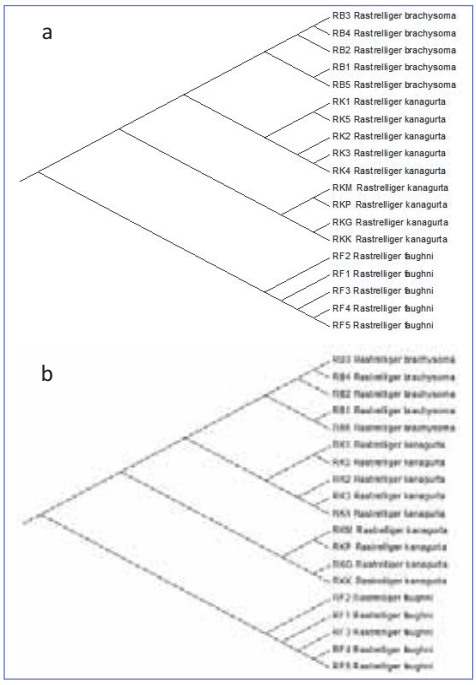
Mitochondrial-based phylogenetic analysis of mackerel species

Mackerel is one of the fish groups in Indian waters having high commercial value. The chub mackerel, *Rastrelliger*, was considered highly variable, and was reported with ten species; which were finally reduced to synonyms of three species. The mackerel fishery along the Indian coast comprises a single species, *R. kanagurta*, although two other species, *R. brachysoma* in Andaman seas and *R. faughni* along the east coast of India, have also been recorded in stray numbers.

Accurate identification of these three species is important for fishery management as their morphological characters are very similar.

a. *Rastrelliger kanagurta*, **b.** R. *faughni*, and **c.** *R. brachysoma*

They have been genetically characterized using mitochondrial COI and 16s rRNA genes. The sequence of these genes has been determined from 19 individuals of three species, *R kanagurta, R. brachysoma* and *R faughni*, from Andamans and Indian mainland to infer phylogenetic relationships. Using COI sequences, the intra-species genetic distance range was found between 0.000 and 0.012, and of inter-species between 0.039 and 0.086. Based on the 16S rRNA sequences, the genetic distance of intra-species was between 0.000 and 0.002, while it varied from 0.007 to 0.015 for inter-species.



K2P distance based UPGMA tree of three mackerel species using: **a.** *COI* gene, and **b.** *16S rRNA* gene

The results also indicated high level of intra-species divergence in *R. kanagurta* of the Andaman Sea compared to that of Indian mainland waters; this warrants further investigations.

ICAR-National Bureau of Fish Genetic Resources
Canal Ring Road
Near Telibagh, P.O. Dilkusha
Lucknow (Uttar Pradesh) 226 002

ICAR-National Research Centre for Grapes, Pune

Mandate: To undertake mission-oriented programme involving basic and strategic research for resolving major biotic and abiotic constraints affecting production, productivity and utilization of grapes

In early 1993, the Indian Council of Agricultural Research (ICAR) took cognizance of the grape-growers need for research support to solve production-related problems of the fruit-crop. Consequently, the ICAR-National Research Centre for Grapes was sanctioned in the VIII Plan on 16 September 1993, and the Institute came into existence at Pune in 1997 at Manjri on Solapur highway on 46.78 hectares; which was on lease from the Mahatama Phule Krishi Vidyapeeth, Rahuri. Apart from conducting research on various aspects of viticulture, the Centre is the Nodal Centre for co-ordinating grape research in India. The Centre has been and continues to be involved actively with grape industries, and with their collaboration it disseminates research results throughout the country.

The research programmes are formulated after the assessment of the need of the grape industry and due inputs from stakeholders for research priority areas. At present, research is conducted under the broad areas of Genetic Resources and Improvement, Production Technology, Plant Health Management and Pre- and Post-harvest Technology.

In the recent years, viticulture has become a major horticultural enterprise in the country. Many innovative grape-growers have taken initiative to export their produce to different countries of the world.

INFRASTRUCTURE

The Centre functions from Dr G.S. Cheema Bhavan, the laboratory-cum-administrative building. It has Director's office, Administrative-cum-Accounts office, Library,

GC-ion trap and single quadruple MS

Orbitrap high resolution mass spectrometer


Manjri Naveen


Medika bunch


Medika teinturien berries


Medika bunch and Juice

Committee room, Seminar hall, Museum, ARIS cell and Laboratories for different research disciplines. Biocontrol laboratory, Farm office, Soil sampling room, FRP house, Polyhouse and Nethouse have also been constructed within the premises. A separate building for the National Referral Laboratory for Pesticide Residue Monitoring in Grapes in the country has also been constructed with the financial assistance from the APEDA.

The Centre has 10 well- established laboratories: plant genetic resources; biotechnology; rootstock, canopy management and other horticultural practices; growth regulators; integrated nutrient, water, diseases and pest management with special emphasis on the pesticide residues; post-harvest management and processing for value-addition. It has latest generation models of LC-MS/MS, GC-MS/MS and ICP-MS, atomic absorption spectrophotometer, multi-channel auto analyzer, infrared gas analyzer, canopy analyzer, osmometer, steady-state porometer, pressure bomb apparatus, plant growth chambers, automated sequencer, sequencing gel apparatus, PCR machines and gel documentation system. Internet and e-mail facilities are made available to all. The Centre's website can be accessed at http://nrcgrapes.nic.in, and it is maintained in Hindi and English with weekly updates.

SALIENT ACHIEVEMENTS

A grape gene bank in the field, comprising more than 400 collections from India and a few from abroad, has been established. The germplasm is characterized based on the phenotypic and the molecular characterstics, using microsatellite markers. A catalogue of germplasm has been prepared. Based on the molecular analysis, a core collection of grape germplasm has been identified. Also an expert system to store molecular data has developed;

Residue Monitoring Plan (RMP) for Grapes

For entry of Indian grapes in Europe, implementation of RMP in India is essential. The National Referral Laboratory is the heart of RMP and it not only demands state-of-the-art facilities (latest generation models of LC-MS/MS, GC-MS/MS and ICP-MS) but highly qualified and competent scientists. The APEDA chose ICAR-NRC for Grapes, Pune, for establishing a National Referral Laboratory (NRL). The NRL is responsible for making list of pesticides residues that need monitoring in exportable grapes. This is the 10th year of the RMP. The NRL, at present, is well- equipped, which has contributed significantly in establishing comprehensive residue analysis protocols for simultaneous analysis of more than 400 agrochemicals with precision, accuracy and sensitivity (at d"10 ng/g). With the proactive actions of the NRL, the percentage of internal alerts for non-compliance to the EU-MRLs has been reduced drastically from 23.7% in 2003-2004 to 3-7% over the last six years. During the ongoing harvesting season, the ICAR-NRC for Grapes, in collaboration with the Maharashtra Rajya Draksha Bagayatdar Sangha, starts analyzing domestic market grapes for agrochemical residues on the experimental basis.

The residue analysis is taken up based on the voluntary declaration by growers on following of the Good Agricultural Practices (GAP).

More than 23,000 farms have registered their vineyards for production of exportable grapes during 2014-15. Handling of such a large number of vineyards traceability details for residue analysis is actually done in coordination with other stakeholders of grape industry through a web-based networking system called Grapenet. The ICAR-NRC for Grapes has contributed substantially in the development of Grapenet, which has also received national award for e-governance. The model of Grapenet is now being implemented for e-governance in many similar activities such as Winenet, Anarnet, Mangonet etc.

Since 2009, the scope of the NRL has expanded to cover all fruits and vegetables and also peanuts for aflatoxins. The NRL is also extending significant support to other ICAR institutes in establishing food safety for various agricultural commodities.

Accredited Nursery for Dogridge

New vineyards are usually established by first planting rooted cuttings of the rootstock and later grafting them *in-situ* with desired scion. The Centre has National Horticulture Board (NHB) accredited nursery, wherein rooted cuttings of popular rootstock, Dogridge, are multiplied for distribution to growers.

Vineyard view

Plants ready for sale

The Centre has played a very important role in identifying genuine Dogridge in mixture of rootstocks and in supplying rooted cuttings of true-to-type Dogridge rootstocks through its nursery. At present, most of the nurseries of the State Departments of Horticulture in Maharashtra, Karnataka, Telangana, and Tamil Nadu have genuine Dogridge rootstocks. The Centre has established nucleus blocks for multiplication of Dogridge and 110R rootstocks. In addition to these rootstock cuttings, the Centre can supply scions of many new varieties. In most grape-growing areas, rootstocks are planted in February-March, and are grafted with scion during August-September.

Planting material of the following varieties is available at the Centre

Rootstocks (Rooted cuttings)	Table grapes (Scion for grafting)
Dogridge	Manjri Naveen
110R	Crimson Seedless
1130P	Fantasy
Wine grapes (White)	Wine grapes (Black)
Sauvignon Blanc	Siraj Cabernet Sauvignon

and a molecular database for accessions has been created and is updated regularly.

Germplasm has been evaluated for desirable traits for direct commercial use or for improvement of the existing cultivars. Regular high fruitfulness, naturally loose bunches, bold and crisp berries, and long shelf-life have been identified as the most desired traits for table-grapes, as these traits would reduce cost of production due to reduced growth regulators' use and manual labour requirement. Manjri Naveen, a table-grape variety, released by the Centre, has most of these traits.

Downy mildew is the most damaging disease in major grape-growing areas in India. A marker-assisted breeding programme is in progress to introgress downy-mildew resistance in the most popular Thompson Seedless variety. Based on the association mapping approach, two promising markers associated with downy-mildew resistance have been identified. Two new polymorphic markers in quality trait loci region for downy-mildew resistance have also been identified. F_1 seedlings, developed by crossing downy-mildew resistant sources with Thompson Seedless, are in evaluation.

As the result of crop improvement in the recent-past, the Centre has short listed two promising hybrids (A 18/3 and Medika) and one clonal selection (KR White). A18/3 is a black seedless table-grape variety with regular good fruitfulness. Medika is a tienturein variety with coloured pulp, and is suitable for juice-making. It has attractive reddish-pink juice, which is exceptionally rich in stilbene, derivative of resveratrol and other phenolic compounds with antioxidant properties. The juice of this hybrid has been well accepted by consumers. KR White, a high-yielding variety, is found suitable for raisin-making in northern Karnataka; adjoining Maharashtra.

Most of the grape-growing areas have limited rainfall; and their soils as well as irrigation waters are with varying levels of salinity. Thus, drought resistance and salinity tolerance are the two most desired characters for the rootstocks. Long-term evaluation of rootstocks for table-grapes has indicated Dogridge, the most popular rootstock, suitable for drought but it has no mechanism to restrict uptake of sodium where soil and irrigation water have high sodium content. Rootstock 110 R has been found to restrict sodium uptake in Thompson Seedless under these conditions.

Stage-wise nutrient and water requirements for Thompson Seedless and Cabernet Sauvignon have been worked out. The fertigation schedule standardized for

Leaf blackening – Na toxicity and K deficiency

Vein reddening – K deficiency

Leaf reddening in Sharad Seedless – Na toxicity and K deficiency

Inward leaf curling – K deficiency

Bunch stem necrosis-Ca-Mg-K imbalance

Thompson Seedless on Dogridge rootstock has been found economical, and it reduced NPK requirement by 60 % over their direct soil application.

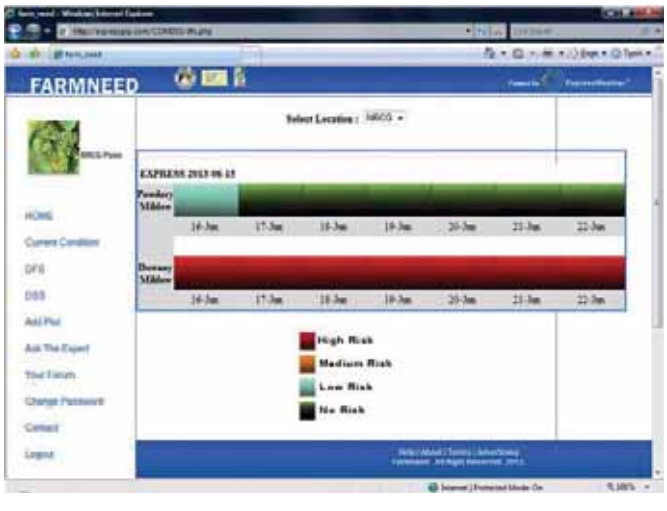
Following nutrient disorders — bunch stem necrosis, inward leaf curl, leaf blackening and necrosis, shiny spots, vein reddening and necrosis , leaf reddening and necrosis — have been corrected with the appropriate nutrients application.

Petiole of the fifth leaf from the shoots developed after each pruning is analysed for nutrients' guidance for fertilizer application. Petiole nutrient standards for N, P, K, Ca and Mg for Thompson Seedless vines, raised on Dogridge rootstock, have been developed for the first time by the Centre, and are found very useful for optimum fertilizer application in vineyards.

Optimum range of petiole nutrient norms for Thompson Seedless grafted on Dogridge rootstock

Nutrient	Nutrient content (%)	
	Bud differentiation stage	Full-bloom stage
N	1.20 – 1.53	1.44 – 1.80
P	0.387 – 0.472	0.283 – 0.356
K	0.590 – 0.680	1.61 – 2.95
Ca	0.727 – 1.03	0.508 – 0.81
Mg	0.877 – 1.28	0.579 – 0.870

Similar petiole N, P and K standards for Cabernet Sauvignon vines raised on 110R rootstock have been developed to benefit wine industry.



Disease forecast

Drip water application below the soil surface at 9 inch depth in black-cotton type soil resulted in 25% saving in irrigation water compared to surface method of drip irrigation. If additional sprays of antitranspirant formulation, Antistress, are given, substantial saving of irrigation water can be achieved. Downy mildew and powdery mildew actually damage crop only under some specific weather and plant growth stages. Understanding the disease progress under varying weathers has helped develop logical models for disease management based on the location-specific real time weather data, forecasted weather and vine growth stages. Day-to-day vineyard specific advisories for disease management are given on smartphones through internet to individual grape-growers. This has resulted in reduction in production cost with lesser fungicide applications. A

Staphylinid predator *Oligota* spp. feeding on red spidermite

Stem-borer larva infected with entomopathogenic nematode, *Heterorhabditis indica*

Anagyrus dactylopii (*left*). Parasitized mealy bugs (*top right*). Parasitized mealy bug with exit hole by parasitoid (*bottom right*)

Coccinelid, *Stethorus rani* larvae, a potential predator of red spidermite

number of efficient *Bacillus* and *Trichoderma* isolates with potential for multiple disease control have been identified, and would be taken forward for large- scale field trials. These biocontrol agents have also shown potential for management of fungicide resistance in pathogens and pesticide residues on berries.

A multi-target insecticide strategy can help farmers for proper selection of insecticides based on the insect-pest complex present in the vineyard. Various potential biological agents such as *Anagyrus dactylopii* and *Scymnus coccivora* against pink mealybug, *Stethorus rani* against red spidermite and entomophagus nematode *Heterorhabditis indica* against stem borer have been identified.

A fermentation room with small fermentors has also been set up for wine-making.

THRUST AREAS

Flagship programme: Development of decision-support system for enhancing productivity of grapes under abiotic (temperature and moisture) and biotic (insect-pests and fungal diseases) stress conditions.

Other Important Areas

1. Exploration of additional germplasm from north-east, north-west Himalayas and Western Ghats; and their evaluation and exploitation.
2. Basic and strategic research for abiotic stress and introgression of downy- mildew resistance in varieties suitable for tropical viticulture.
3. Fungicide resistance management strategy based on the use of alternative fungicides, biocontrol agents and safer biological products.
4. Use of plastic cover for protection of vineyards from cold, untimely rains and hailstorms.
5. Evaluation and adoption of modern machines and tools for vineyard operations.
6. Geographical indicators for grapes and processed products.
7. Validation of technologies developed by the Centre through on-farm and participatory research.

S.D. Sawant
ICAR-National Research Centre for Grapes
PB No. 3, Manjri Farm Post , Solapur Road
Pune (Maharashtra) 412 307
*e-mail:*dirnrcg@gmail.com

Histopathological studies for diagnosis of PFSR pathogens in asymptomatic maize

Post flowering stalk- rot (PFSR) of maize causes serious problem in India every year. This results in internal decay and discolouration of the stalk tissues, and reduces yield by blocking translocation of water and nutrients, and can result in the death and lodging of plants. The potential grain yield loss from rotted plants is estimated up to 42.9%.

Fungal mycelium invading epidermis and cortex tissues of susceptible plant

Acidic-neutral carbohydrates (Violet) and polyphenolic substances (blue-green) in resistant plant

Histopathological study of 30 days old asymptomatic resistant (CM 123) and susceptible (BML 6) genotypes planted in the inoculated soil

Macrophomina phaseolina and *Fusarium verticilloides* are the fungi associated with the stalk- rot. These fungi may be present in the plants without showing any visible symptoms of the rot. To authenticate their presence in the host- plant, extensive histopathological studies were carried out. Isolation of the above fungi from the asymptomatic plants proved their infection in the plants. It was observed that the pathogen penetrated from host root, and developed further systemically with inter-and intracellular colonization in vascular bundles and adjacent tissues, including protoxylem lacuna, xylem vessels and metaxylem.

The notable observation has been that PFSR pathogens are able to invade roots of both resistant and susceptible maize cultivars; proving that resistance is tissue-specific. Since, infection was found internally in the growing plant through conducting system, reducing inoculum load in the soil can be one of the best options to control disease.

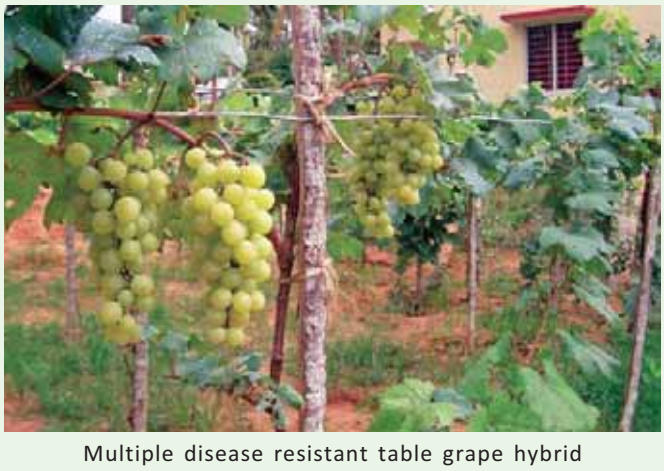
The PFSR pathogens present inside the host penetrate through root from the infected soil but plants appear almost healthy. Symptoms are visible only at the grain-filling stage when natural resistance of the stalk is reduced because of the production of chemicals for defence by plant tissues due to various stresses. Hence, grower needs to be vigilant at the critical flowering time even when crop looks healthy, and should be ready to manage stresses that occur after flowering to avoid losses. It is difficult to manage pathogens once symptoms appear.

Meena Shekhar
ICAR-Indian Institute of Maize Research
Pusa Campus, New Delhi 110 012
e-mail: meena.shekhar@icar.gov.in

New table-grape variety for mild humid tropics at Hirehalli

A multiple disease-resistant table-grape hybrid (Katta Kurgahan × Seveye Villard) with a short vegetative cycle, suitable for production of 2 crops per year, has been identified at Hirehalli, near Tumkur.

Its vines are precocious and are tolerant to downy mildew, anthracnose; and to powdery mildew also to some extent. Fruit clusters are 1-2 per shoot on a spur/ short cane, are with long peduncle, are medium sized, weighing 200-300 g, and are slightly conical to cylindrical in shape, and are with milky white, spherical to obovate medium bold berries, attaining 18-20 mm dia. with crisp pulp and mild muscat flavour, TSS 16° Brix and acidity 0.70 %; found suitable for both table purpose and wine-



Multiple disease resistant table grape hybrid (Katta Kurgahan x Seveye Villard)

making. Skin of its berries is rain- tolerant, and thus can be grown wherever traditional Bangalore Blue variety is grown. This variety is suitable for organic farming in mild humid tropical climate. Berries ripen in 95-100 days during April – July from flowering to harvest and 115-120 days during October-February.

ICAR-Indian Institute of Horticultural Research
Hessaraghatta Lake P.O.
Bengaluru (Karnataka) 560 089

Disease-resistant vegetable varieties

Frenchbean resistant to mungbean yellow mosaic virus: Mungbean yellow mosaic virus (MYMV) and high temperature limit Frenchbean cultivation in summer.

Pole-type dolichos resistant to rust and tolerant to high temperature: In dolichos pole- type, 14 lines, from cross between Arka Amogh/Arka Swagath and the breeding line 10/DOLPVAR- 1 (F_6), with different pod types

French bean Var. Arka Arjun showing resistance to MYMV along with susceptible lines and pods

Arka Swagath x 10/ DOLPVAR- 1 (F_6)

A MYMV-resistant variety, Arka Arjun, with yield potential of 17.4 tonnes/ha and suitability for summer cultivation under Bengaluru conditions (up to 35°C) has been developed through pedigree method of breeding. Its pods are green, round, smooth and are string-less.

and rust resistance have been selected for photo-insensitivity, earliness (60-65 days pod maturity) and average pod yield potential of 32 tonnes/ha.

ICAR-Indian Institute of Horticultural Research
Hessaraghatta Lake P.O.
Bengaluru (Karnataka) 560 089

Tribals' livelihood support through mango orchards in Odisha

A significant proportion of tribals were engaged in shifting cultivation without any soil- conservation measures, especially on the high lands of Odisha. High level of soil erosion was observed in Kashipur block of Rayagada district of Odisha, located in the interior of forest at 500-km away from the state capital. High lands have gravel on the surface, and are found suitable for tree- based perennial horticultural crops.

State Govt since long was making all efforts for mango-growing, but somehow the tribals were not able to realize the commercial value of mango. Pest incidence in some of the existing orchards and absence of assured mango marketing channel were the key constraints for mango growing.

Some non-tribal farmers with mango-orchards served as the risk- bearer technology demonstrators and a link between tribals and the research station. In the existing orchards, nutrient management, fruit-fly management, hot-water treatment (HWT), fruit packing and transportation, pre- and post-harvest interventions for

healthy fruits were demonstrated. And the market channel was established to a distance of 500 km. This inculcated confidence among the tribals and increased mango acreage in tribal villages. The motivated households were supported with technological interventions such as planting material supply, planting technology, soil management in sloppy lands and social mobilization through village meetings. Meanwhile, the villagers have also been organized under a society "Horticulture and Agriculture Related Panchayats' Association for Livelihood (HARPAL). The neighbourhood effect in tribal villages motivated 550 households for mango planting in 27 hamlets of 8 Gram Panchayats—Kashipur, Sulgunja, Sunger, Taljhari, Chandragiri, Shankara, Kudipari and Manusgaon —on 1,150 acres under the high- density mode (5m × 5 m) on the unused foot -hills, gentle hillocks and sloppy lands.

Mango planting has reduced soil erosion, and there has been a significant fall in tradition of shifting cultivation due to availability of alternative source of livelihood. Many orchards have started fruiting, and families are realizing monetary benefits.

Most of the present plantations have been done on the sloppy lands, and *in-situ* soil- and- water conservation practices are also being followed. Most orchard soils are poor and have disadvantageous locations hence attempts have been made to introduce IIHR Mango Special in the areas. All the fields are with high density plantation, and management techniques for hoppers, stone weevil, fruit borer and fruit flies, which are prevalent, have been demonstrated and adopted.

Developing facilities for collection and packaging infrastructure and developing new marketing channels outside the state, especially in south India, are also being explored. The multiplying impact of the success would be visible shortly; however, further technological back-up is needed for converting this tribal area into a mango belt. The area has been selected for the implementation of the tribal sub- plan by the CHES-IIHR.

H.S. Singh
Central Horticultural Experiment Station-IIHR
P.O.Aiginia, Bhubaneswar(Odisha) 751019
e-mail: mailto:singhhs@rediffmail.com

Pre- and post-harvest management of custard-apples in tribal region of Udaipur

Custard-apple fruits have a short shelf- life, and need to be sold fast. Being unaware of the regular markets, the tribes carried out marketing in an unorganized way. Due to inadequate handling facilities, tribes collected fruits and sold them at the road side; causing tremendous produce losses. In 2009, most of the produce was sold in the local market. In traditional marketing, the price they got was between ₹ 1.5 and 2 per kg and with group marketing, they were able to get ₹ 10 and 15 per kg.

Vanwasi Forest and Agricultural Produce Cooperative Samiti, Devla, members felt that if proper post- harvest management practices are introduced than the crop losses can be reduced.

It was decided to conduct surveys regarding production data, post-harvest losses and to identify the present mechanism adopted for harvesting, collecting, and packaging, handling and transporting of the custard - apples. A Performa was prepared and for each collection centre, one investigator was identified and was assigned to collect production data of five shrubs. The number

Shelf-life of custard-apple fruits in the Evaporative Cool Storage Structures (ECSS)

Remarkable decrease in mass loss of the product kept inside the chamber was observed. In control, fruits with 1-2 cm stem showed mass loss inside the ECSS from 0% to 22.46% while outside, it was from 5.81% to 87.74% in 4 days, and the fruits without stem showed mass loss inside the ECSS from 4.15% to 35.79% while outside the ECSS, it increased from 11.04% to 83.79% in 4 days. When the custard-apples were dipped in water than the fruits with 1-2cm stem showed mass loss inside the ECSS from 16.67% to 55.77% while outside it increased from 17.81% to 91.09% in 4 days and the fruits without stems showed mass loss inside the ECSS from 7.44% to 58.97% while outside the ECSS it increased from 8.46% to 91.69% in 4 days.

and mass of fruits harvested per plant and total mass of fruits obtained from one plant were measured. The physical losses (mass, quantity, quality) at various stages of post- harvest chain with various packaging material were also measured. The normal practice of the tribals was to fill 20 kg fruits in plastic crates without any cushioning material, just covering top with newspaper before transportation; 3-5 % loss in fruit mass occurred with this practice during 150-km transportation.

In consultation with the Samiti, Devla, only the collection centres were identified. The training was also imparted to farmers for appropriate method of harvesting custard-apples, grading and packaging. And the necessary study material with printed performa was made given to one person at the fruit collection centre. During the training programme, the farmers were explained maturity symptoms of fruits also.

The sheets of packing material (bubble- sheet and foam-sheet) were given to collecting centres of selected tribes, and packing techniques were shown to them in a training programme. At five centres, fruits were packed by using different packages, wrapped in newspaper, packed in bubble-sheet and foam-sheet with the control in which only top of the crate was covered with the newspapers; as practised by the farmers. The mass of the samples before and after the transportation was measured, and the mass loss was determined.

The data indicate that on an average custard- apple plant can produce nearly 45 fruits annually with approximately 170 g average fruit mass and about 7-8 kg fruit yield per plant. The range of different parameters was found to vary among centres mainly because of genetic characters of plants; as they are growing wild. Further, age and health of the plants, topography of soil, intensity and

Effect of packaging material on mass loss, hardness and colour of custard-apples during transportation

Treatments	Initial mass of fruits with packaging, kg	Final mass of fruits with packaging after transportation, kg	Mass loss during transportation, per cent	Initial hardness of custard-apple, g	Final hardness of custard-apple, g	Reduction in hardness after transportation, per cent	Initial colour score before transportation	Final colour score before transportation
T_1 (control without cushioning)	20.00	19.41	2.95	2156	1986	7.88	8	9
T_2 (with newspaper)	20.45	20.11	1.66	2155	2014	6.54	8	9
T_3 (packed in bubble sheet)	20.78	20.61	0.82	2158	2083	3.47	8	9
T_4 (packed in foam sheet)	20.85	20.71	0.67	2154	2089	3.02	8	9

amount of rainfall, moisture availability are other reasons affecting productivity.

It was found that the fruits packed in foam- sheet had minimum loss in mass (0.67%) and loss in hardness (3.02 %) while colour was same in all treatments.

With the intervention of the AICRP on Application of Plastics in Agriculture, the custard-apple fruits were harvested at proper maturity stage, packed in systematic manner with appropriate packaging material and marketed collectively at the distant places like Udaipur, Sirohi, Pali, Jodhpur, Jaipur, and even in nearby state Gujarat.

Maharana Pratap University of
Agriculture and Technology,
Udaipur (Rajasthan) 313 001

Fertilizer-application device, *CHES FERTREE DRILL*, for perennial trees

The CHES Fertree Drill has been designed in such a manner that it can be conveniently attached with the power-tiller to deliver fertilizers effectively in the feeder root zone. The implement has three units – storage unit, transmission unit and delivery unit. Hopper has a funnel-shaped two- chambered fertilizer box of 65cm ×50cm × 40 cm with fertilizer carrying capacity of 20 kg. Separate chambers are meant for granular and powdered fertilizers. Agitator (non-screw type) has been attached at the base of the box to ensure continuous flow of fertilizers. It gets power through a pulley attached with the crank of the power-tiller. To control fertilizer flow, two valves (one in each chamber) have been provided at the base of the hopper, which can be manually controlled. The transmission unit has two PVC delivery pipes (5 mm dia.) which receive fertilizers from the box and transmits to the delivery unit. The delivery unit has a funnel -shaped collection box (20cm ×20 cm ×20 cm) without valve, wherein delivery pipe (4 cm dia.) is attached. The delivery pipe is attached with tyne and furrow opener. The delivery GI pipe (4 cm dia.) places fertilizer (@ 4-10 kg/minute) just behind the furrow opener. The depth of the furrow can be adjusted with two wheels attached with both ends of the cultivator bar.

The CHES Fertree Drill has been designed to deliver fertilizers effectively in straight lines with enhanced labour efficiency. It has the potential to increase input-use efficiency and may reduce cultivation cost of fruit-crops. The devise has been tested and used in mango orchard but can be used for litchi, *aonla*, sapota, guava and plantation crops also. Its efficacy, however, needs to be tested in plantation crops.

Features of the fertilizer drill

Number of furrow openers	1
Tilt angle of furrow opener with respect to vertical	30°
Width of furrow opener	80mm
Depth control	20-30 cm
Capacity of fertilizer box (65cm × 50cm × 40cm)	20 kg
Fertilizer box design (Funnel shaped)	Separate chamber for granular and powdered forms of fertilizers
Suitability	Fruit/plantation crops
Fertilizer delivery system	Adjustable
Fertilizer delivery rate	4-10 kg/minute
Depth of fertilizer placement	20-25 cm
Coverage area/day (8 hr)	1ha (planting density-400/ha) 2ha (planting density-100/ha)
Cost of application/day labour (3) + fuel (1.5 litre/hr)	₹1,800/day
Labour required for manual application	16/ha/day (400 plants/ha)
Cost of manual application/ha	₹4,000
Cost effectiveness (FerTree Drill : Manual)	1,800:4,000 (222%)
Labour/work efficiency (FerTree Drill : Manual)	3: 16 (533%)
Cost of the implement	₹20,000-25,000

ICAR-Indian Institute of Horticultural Research
Hessaraghatta Lake P.O
Bengaluru (Karnataka) 560 089

Cassava *pappad*-making licensed

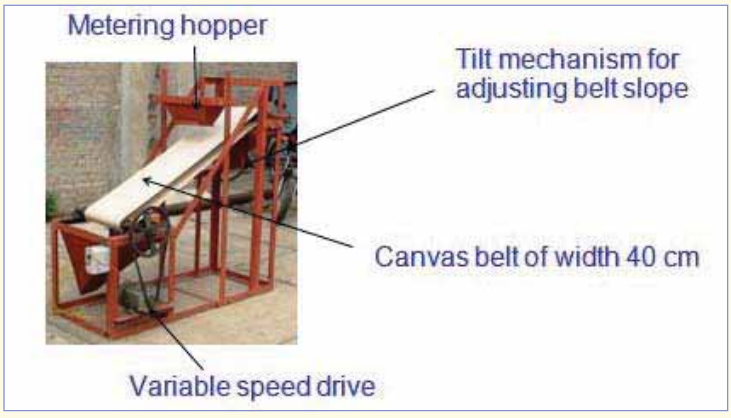
Cassava *pappad* is very popular in the southern parts of India, and it was prepared in a small scale at Thiruvananthapuram, Kalady, Palghat and Kallakurichi. To mechanize cassava-*pappad* production, properties of cassava- mash was needed to be altered suiting to machine feeding.

A process technology to enable production of low-moist gelatinized dough, meeting the requirement of the machine feeding, has been developed. And this process technology for production of dough for *pappad*-making machine has been licensed by the ICAR-Central Tuber Crops Research Institute to M/s Boosters International Kanyakumari District, Tamil Nadu.

ICAR-Central Tuber Crops Research Institute
Thiruvananthapuram (Kerala) 695 017
*e-mail:*ctcritvm@gmail.com

Inclined belt draper for berseem and chicory seeds separation

Inclined belt draper has been developed to separate materials on the basis of difference in shape and surface texture of the seed mixtures such as berseem and chicory. Its essential parts are —a metering hopper, which feeds seeds across the width of the belt, at its length-wise centre; a canvas belt of width according to the model of the machine; a tilt mechanism, which allows slope of the belt to be adjusted; and a variable speed drive to permit adjustment of upward-moving speed of the belt. The rough canvas belt was used considering rolling tendencies of the berseem. The developed belt draper has an overall dimension (L×W×H) of 1,520 mm × 615mm × 1,530 mm.



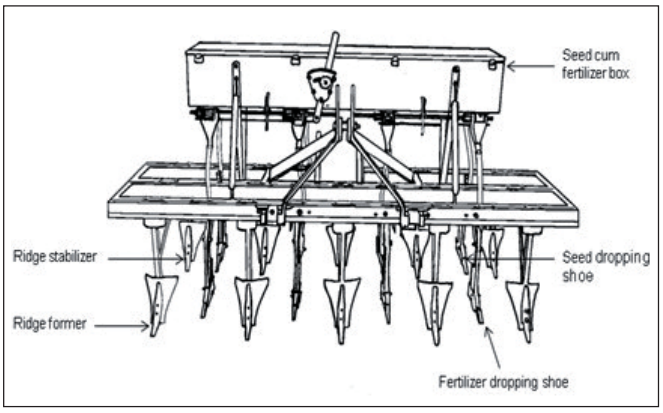
Mixture of berseem and chicory seeds is fed over the centre of the draper belt moving in the upward direction. The round and smooth grains (berseem) roll or slide down on to the draper at a faster rate than the upward motion of the belt and the rough surfaced grains (chicory) are carried to the top of the draper, and thus both types of seeds separate out and are collected from different outlets. Feed rate, draper speed and angle of inclination are the most important variables for effective separation of dissimilar materials. Generally, feed rate is kept low enough for separation of each type of grains. The inclination angle is adjusted to assure rolling or sliding of the desired fraction. This machine separated berseem seed at a maximum purity of 99% from berseem-chicory seed mixture (17:3) at 21° angle of belt inclination, 50 rpm draper speed and 8% moisture content (db). The achieveable capacity of the machine is 13.8 kg/hr. The cost of the machine hardware is ₹ 15,000; excluding DC motor cost.

ICAR-Indian Grassland and Fodder Research Institute
Jhansi (Uttar Pradesh)284 003
e-mail: pkpathakigfri@yahoo.co.in

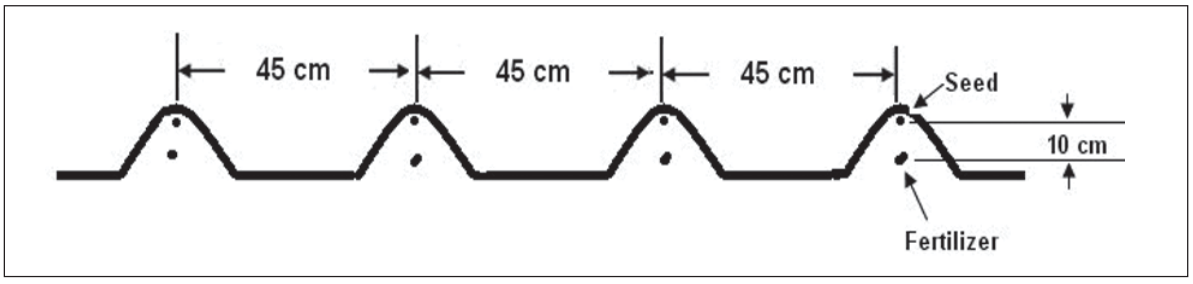
Ridge fertilizer- drill- cum- planter for moisture management and fertilizer save-on in Vertisols

In this ridge fertilizer-drill-cum-seed planter, provision for two sets of furrow openers is given; the front set is narrower than the rear one. The rear set also performs as a ridge stabilizer. It can sow soybean in 0.7 hectare

Machine in operation



Diagrammatic sketch of the machine



Diagrammatic sketch of the placement of fertilizer and seed in the ridge by the machine

of land in just an hour. The three- point linkage design of the machine is as per the category III of the OECD standards. It can be operated with 50 PTO HP tractor. High carbon steel is used for making different components of the machine.

This planter can manage with moisture problem of deep Vertisols and associated soils and in soils with calcareous strata of the Central and Peninsular India. It helps recharging groundwater, extends period of optimum soil moisture in the root zone, reduces ill effects of water stagnation on the crop, improves oxygen availability to roots, and thereby increases productivity of soybean- crop approximately by 30 % and saves 40% on basal dose of fertilizers. This machine can also be used for chickpea, maize and pigeonpea sowing by changing seed- roller. It has provision to maintain different row spacings for sowing different varieties of soybean -crop and of other crops as well.

License has been issued for manufacturing and commercial sell of this machine to two renowned manufacturers from Indore and Pune.

Dev Vrat Singh
ICAR-Directorate of Soybean Research, Khandwa-Road
Indore (Madhya Pradesh) 452 001

Public Distribution System impacts *Food and Nutrition Security* of the country

The concept of food security, in its wider connotation has four dimensions – availability, accessibility, utilization and vulnerability – and the relationship among them determine how food secure a country is or how adequate, steady and risk- free food consumption is at the household level and at the individual level. Though substantial progress has been made in reducing food insecurity, maintaining food security at the national and at the household level continues to be a major challenge for India. The Government has tried a number of strategies and approaches to improve food security in the country. These efforts include measures to increase production, interventions in grain markets, public distribution of food and maintenance of national food security stocks and promulgation of the National Food Security Act (NFSA). However, in spite of several initiatives and strategies, India still homes one-third of the world's undernourished children, one-third of Indian women are underweight, and almost half of Indian children are stunted and 40% are underweight. Concerned with alacrity of food and nutrition insecurity, the

Trends in contribution of PDS to cereal consumption in India (in percentage)

Commodity	Share of PDS in total consumption of rice & wheat			Households purchasing cereals from PDS		
	Rice	Wheat	Rice & Wheat	Rice	Wheat	Rice & Wheat
Rural						
1993-94	9.4	0.3	6.0	23.3	10.4	—
2004-05	12.8	7.2	10.6	24.4	11	26.6
2011-12	27.4	17.0	21.7	46.1	33.9	52.1
Urban						
1993-94	13.1	0.6	6.4	23.8	17.6	—
2004-05	10.9	3.6	7.3	13.1	5.8	14.7
2011-12	19.0	9.4	13.9	23.6	19.4	28.5
All						
1993-94	9.9	0.4	6.0	23.5	12.3	—
2004-05	12.4	6.2	9.8	21.3	9.6	23.3
2011-12	25.4	14.9	19.7	39.1	29.4	44.8

Source: Author's estimates based on unit level data from NSSO on consumer expenditure from 50th, 61st, and 68th rounds

Contribution of PDS in consumption of rice and wheat across social groups, 2011-12

Commodity	Share of PDS in consumption (%)				Per capita consumption through PDS (kg/year)			
	ST	SC	OBC	Other	ST	SC	OBC	Other
Rural								
Rice	32.3	32.3	28.1	18.9	27.6	24.1	20.1	14.2
Wheat	31.6	23.6	13.6	12.5	12.5	13.3	7.6	6.7
Rice and wheat	28.7	27.3	20.4	15.4	40.1	37.4	27.7	20.8
Urban								
Rice	21.9	23.5	23.6	10.6	15.3	13.2	14.8	5.3
Wheat	14.8	14.3	11.3	5.7	6.5	7.8	5.5	3.3
Rice and wheat	18.3	18.3	17.6	7.8	21.8	21.2	20.3	8.6
Total								
Rice	31.4	30.7	27.0	16.3	26.2	21.6	18.7	10.5
Wheat	29.5	21.5	13.0	9.6	11.8	12.1	7.1	5.3
Rice and wheat	27.6	25.5	19.8	12.7	38.1	33.8	25.7	15.8

Source: Author's estimates based on unit level data from NSSO on consumer expenditure from 68th round

Government of India has enacted the National Food Security Act (NFSA) in September 2013.

The public distribution system (PDS) is the most important intervention ensuring food security. Although the objectives and working of the PDS underwent significant changes since its inception; it essentially still remains a food intervention programme. The proportion of foodgrains purchased from the PDS to total household consumption provides a glimpse of its contribution in ensuring food security in the country. The share of PDS in total consumption of rice and wheat in India increased from 6 % in 1993-94 to about 20 % in 2011-12. The contribution of PDS in food intake is higher in rural areas (21.7%) than urban areas (13.9%).

Further, the access to PDS seems to be inclusive as higher proportion of the vulnerable section of the society (SCs and STs) is taking advantage of the PDS. PDS grains accounted for 28% of the total consumption of rice and wheat of ST households, 25% of SC households and 20 % of OBC households in 2011-12. About 13% of the rice and wheat consumption for other categories of households was also contributed by PDS.

The share of PDS in consumption of rice and wheat indicated wide inter-state variations. PDS share in total consumption of rice and wheat accounted for more than 10% of their consumption in 6 out of 20 major states of India in 1993-94; the number rose up to 10 in 2004-05. By 2011-12, the PDS contributed more than 10 % of rice and wheat consumption in all the states, except Gujarat. The trend clearly shows widespread revival and expansion of PDS. The spectacular performance by Asom, Bihar, Jharkhand, West Bengal in the recent years enthuse great

Impact of PDS on poverty and food security, 2011-12

Sector	Incidence of poverty (%)			Nutrition deficiency (%)		
	Poverty with PDS	Poverty without PDS	Reduction in poverty due to PDS	Nutrition deficiency with PDS	Nutrition deficiency without PDS	Reduction in nutrition deficiency due to PDS
Rural	25.3	29.0	3.8	24.2	47.2	23.0
Urban	13.7	15.1	1.4	12.3	25.6	13.3
All	22.0	25.0	3.1	20.8	41.0	20.2

Source: Author's estimates based on unit level data from NSSO on consumer expenditure from 68th round

State-wise share of PDS in rice and wheat consumption

State	Share of PDS in Rice and Wheat Consumption (%)		
	1993-94	2004-05	2011-12
Andhra Pradesh	20.4	20.4	27.1
Asom	3.1	3.5	22.1
Bihar	0.3	0.8	17.8
Chhattisgarh	2.3	11.3	34.3
Gujarat	6.6	9.3	7.6
Haryana	0.4	2.7	11.2
Himachal Pradesh	12.3	30.2	43.3
Jammu and Kashmir	2.2	28.6	47.1
Jharkhand	0.7	2.0	15.0
Karnataka	12.5	34.5	26.0
Kerala	41.8	18.7	34.0
Madhya Pradesh	2.0	11.2	16.6
Maharashtra	7.2	15.4	17.6
Odisha	0.9	6.0	27.2
Punjab	0.3	0.3	10.1
Rajasthan	0.3	8.1	10.4
Tamil Nadu	17.1	35.1	47.8
Uttar Pradesh	0.9	2.4	12.4
Uttarakhand	20.6	13.1	25.9
West Bengal	1.7	2.9	12.3
All India	6.0	9.8	19.7

Source: Author's estimates based on unit level data from 50th, 61st and 68th rounds of NSSO survey on consumption expenditure

confidence for improvement in the functioning of the PDS.

Increased access to PDS has also played a role in reducing poverty and increasing food security. The PDS contributed to overall reduction in poverty by 3.1% in 2011-12— 3.8% in rural areas and 1.4% in urban areas. Though in percentage it appears small, but in spite of its all inherent weaknesses, PDS has been able to move more than 40 million people out of poverty. In the absence of PDS, nutrition deficiency in terms of calorie would have been 41% but PDS has fixed it at 20.8%; almost 50% reduction in nutrition deficiency is attributed to PDS. Several other studies have also reported positive impact of PDS on poverty reduction and food security. There is a clear evidence that food transfers through PDS have considerable impact on improving food security and thus should be further strengthened.

The recent efforts made to revive and expand PDS coverage bring a ray of hope for effective implementation of the NFSA.

Anjani Kumar
National Institute of Agricultural Economics and Policy Research (on deputation to IFPRI)
New Delhi 110 012

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WAY FORWARD

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

As early as in late sixties, potential of hybrid technology was realized in India. Understanding the potential of hybrids even in the case of conventional non-hybrid crops like rice, mustard and safflower,a special project on the *Promotion of Research and Development Efforts on Hybrids in Selected Crops* (maize, sorghum, pearl millet, rice, cotton, sunflower, castor, rapeseed-mustard and pigeonpea) was launched in 1989 by the ICAR. And considerable progress has been made since its launch in most of the crops in terms of developing pollination control mechanisms for hybrid-seed production.

With the launch of this special project in the country, the hybrid rice research and development also got an impetus, and a total of 70 rice hybrids have been released – 31 from public sector and 39 from private sector. During *rabi* 2013-14, 30,000 million tonnes of hybrid rice seeds were produced, covering nearly 2.8 m ha during *kharif* 2014, which was only 6% of the total rice area in the country (as against 60% coverage in China). There exists a potential of increasing hybrid rice in 8-10 m ha, which would be nearly half the area under irrigated rice, provided highly heterotic region- specific hybrids showing > 20% heterosis consistently over best varietal check, possessing resistance to biotic and abiotic stresses and better grain quality and suited for varied agro-ecologies are made affordable to farmers.

Pusa RH10-The first superfine grain aromatic rice hybrid

Development of hybrid wheat through cytoplasmic genetic male sterility (CGMS) system appears to be one of the important approaches to enhance wheat productivity under optimum inputs. Maize is the third most important crop in the the series. Single-cross hybrids (SCHs) of maize, which are most productive and input-responsive, are Buland, DHM 117, HM 10, HM 11, PMH 1, PMH 3, Sheetal, Vivek Hybrid 21 and Vivek Hybrid 43 from public sector and Bio 9681, Bio 9637, NK 6240, Pinnacle, 30 V 92, DKC 9108, 900 M Gold, PAC 740, PAC 751, RMH 4726 and Seed Tech 2324 are from private sector. Currently, 65% of maize area is under improved cultivars, and SCHs are grown in 20-25%. Quality protein maize versions of parental inbreds of commercial single- cross maize hybrids have also been developed. Among various specialty types, sweet corn has emerged as one of the most important types. Cultivation of pop corn and baby corn is also coming up well in peri-urban areas. Starch has been one of the important by-products of maize-grains, used in the starch industry. A three-way cross hybrid 'Histarch Hybrid Makka', rich in starch, and recently, HM-13, a single-cross hybrid with higher starch, have been released. The area under pearl millet hybrids has increased tremendously, and is estimated at present to be about 68% of the total pearl millet grown in the country.

Among horticultural crops, India is the largest producer of vegetables. Heterosis has been exploited in vegetable crops for early and high yield and several fruit/ root quality attributes. At present, hybrid vegetable varieties widely cultivated in India are of tomato, cabbage, cauliflower, cucurbits, okra, chilli etc. However, only negligible quantity of vegetable hybrid seeds are produced. Availability of the suitable pollination control mechanisms is the most important determinant factor for production of vegetable hybrid seeds.

Quality seed is the prime driver of increasing productivity. Farmer-saved seeds, which are continued to be used in more than 60%, has a major demerit of unsure seed quality/viability. And the 'Hybrid' label is one seed technology that ensures seed replacement by farmers. Thus, hybrid development would provide double benefit of increased productivity because of hybrid vigour and higher production, owing to large-scale seed replacement in each season.

Transgenic technology and molecular cytogenetics have also enabled development of hybrid-seed production where naturally occurring CGMS does not work. Transgenic approaches (Seed Production Technology (SPT) and Barnase-Barstar system) in some crops as well as development of the '**National Platform for Hybrids**' for developing and organizing critical mass for hybrid development in each targeted crop for subsequent dissemination of proven hybrids, using public-public and public-private partnerships, would help spread hybrid-seed technology far and wide to ultimately increase agricultural productivity.

(S. Ayyappan)
e-mail: dg.icar@nic.in