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ICAR NEWS

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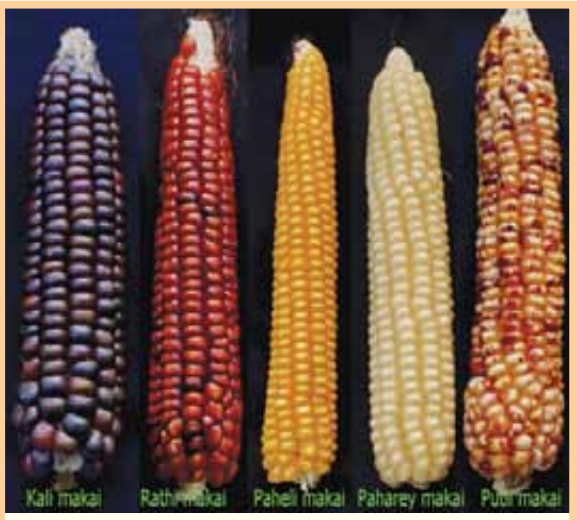
RESEARCH UPDATE

PROMISING TECHNOLOGIES

Maize landraces in India – Phenotypic and molecular characterization

IARI, New Delhi. Diversity of maize is impressive in the North-Eastern Himalayan region, specifically in Sikkim, including Murli makai (Sikkim Primitive), Kali makai (with dark purplish-black kernel type), Rathi makai (with dark- red kernels), Paheli makai (with yellow/orange flint kernel type), Seti makai (with white kernel type), Putali makai (with transposon-induced pericarp variegation), Chaptey makai (with white, dent-type kernels), Gadbade makai (predominantly white kernels with some purple flint kernels), Bancharey makai (a high-altitude maize with



Ear diversity in some landraces of Sikkim

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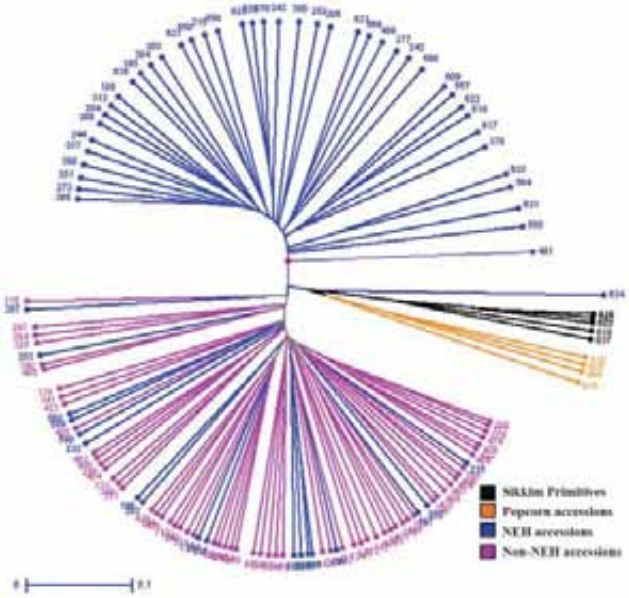
yellow, flint kernel type), Kukharey makai (with short-statured plants), Kuchungdari (with orange coloured popcorn-type kernels), and Kuchungtakmar (with a mix of yellow, white, purple and red kernels).

Intensive phenotypic and molecular characterization was carried out on a set of 132 maize landraces/locals, comprising 69 accessions from eight North-Eastern Himalayan states and 63 accessions from non-NEH region (tribal regions / plains in 15 states in India). Evaluation of the agronomic performance was undertaken at (i) Bajaura, Himachal Pradesh; (ii) Almora, Uttarakhand; (iii) Tadong, Sikkim; (iv) Hyderabad, Andhra Pradesh and (v) New Delhi in 2006-07. Apart from the data related to flowering behaviour, various yield parameters including grain yield, 100-kernel weight, ear length, ear diameter, number of kernel-rows per ear, number of kernels per ear-row and number of kernels per ear were recorded.

Multilocation evaluations of the selected landraces were done. 'Sikkim primitives' showed high prolificacy at Tadong (Sikkim) and to a moderate extent at Bajaura (Himachal Pradesh) and Almora (Uttarakhand). Although genotype × environment (G × E) interaction played significant role in agronomic performance of the landraces; several accessions with adaptation and promising performance in the specific locations belonging to one agro-ecological zone (Zone 1; Tadong, Bajaura, Almora) as well as across the zones (both hills and plains) could be identified. Noteworthy among these were IML181 (IC98180; Himachal Pradesh), IML452 (IC332276; Madhya Pradesh), IML454 (IC333247; Madhya Pradesh), IML615 (IC565883; Red-coloured popcorn local; Sikkim), IML298 (IC251270; Meghalaya), IML331 (IC331594; Bihar), IML332 (IC332300; Madhya Pradesh), IML390 (Sikkim local); IML459 (IC337439; Gujarat), IML496 (IC430635; Andhra Pradesh), IML498 (IC436850; Andhra Pradesh); IML499 (IC565898; Popcorn local; Karnataka). Specific accessions that performed well in the NEH region include IML580 (IC565876; Bancharey makai; Sikkim), IML609 (IC565890; Paheli makai; Sikkim), IML564 (IC565877; Chaptey makai; Sikkim), IML242 (IC130980; Assam), IML195 (IC130591; Manipur), IML622 (IC565869; Seti makai; Sikkim), IML619 (IC565867; Kuchungtakmar; Sikkim), IML557 (IC565888; Kali makai; Sikkim), IML569 (IC565872; Gadbade makai; Sikkim), IML315 (IC251354; Tripura) and IML216 (IC130749; Arunachal Pradesh). **Thus, the study clearly demonstrated that despite environment-specific adaptations, many of the accessions are capable of showing high adaptability across agro-ecologies.**

For the first time in India, detailed population genetic analysis of maize landraces using microsatellite markers was undertaken. Genomic DNA was isolated from each of the selected landraces using 'population bulk strategy'. Twenty-seven fluorescent dye-labelled microsatellite/ Simple Sequence Repeat (SSR) markers were used for DNA fingerprinting, with allele resolution using MegaBACE automated DNA Sequencer, followed by estimation of allele frequencies using 'FreqsR' software and subsequent conversion of frequencies to lengths using 'F-to-L' software. The datasets were further subjected to statistical analysis using POWERMARKER v3.25.

The analysis revealed a large number of SSR alleles (504), with high mean number of alleles per locus (18.7), and PIC (Polymorphism Information Content) of 0.68. This reflects diversity in Indian maize landraces as well as the informativeness of the SSR markers in differentiating populations. A large number (127) of 'unique or private' alleles were identified; clearly differentiating 67 out of 132 accessions. The study also revealed two highly frequent alleles across accessions, namely *phi062*$_{162bp}$ and *phi112*$_{152bp}$. These SSR alleles tag two important loci, namely *mgs1 (male gametophyte specific1)* gene that controls pollen fertility, and *Opaque2* locus regulating storage protein synthesis in maize endosperm. *phi112* was also earlier reported to be associated with a major quality trait locus for anthesis-silking interval in maize, which is an important secondary



An unrooted tree based on molecular data indicating genetic diversity in the NEH maize landraces, and the distinctness of Sikkim primitives

trait for drought stress tolerance. Thus, it was evident that genomic regions harbouring these highly frequent SSR alleles are not selectively neutral.

To partition genetic variations within and among populations, Analysis of Molecular Variance (AMOVA) was performed using ARLEQUIN v2.0 software. The analysis showed that 61.4% of the genetic variations in these accessions could be attributed to intra-population diversity, while the rest were accounted by inter-population diversity. An overall F_{ST} (è) value of 0.38 indicated high level of genetic differentiation among these populations. Cluster analysis was undertaken using Roger's (1972) genetic distance and UPGMA clustering algorithm and that resulted unrooted tree. The dendrogram revealed distinct genetic identity of the 'Sikkim Primitives' from rest of the accessions in India, which could be attributed to alleles associated with the unique features of this landrace. The popcorn accessions from Sikkim (IML608, IML610, IML615) along with a Karnataka local popcorn, clustered in another group; this group was genetically more closer to Sikkim Primitives as compared to the rest of the NEH accessions. Accessions from the non-NEH regions were found to form a different cluster, but some of the NEH accessions also featured in this cluster; indicating possible gene flow or utilization of NEH landraces by farmers in other regions of the country, particularly in the neighbouring states. Another large cluster comprised exclusively NEH landraces. Thus, analysis clearly demonstrated high genetic diversity in NEH landraces as compared to other regions as well as the genetic distinctness of the 'Sikkim Primitives'.

Landraces represent a rich source of genetic variation, and must be well characterized for efficient management and effective utilization in the breeding programmes. **The present study is the first of its kind on maize landraces in India including both phenotypic and molecular characterization.** The study led to (i) identification of several promising accessions with respect to agronomic performance, (ii) clear differentiation of the 'Sikkim Primitives' from the rest of the landraces, based on the molecular data, and (iii) revelation of high levels of genetic diversity in the Indian maize landraces, particularly those from the NEH region. The promising accessions identified in this study can be potentially utilized to find novel alleles for important genes using association mapping and allele-mining, besides utilization in breeding programmes.

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Aphid repellent mustard

NRCPB, New Delhi. Indian mustard suffers due to aphid *Lipaphis erysimi,* which causes yield losses ranging from 35.4 to 91.3%. Average yield loss has been reported at around 56.2%. Damage is mostly by nymphs and adults, which suck away plant sap, often covering entire shoot surface, floral buds and pods. Flowers fail to form pods, and developing pods do not produce healthy seeds. Besides, aphids act as vector for many viruses and pathogens.

Intensive use of chemical pesticides poses serious threat to environment, and breeding resistant cultivars has not been possible over years, mainly because of lack of resistant source within cultivated and even wild relatives of the plant. Therefore, genetic engineering has become imperative to compliment conventional breeding to incorporate resistance against this insect-pest. Genetic resistance in mustard cultivars against aphids is being developed through genetic engineering in three ways: screening insecticidal proteins effective against aphids, like plant lectins and protease inhibitors of diverse sources; making gene constructs for deployment of insecticidal genes into target cultivars and development of transgenic lines to test efficacy of novel gene(s) *in planta* against aphids. Several lectin and protease inhibitor genes have been isolated from chickpea, lentil and cowpea, and cloned in plant transformation vector for incorporation into mustard cultivars. These constructs are being used to develop aphid-resistant transgenic lines of mustard.

Also, transgenic mustard lines capable of emitting a sesqueterpene compound (E)-β-farnesene have been developed. Farnesene is an alarm pheromone, and plants producing this volatile develop repellency to aphids. Aphid-repellent mustard lines will provide an important component in the integrated approach of pest management against aphids. Such plants do not have insecticidal effects on aphids, and thus the possibility of insect population developing resistance to compound is reduced.

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NEW INITIATIVES

Participatory Land-Use Planning improved employment opportunity

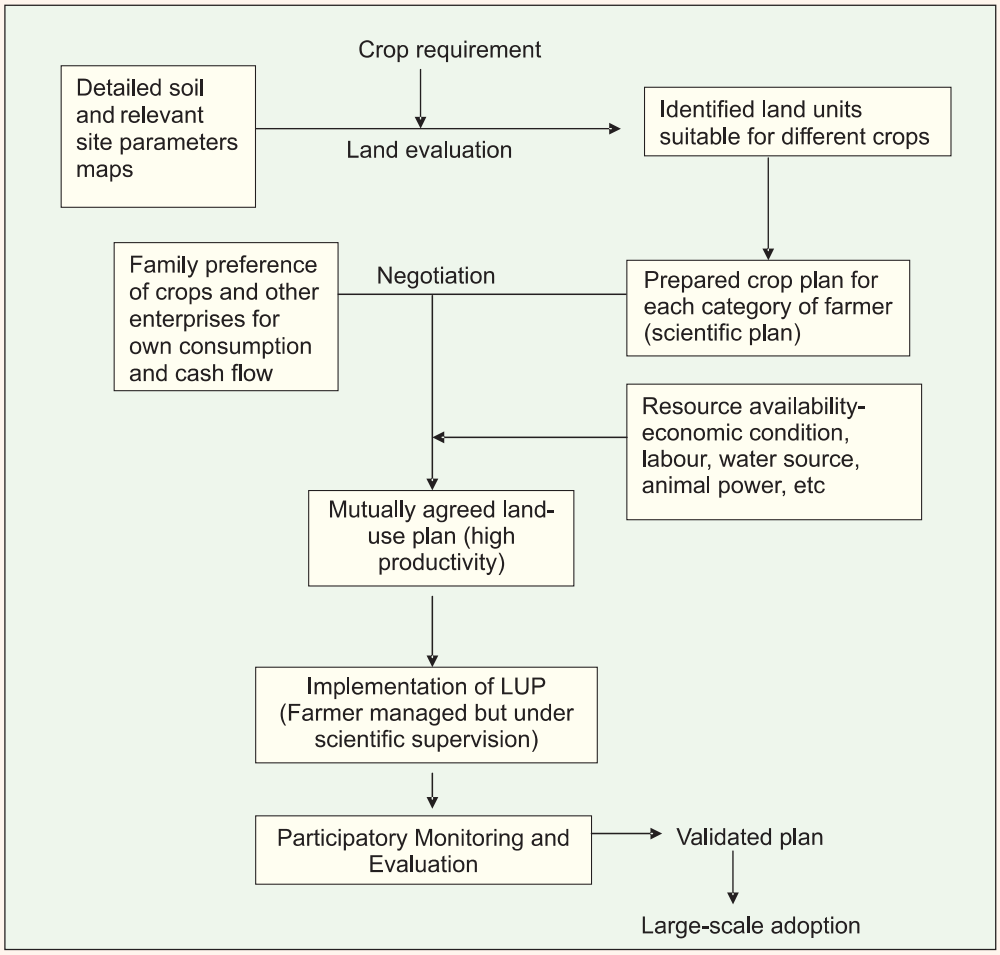
NBSS&LUP, Nagpur. In India, land-use planning at the local level is governed by farmer's own requirement and market prices rather than land-suitability criteria, which are followed in developed countries. The land-use plans suggested by the national and the state land-use boards and research institutes are seldom adopted by local communities/stakeholders because of the non-involvement of the local people in planning process, and the techniques suggested being highly innovation oriented. Moreover socio-economic and political factors at the household, community and national levels, which influence land use, are often neglected.

The aim of the PLUP is to strike a balance between the technical approach and the farmer's requirements to utilize natural resources in the sustainable manner. For PLUP validation, Kokarda and Kaniyadol villages of Kalmeshwar tehsil of Nagpur district were surveyed and evaluated. The participatory tools–participatory situation analysis, village

Natural resource mapping

Participatory land-use plans implemented in Kokarda and Kaniyadol village

Farmers / Category	Before PLUP	After PLUP	% Increase in income	Employment (Man-days)
Landless farmer	Agrl labour Goat rearing	Backyard poultry with Giriraja breed, Goat rearing (10 local breed +1 Osmanabadi buck)	60	Throughout year
Small farmer	Farming (mostly shallow soils)-cotton hybrid/ soybean/sorghum/ wheat+goat+ orange orchard	**Farming** (cotton variety(LRK 516) with 90 cm × 45 cm spacing + pigeonpea, early sowing of sorghum/marigold, liquid rhizobium treated soybean, chickpea/ coriander in rainfed, wheat in medium deep/deep soil with irrigation, vermicompost application to orange) + **Backyard poultry** (Giriraja) + **Goat rearing** (10 local breed +1 Osmanabadi buck) + **Mushroom cultivation** + **Honeybee keeping**	79	450
Medium farmer	Farming (shallow, medium-deep and deep soils)-cotton, sorghum, soybean, wheat/chickpea + cattle + goat + backyard poultry	**Farming** (cotton variety (LRK 516) with 90 cm × 45 cm spacing + pigeonpea, early sowing of sorghum (CSV 15)/ marigold/ coriander in shallow soils, liquid rhizobium-treated soybean, early sowing of sorghum, Bt cotton, followed by seed primed chickpea/ coriander (rainfed) and mulberry + mung-chickpea and wheat in medium, deep soil, cotton hybrids, soybean, sorghum, followed by seed primed wheat and vermicompost application to orange orchard) + **Dairying** + **Sericulture** + **Giriraja poultry** + **Vermicomposting**	60	600
Large farmer	Farming (deep, medium-deep and shallow soils)-cotton+pigeonpea, sorghum, soybean, wheat, vegetables	**Farming** (sorghum cv BJH 117, CSV 15, cotton hybrids + pigeonpea, Bt.cotton hybrids, liquid rhizobium-treated soybean, vermicompost application to vegetables and orange, seed primed chickpea/coriander in rainfed and wheat in irrigated) + **Dairying** + **Sericulture** + **Vermicomposting** + **Honeybee keeping**	70	225+



Participatory Land-Use Planning (PLUP) – Approach

meetings and workshops, open questionnaires, interviews with stakeholders, social mapping, gender analysis, training of local facilitators and creation of village committees and self-help groups (SHG's)–were employed. Through active participation of farmers as well as villagers, natural resource mapping including types of soils and other interpretive maps, topographic mapping, transect walks and land-use maps were prepared. Crop plans for each farmer were prepared.

The prepared PLU plans not only increased income of different category of farmers but also improved employment opportunities for farm families and non-agriculturists of the villages and also brought diversification at the farming system level .

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SPHR 1.0 – Statistical package for horticultural research

A menu-driven statistical package for horticultural research (SPHR 1.0) has been developed on windows platform having features of performing horticultural crop data analysis using first order and second order statistics. In addition, this software has modules for performing analysis based on the experimental designs like one-way, two-way and various interaction analyses. A separate module is provided for qualitative data analysis using non-parametric tests. Modules for horticultural crop-specific techniques useful in annual and perennial crop-breeding experiments, nutritional trials, entomological trials and related experimental techniques have also been developed. Programming codes were tested and debugged for providing consistent results.

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Networking herbal gardens

DMAP, Anand. The networking of the herbal gardens maintains information on gardens and species maintained not only of the most common and important species of medicinal and aromatic plants, which are being used in day-to-day primary health-care, but also of those which are under various degrees of threats in India. The database maintains species information based on the plant habit—herb, shrub, tree as well as climber. It also provides number of plants maintained in each species with quality parameters identified and availability of planting material based on the information given by the participating members of the herbal gardens. Members of this herbal garden network have access to website for updating their data from time-to-time. At present, a total of 70 herbal gardens across the country are registered as members in the network. Provision has also been created to add new gardens in the database by sending request to the DMAP. This network provides access to common people about information of the herbal gardens in India.

With the networking of herbal gardens one can access information on availability of species, planting material etc.,

at various herbal gardens. This would also facilitate collectors to approach nearby garden for the material.

A database website for this networking project has been developed and hosted at URL: http://www.herbalgardenindia.org by the DMAP.

MEMBER HERBAL GARDENS

Ausadhiya Poudh Vatika / Model Medicinal Plants Garden, Pantnagar; **Ausadhiya Vatika,** Hisar; **Ausadhiya Udyan,** Jabalpur; **Azad Hitech Herbal Garden,** Kanpur; **Botanical Garden,** Chandigarh; **Botanical Garden,** Nauni-Solan ; **Botanical Garden,** Sarangpur; **Botanical Garden,** Waghai; **Department of Agronomy,** Lothian; **Dhanvantari and Sanjivani Herbal Garden,** Junagadh; **Dhanvantary Udyan,** Rahuri; **Gopabandhu Ayurveda Mahavidyalaya, Herbal Garden,** Puri; **Govt Medicinal Botanical Garden,** Antarsuba; **Govt Medicinal Botanical Garden,** Bhuj; **Govt Medicinal Botanical Garden,** Danta; **Govt Medicinal Botanical Garden,** Jeetnagar, Rajpipla; **Govt Medicinal Botanical Garden,** Rajpipla; **Govt Medicinal Botanical Garden,** Saputara; **Govt Medicinal Botanical Garden,** Sasangir; **Govt Medicinal Botanical Garden,** Vansada; **Harishankar Herbal Garden,** Nandupala; **Herbal Garden – Tandijoda,** Telkoi; **Herbal Garden JNKVV,** Jabalpur; **Herbal Garden Motibaug,** Junagadh; **Herbal Garden of Dr Y.S. Parmar University,** Nauni-Solan; **Herbal Garden of Govt Ayurveda College,** Bolangir; **Herbal Garden, A&M Plants Research Station (KAU),** Asamannoor; **Herbal Garden,** Bolangir; **Herbal Garden, Deptt of Horticulture,** Dharwad; **Herbal Garden,** Dumreda; **Herbal Garden,** Faizabad; **Herbal Garden, Govt Hr Sec School,** Sadayampatti; **Herbal Garden, Instructional Farm,** Vellayani; **Herbal Garden,** Joginder Nagar; **Herbal Garden,** Khandagiri; **Herbal Garden,** Namakkal; **Herbal Garden,** Neri; **Herbal Garden,** Nrusinghnath; **Herbal Garden, S.K.N. College of Agriculture,** Jobner; **Herbal Garden,** Sadayampatti; **Herbal Garden, TBGRI,** Karimancode P.O.; **Homoeopathic Medicinal Plants Research Garden,** Kundah; **Institute of Himalayan Bioresource Technology (CSIR),** Palampur; **Jawaharlal Nehru Govt Medicinal Botanical Garden,** Gandhinagar; **Kamalapur,** Digpahandi; **Kasturba Sewa Samiti Nursery, Deothi,** Solan; **KFRI Medicinal Plants Garden,** Peechi; **Koinpur *Ex-Situ* Conservation/ Live Herbarium,** Paralakhemundi; **M.A.K. Govt H.S. School Herbal Garden,** Karaiyur; **Medicinal Germplasm Garden RPRC,** Bhubaneshwar; **Medicinal Plant Garden R.R.I. (Ayurveda),** Guwahati; **Medicinal Plant Garden cum Gene Pool Conservation Plot,** Sangmein; **Medicinal Plant Garden cum Gene Pool Conservation Plot,** Umsaw Nongladew; **Medicinal Plant Garden cum Gene Pool Conservation Plot,** East Khasi Hills; **Medicinal Plant Garden cum Gene Pool Conservation Plot,** Rongrenggiri; **Medicinal Plant Garden cum Gene Pool Conservation Plot,** Umkhuti; **Medicinal Plant Garden,** Jabalpur; **Motibaug Herbal Garden,** Junagadh; **North-East Ecological Park,** Jorhat; **DMAP Herbal Garden,** Boriavi, Anand; **Pana Nuagam,** Khallikote; **Plant Biodiversity Park cum Genomic Valley (Charak Vanoshdhi Vatika),** Dapoli; **Regional Research Institute of Ayurveda,** Gwalior Road, Jhansi; **Jawaharlal Nehru Ayurvedic Medicinal Plants Garden and Herbarium,** Kothrud; **S.M.P. Garden,** Terikhet, (Ranikhet); **Sanjivani Kutira,** Bhanjanagar; **Sartuli,** Kallikote; **Sasan Ambagam,** Hinjilikatu; **St Claret's Herbal Garden,** Karumathur; **Viswanathan Memorial Herbal Park,** Vellanikkara.

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Pollen cryopreservation – simple and cost-effective

NBPGR, New Delhi. Pollen conservation being a cost-effective and simple method is easily adopted by cryogenebanks, where their long-term storage is ensured. Pollen storage has still not been very effective for PGR preservation, since there are no effective protocols for regeneration of plants from stored pollens. This may be overcome by long-term storage of immature pollen (at uninucleate stage), which may later be inducted for embryogenesis. At the National Cryogenebank of the NBPGR apart from regular cryobanking of desiccative sensitive tissues, pollen conservation has been carried out selectively in the following cases: (i) For species where there are no other conservation methods available; (ii) For wild and endangered species, which are found flowering in nature; (iii) For assisting breeders by cryostoring desiccation sensitive pollen and providing frozen pollen near female parents.

Pollen cryobanking

Pollen processing involves its desiccation to optimum moisture level before liquid nitrogen (LN) exposure to avoid ice formation. Desiccation-tolerant pollens on drying to moisture level below which freezable water does not exist, usually retain original viability after LN storage. For desiccation-sensitive pollens (mainly belonging to family Poaceae, Asteraceae), desiccation is done till no freezable water exists but above the levels where desiccation injury is apparent. Samples are invariably frozen by direct cooling in liquid N and are later thawed by warming to room temperature.

At the NBPGR, pollens of mainly recalcitrant seeded species and wild species comprising more than 200 accessions have been successfully cryostored. And 180 accessions of highly recalcitrant seed species of mango have been cryostored and their viability tested by field pollinations in collaboration with the CISH, Lucknow.

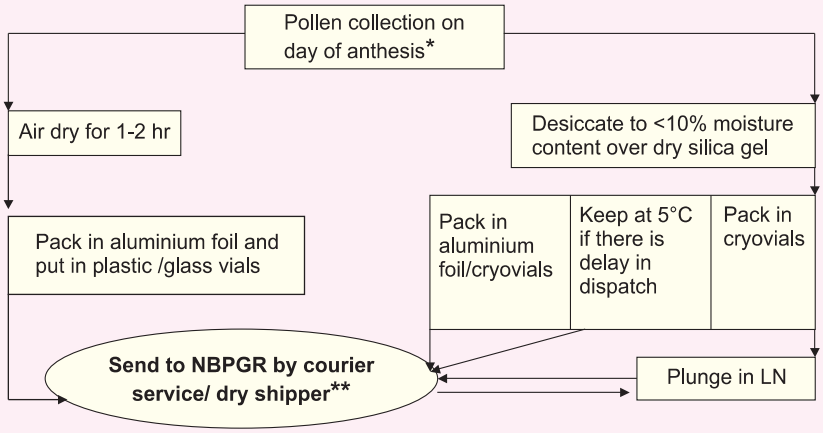
Retrieval and post-storage viability assessment

In-vitro germination has been commonly used for testing viability. Tetrazolium (TTC) test is also conducted. Fluorochromatic Reaction (FCR) test is conducted to test presence of esterases in the cytoplasm and to check membrane intactness. The best method to test viability is by field pollination, and quantifying it by seed-set percentage.

Our detailed studies have showed that it is feasible to cryogenically store pollen-grains of oilpalm for longer periods beyond 8 years without any significant losses in viability and germinability. There were no reports till now of successful oilpalm pollen storage for more than 1 year at temperatures of –15°C and –10°C. Cryopreserved oilpalm retained as high as 54% viability as judged by the FCR test and 49% by *in-vitro* germinability. This was comparable to 52% germination before storage.

Cryostored fresh pollen of mango var. Neelum on crossing with var. Amrapali yielded 4.2% fruit set. And, one year cryostored pollen on crossing with Amrapali yielded 20.8% fruit set. Similarly, pollen of Bombay Green, fresh and one year cryostored on crossing with var. Neelum yielded fruit set percentage of 2.1 and 8.3. These results confirmed that pollen storage and transport to long distances did not affect their fertilizing ability. The methods developed for pollen cryostorage are thus leading to successful cryopreservation of diverse germplasm.

Collection and storage of pollen in cryobank



*Collect pollen of fruit tree, mangrove and selected genera like *Artocarpus, Achras zapota, Garcinia Avicennia,* mulberry, *Hevea,* litchi, *Mangifera, Shorea, Syzygium, Theobroma.* Collect pollen of members of Poaceae, Brassicaceae and Asteraceae only when they can be cryopreserved the same day.
**Dry shipper are available at the National Cryobank at the NBPGR, which can be lent out to collaborators.

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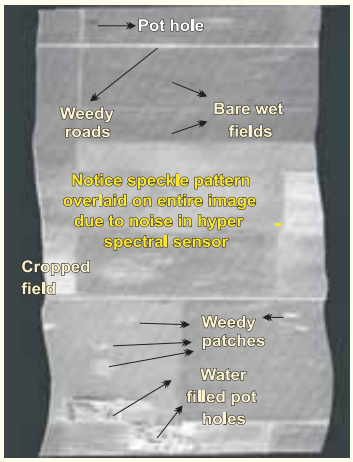
Img2Info© user-friendly utility for processing aircraft/satellite data

IARI, New Delhi. In airborne remote-sensing, earth features are primarily characterized through digital processing of grey values (recorded as digital numbers, DN) in each pixel of an image acquired in 2 or more spectral channels/ wavebands. For quantitative characterization of earth features, current digital image processing methods either compress spectral information or apply some complex spectral data-analyzing procedures such as Principal Component Analysis and Partial Least Squares. Hence current spectral data-analyzing methods lead to partial quantification/ compression of spectral information on any earth feature. Img2Info©, Ver. 1.2.2000 (Image to Total Information Content) is a user-friendly digital image-processing utility that has been developed to overcome this limitation.

Img2Info© has showed tremendous potential in many land-use planning and change detection regulatory programmes.

Img2Info© generated Output for 120 band hyper-spectral data of 3 nm band width and 1 m spatial resolution

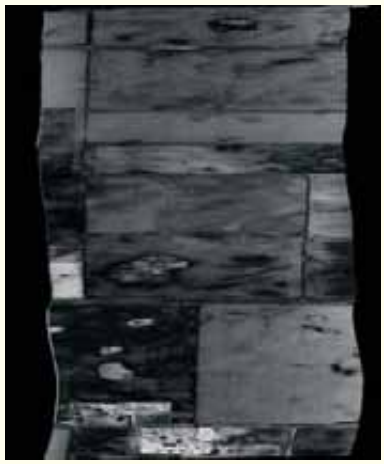


OVERALL USER ACCURACY: 70%

Hyper-Spectral Sensor Defect Detection

Note: Speckle pattern (Noise) in the single channel image generated through the Img2Info© utility applied on 120 band hyper-spectral data (on LEFT). In contrast to this, the single channel image generated through the application of the same Img2Info© utility on the conventionally used 3 hyper-spectral bands (on RIGHT) showed no noise thereby confirming an inherent noise in the (other than these three) spectral bands & illustrating sensor defect detection potential of the new hyper-spectral data analyzing technique.

Img2Info© generated Output for 3 band (Red, Green and Blue) hyper-spectral data of 3 nm band width and 1 m spatial resolution



OVERALL USER ACCURACY: 90%

Distinctive features of the new spectral data-analyzing technique

- **Capability to collectively analyze any number (from 2 to 8,192) of multi (broad) or hyper (narrow) band spectral data** as opposed to conventional techniques, which generally use a maximum of 3 bands at a time.
- As the technique can process information contained in all the available spectral channels, **it enables complete data quantification**; an aspect not possible with any of the conventional spectral data- analyzing techniques.
- **Good edge detection tool** as it transforms a 4, 8 or 16-bit input image into a 6, 11 or 20- bit (radiometrically enhanced) output image.
- Generates a single channel 6, 11 or 20-bit high resolution output image with **less data storage space requirement**. *For example:* In one case, the aircraft acquired hyper-spectral data occupying 90,959 KB. However the new technique based output image was of only 1,908 KB, only 2% of the original size. Similarly in another case, the original sizes of satellite imageries were 18,955 and 13,165 KB, and the new technique-based output imageries were of only 6,316 and 4,387 KB, only 33% of the original size.
- **Enables excellent data compression**.
- Capable of delivering high accuracy levels with radio-metrically enhanced (6, 11 or 20- bit) output imageries.
- Enables **easy detection of systemic noise in hyper-spectral sensors**.
- Requires simple 1-D clustering analysis techniques for image classification as the output image generated by Img2Info is a single channel image.
- **Easy to use and compatible with all existing Image Processing Softwares** like ERDAS, EASY PACE, IMAGINE, ENVI etc.

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Directorate of Medicinal and Aromatic Plants, Anand

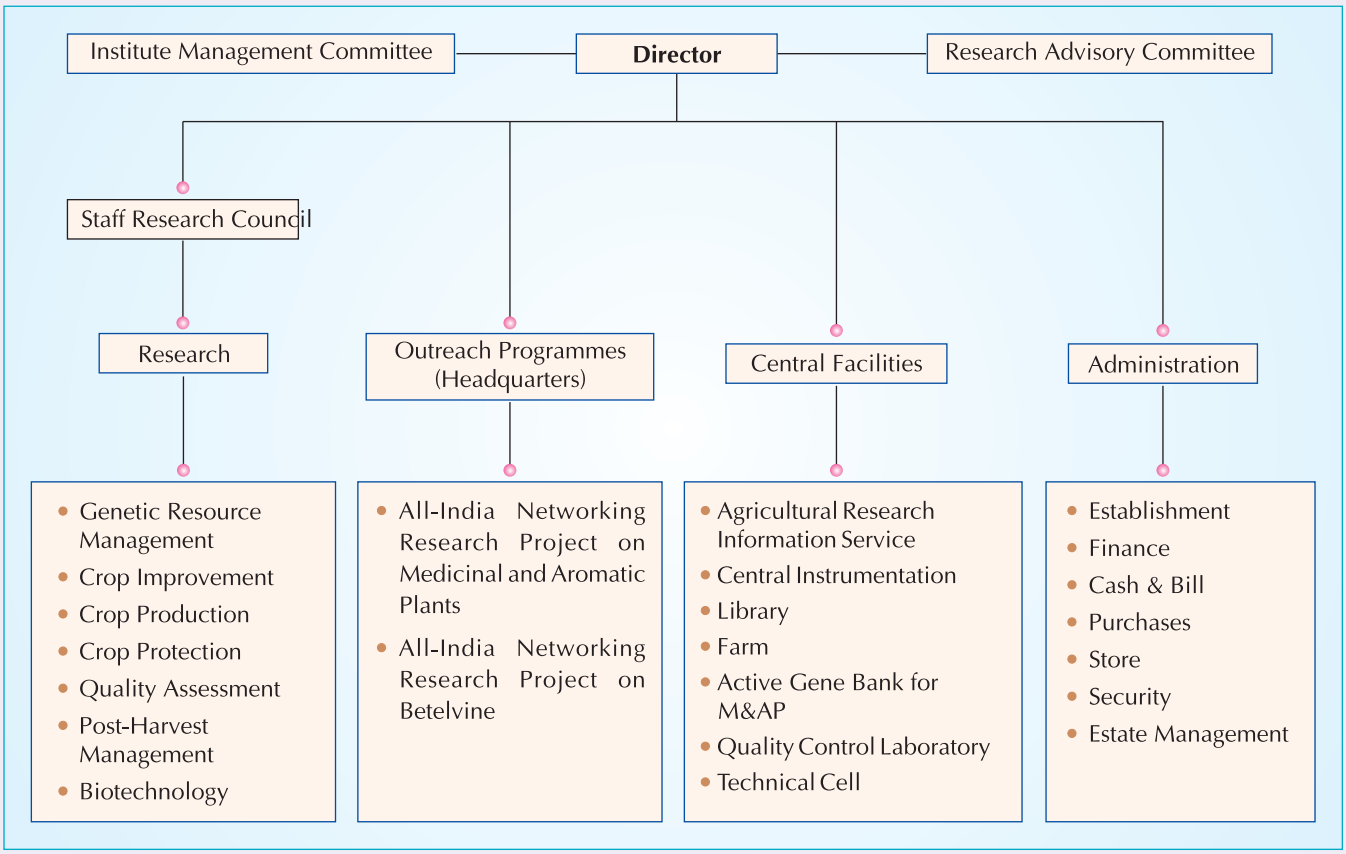
Human civilizations are dependent on plants for food, clothes, shelter and healthcare from time immemorial. All civilizations, old or new, hence have rich descriptions of medicinal properties of plants. Medicinal plants include herbs, shrubs, climbers and trees, which provide various parts such as roots, stems, leaves, flower, heart-wood, bark, latex, gum, resin, etc, for use in medicine preparations. These are mostly collected from forests. However, increased human population, rapid expansion of the area under food and commercial crops, deforestation and extension of urban area has resulted in the fast depletion of the herbal wealth. Hence, it becomes necessary to grow these plants in *ex situ* to meet growing demand and to provide quality as well as to conserve herbal wealth. With these aims the Indian Council of Agricultural Research (ICAR) had set up an All-India Co-ordinated Research Project (AICRP) on Medicinal and Aromatic Plants in 1972 to initiate research on this group of plants. During VIII Plan period, the ICAR established a National Research Centre for Medicinal and Aromatic Plants in 1992 at Anand, Gujarat, to further strengthen the basic, strategic and applied researches with more concerted efforts. To facilitate efficient forward and backward integration of basic, strategic and applied researches in various agroclimates, the Centre has been upgraded to Directorate in XI plan.

OUTREACH PROGRAMME

The headquarters of the All-India Co-ordinated Research Projects on Medicinal and Aromatic Plants and Betelvine are housed at the DMAP as its outreach programme. The Director of the Institute is responsible for co-ordination and monitoring of research work as Project Co-ordinator. Various stations are at YSPUH&F, Solan; GBPUA&T, Pantnagar; CCSHAU, Hisar; NDUAT, Faizabad; UBKV, Cooch Behar; AAU, Jorhat; RAU, Pusa; RAU, Islampur; MPUAT, Udaipur; AAU, Anand; RVSKVV, Mandsaur; JNKVV, Jabalpur; BCKV, Kalyani; OUAT, Bhubaneshwar; PDKV, Akola; MPAU, Sangali; APHU, Bapatla; TNAU, Siugamani; KAU, Thrissur.

INFRASTRUCTURE

The DMAP is bestowed with two well maintained experimental farms. One of these harbours medicinal-tree botanical garden and field gene bank. The Directorate also has modern sophisticated instrumentation facilities such as GLC, HPLC, GC/MS, LC/MS, photosynthesis system with chlorophyll fluorescence analyser, spectrophotometers, freeze microtome, lyophilizer, flow-cytometer, fluorescence microscope with image analysis system, nitrogen auto-analyser and soil-moisture meter. The Institute has state-of-the-art tissue culture and molecular biology labs. It has a fully functional computer lab (ARIS Cell) with various databases such as Medicinal and Aromatic Plants References Information System, Traders Information System on Medicinal and Aromatic Plants, Digital Photo Library of Medicinal and Aromatic Plants and Digital Herbarium of Medicinal and Aromatic Plants in India. Other facilities created in the Institute are library having latest CD-ROM databases, conference room, auditorium and well laid-out herbal garden with 250 species.



RESEARCH ACHIEVEMENTS

- More than 25 medicinal and 8 aromatic plants' varieties have been developed.
- Seven elite germplasm, two each in safed musli (INGR No. 04114, INGR No. 04113) and aloe (INGR 06023, INGR 06024) and one each in gilo (INGR 06025), kalmegh (INGR 07041) and mandukaparni (INGR 08105) have been identified and registered with the NBPGR, New Delhi.
- Many new crops were introduced and cultivation practices for different agro-ecological conditions have been developed.
- Basic research on reproductive biology of some important medicinal plants (aloe, ashwagandha, tinospora, guggal, Indian gentian and shankhpushpi) have been studied, which would be useful for taking up future breeding programmes.
- Good Agricultural Practices for senna, isabgol, palmarosa, lemongrass and patchouli have been developed and are being refined further.

Guggal (*Commiphora wightii*)

Lemongrass (*Cymbopogon flexuosus*)

Mandate

- Develop Good Agricultural Practices (GAP) for important medicinal and aromatic plants through basic, strategic and applied research.
- Germplasm enhancement of various medicinal and aromatic plants.
- Production of parental lines and breeder's stock.
- Act as a National Repository for the genetic resources of some important medicinal and aromatic plants.
- Act as an Information Data Bank on medicinal and aromatic plants.
- Transfer of technologies developed by the Directorate to the farmers through co-operation with the developmental agencies.
- Co-ordinate research under the All-India Networking Research Project (AINRP) on Medicinal and Aromatic Plants and Betelvine.


Ashwagandha (*Withania somnifera*)


Safed musli (*Chlorophytum borivilianum*)


Isabgol (*Plantago ovata*)


Aloe (*Aloe barbadensis*)


Geloi (*Tinospora cordifolia*)

Senna (*Cassia angustifolia*)

Palmarosa (*Cymbopogon martinii*)

- *In-vitro* mass multiplication protocols for aloe, safed musli and liquorice have been standardized for supply of quality planting material.
- A method has been developed for preparation of aloin (90-95% purity) from aloe, which is easy, quicker, efficient (recovery up to 90%) and cost-effective. An Indian process patent has been filed by the DMAP for this technology.
- Protocols for extraction and estimation of active principle components from various medicinal plants have been standardized.
- Screening method for resistance against soft-rot for aloe has been developed.
- Forecasting system for downy mildew for isabgol has been developed.
- **DMAP has independent website.** The software packages like "Medicinal and Aromatic Plants References Information System", "Traders Information System in Medicinal and Aromatic Plants", "Digital Photo Library of Medicinal and Aromatic Plants" and "Digital Herbarium of Medicinal and Aromatic Plants in India" have been developed.

Thrust Area under XI Plan

- Genetic enhancement and search for novel gene in medicinal and aromatic plants
- Development of high-yielding varieties with superior quality of major medicinal and aromatic plants
- Development of Good Agricultural Practicies (GAP) for mandate crops
- Post-harvest management of medicinal and aromatic plants
- Development of various standards such as seed standards; quality standards; minimum pesticide-residue standards; minimum mircobial load standards for raw drugs
- Development of various IT-based decision-support systems for selection of crops.

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Natural colours from palas (Butea monosperma) flowers

Most holi colours sold in the market are oxidized metals or industrial dyes mixed with engine oil, and are toxic, and contact with these colours can result in anything from skin allergies, eye irritation, blindness and much more.

In light of the above potential hazards of synthetic colours, an experiment was conducted on extraction of natural dye from *palas* flowers. A good quantity of orange-dye was recovered to the extent of 10-12% on the weight basis from the petals of the shade-dried *palas* flowers.

The dye obtained was utilized for developing eco-friendly natural holi colours. The dazzling yellow-colour powder *gulal / abeer* (4.0 kg) was prepared on a lab scale by mixing 80.0 g *palas* dye in 3.20 kg of talcum powder using organic solvent for admixing.

The natural colours are safe for skin and also for environment.

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Varietal Releases

CISH J 42, a seedless jamun selection

A seedless genotype of jamun CISH J 42 was selected from Chandauli district of Uttar Pradesh. *In-situ* evaluation has revealed that it has 18- 60 flowers in a panicle, which bloom slightly earlier than normal flowering in Lucknow. Fruits are seedless with 97.9% pulp, are ovoid in shape with good taste and 14.47 ° Brix TSS. Fruits length is 2.57 cm, breadth

is 2.18 cm, and weight is 8.0g. They contain 34.14mg ascorbic acid/100g, 0.231% tannins, and 1.56% anthocynins. Total antioxidant value of this accession was 15.54 mg/g of fresh weight AEAC units, using ferric-reducing antioxidant potential. Total phenol content recorded was 26.78 mg/g of fresh weight, and flavonoids were 1.21mg/g of fresh weight. The selected genotype has good processing potential due to absence of seeds. The plants of this genotype have been multiplied by soft-wood grafting and planted at the CISH field gene bank.

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Bush dolichos

Evaluation of advance breeding lines (bush types) revealed that maximum green pod yield was from line IIHR 2-1 in 90 days, followed by IIHR 3-3 (12.50 tonnes/ha). The percentage pod yield increase in IIHR 2-1 over Arka Jay was 70.29 and over Konkan Bhushan was 52.55.

IIHR 2-1

Dwarf watermelon line

Advance lines including commercial cultivar Arka Manik were evaluated in a randomized block design with three replications in late *kharif* 2008. IIHR-81-3-6 was found promising with highest fruit yield of 65-70 tonnes/ha. This was followed by IIHR-60-1-2 (67.5 tonnes/ha). Commercial

IIHR 81-3-6 watermelon dwarf line

check Arka Manik gave fruit yield of 58 tonnes/ha. IIHR-81-3-6 fruits matured in 70-75 days after sowing. Its plants are of bush type (unique in nature) with less than 1-m vine length. Fruits are round, juicy with good taste alike Sugar Baby pattern with red flesh and TSS 16.5 % sweet.

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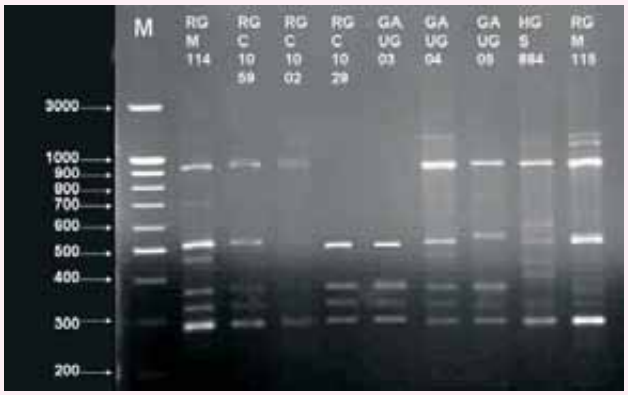
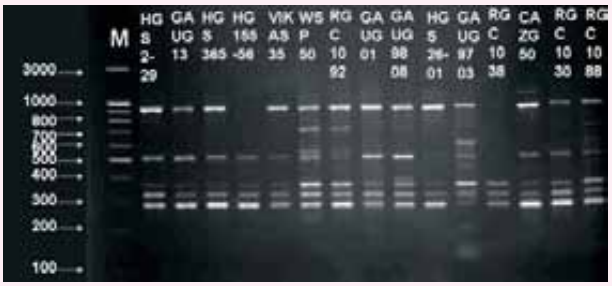
Guar genotypes diversity

Genetic differences were studied using RAPD markers among 24 guar genotypes. Out of 12 primers tested, 9 were highly reproducible and generated 113 RAPD bands with 85.9% polymorphism (99 polymorphic bands). Eight



RAPD profile generated by OPB 12



RAPD profile generated by primer OPB 12 in *guar* genotypes

primers gave distinct diagnostic markers for individual genotypes and were useful for differentiation of genotypes. The genetic differences were calculated using Jacquard's similarity coefficient and they ranged from 58 to 92%. Genetic distances revealed that HGS 02-29 and GAUG 0013; WSP 50 and RGC 1092; RGM 114 and RGC 1059 were similar and HGS 884, RGC 1002, GAUG 005, RGM 115, RGC 1029, GAUG 003, RGC 1088, GAUG 9703, RGC 1038, CAZG 50, RGC 1030, HG 155-56, GAUG 0001, HGS 365, VIKAS 35, GAUG 9808, HGS 26-01 and GAUG 004 were most distant guar genotypes. These distances can be utilized in breeding programmes for selection of diverse parents.

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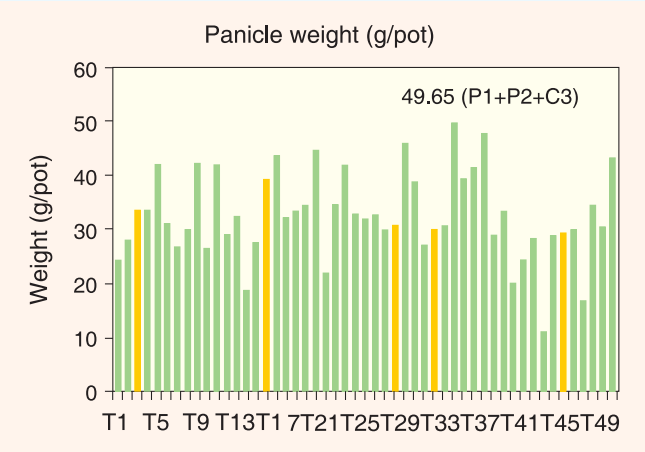
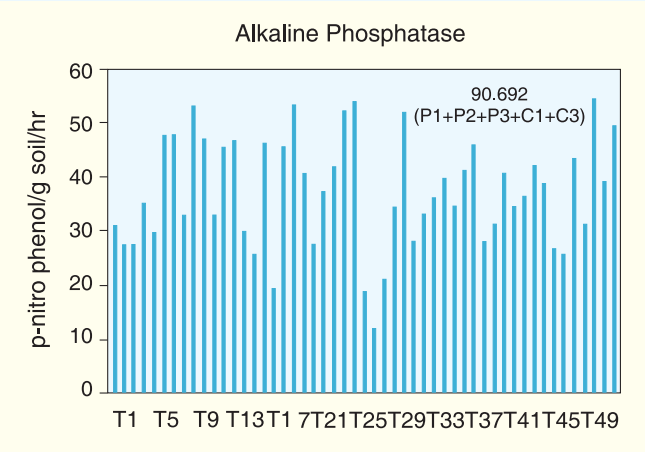
Bacterial and cyanobacterial strains for growth promotion of wheat

Pot experiments (51 treatments) were conducted on wheat HD 2687 along with fertilizer controls. From wheat rhizosphere three bacterial isolates (P1, P2 and P3) and three cyanobacterial isolates (C1, C2 and C3) were used in various combinations along with 1/3 N and full dose of P and K fertilizers. Significant enhancements in soil microbiological (dehydrogenase activity, FDA, alkaline phosphatase and microbial biomass) and plant growth/ yield parameters were observed. A two-fold increase in panicle weight and alkaline phosphatase activity in selected combinations (P1+P3+C3; P1+C1+C2/C1+C3; C2+C3) was observed as compared to control, involving full dose of chemical fertilizers. Such combinations, which



Influence on wheat panicle weight



Influence on soil alkaline phosphatase activity

also provided N saving (80 kg N/ha), are being evaluated in 2008-09 *rabi*. Electron microscopic observations of root sections of wheat revealed intracellular presence of short filaments and single cells of *Nostoc* sp.; emphasizing colonization potential of the cyanobacterial strains. This study illustrated positive and dynamic interactions among bacterial and cyanobacterial strains, and their promising utility in integrated nutrient management of wheat.

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Eucalyptus gall-wasp natural enemies

Gall wasp *Leptocybe invasa* (Eulophidae: Hymenoptera) was accidentally introduced into India three years back; it is a serious pest on eucalyptus causing terminal and petiole galls, arresting further plant growth. Parasitoids *Quadrastichus mendeli* and *Selitrichodes kryceri* (Eulophidae: Hymenoptera) have been imported from Israel for *L. invasa*. These parasitoids are currently under quarantine testing.

National Bureau of Agriculturally Important Insects
Hebbal, Bengaluru (Karnataka)

Kappa casein gene of mithun characterized genetically

Kappa casein genetic polymorphism was studied in mithun using PCR-RFLP technique. In cattle, two alleles (A and B) have been identified with a restriction site polymorphism for *Hind III*. Screening of mithun for *Hind III* and *Mbo II* was carried out. Amplified DNA was digested with 5 units of *Hind III* or *Mbo II*. Digested DNA was separated in 1.4% agarose gel with TBE buffer. Gel was stained with ethidium bromide and photographed in a gel documentation system. Only *Hind III* could produce restriction digestion in the samples and produced a definite pattern. It produced 200 bp and 70 bp bands in BB genotype; an uncut DNA of 270 bp size (AA genotype) and three bands of 270 bp, 200 bp and 70 bp for heterozygous AB genotype.

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Erratum

In *ICAR NEWS* (April-June 2008) on p. 5, first author name should be read as *Satyendra Kumar;* not *Satinder Kumar.*

PUFA synthesizing enzymes transcript in rohu

EPA (20:5n-3) and DHA (22:6n-3) are n-3 polyunsaturated fatty acids (PUFA), essential for human health, and are predominantly derived from fishes. EPA and DHA contents in muscles and eggs of rohu have been reported lower than marine and temperate species. The respective primers were designed and partial cDNA fragments of essential enzymes delta-6 desaturase and long chain PUFA elongase were amplified from rohu liver RNA and were sequenced. The rohu desaturase and elongase sequences showed maximum identity with those of *Cyprinus carpio* and *Danio rario*. Both rohu sequences have been submitted in GenBank database of NCBI under the accession numbers delta-6 desaturase (Acc.# EF634246) and elongase (Acc.# EU182581).

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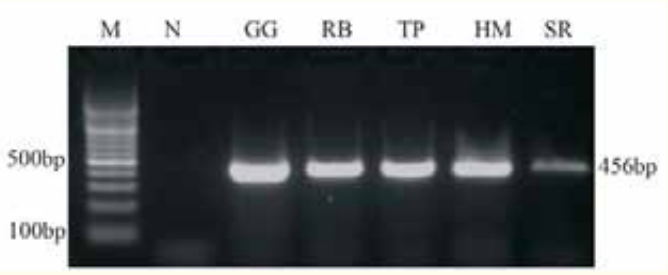
Molecular systematics of cyprinid fishes using mitochondrial gene sequences

The taxonomic positions of coldwater fish species of India, snow trout, *Schizothorax richardsonii* (Gray); golden mahseer, *Tor putitora* (Hamilton -Buchanan); Indian trout, *Raiamus bola* (Hamilton-Buchanan) and garra, *Garra gotyla* (Gray) vary according to different sources. The universal primers uniformly amplified 456 bp lengths of 12S rRNA genes of all the species. The amplified genes were sequenced further and the base composition and the alignment of sequences were compared. Nucleotide sequences of 12S rRNA gene of different fish species were submitted to EMBL nucleotide sequence database and their GenBank accession numbers are AM778102 to



PCR product of mitochondrial 12S rRNA gene amplified from 5 coldwater fish species

(M-100 bp molecular marker, N- negative control, GG: G. gotyla, RB: R. bola, TP: T. putitora, HM: H. molitrix, SR: S. richardsonii)

AM778106. The presence of a common conserved core region in all fish 12S rRNA genes indicates that all these belong to Cyprinidae. The phylogenetic tree constructed based on these 12S rRNA gene sequences suggests possible occurrence of three subfamilies such as Schizothoracinae, Cyprininae and Rasborinae within the Family Cyprinidae.

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Multiplier onion-peeler

A batch-type multiplier onion-peeler, developed in collaboration with a vegetable-process equipment manufacturer at Coimbatore, consists of an aluminium-drum seated over a rotating disc. Inner surface of the aluminium-drum and the top surface of the disc are

covered with corrugated rubber sheets, which aid in peeling process. The multiplier onion needs to have ends cut with a knife and soaked in clean water for 10 min. to assist in loosening of peel, followed by air-drying for 1-2 min. to remove surface water. The capacity of the peeler is 60 kg/hr. The peeling efficiency is 92%; unpeeled and damaged being 6% and 2%, respectively. Peeling cost by machine is about Rs 1.20/kg as compared to Rs 4.0/kg for manual peeling. The cost of the machine is Rs 15,000, and it has been adopted by a manufacturer for commercial production.

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Tractor-mounted turmeric harvester

A tractor-mounted harvester has been modified for turmeric in southern region of the country. The modified equipment was evaluated to harvest rhizomes on the

raised-bed, and indicated reduction in soil load by 30-35%. The harvester was also tested on farmers' fields at Thondamuthur in Coimbatore district. The harvesting efficiency was found 98 % at forward speed of 2.5 km/hr. Damaged and undug rhizomes were 4 % and 2-3%.

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Tractor-mounted controlled traffic zero-till slit drill

The tractor-mounted controlled traffic "zero-till slit drill" has been designed and developed for direct sowing of wheat in rice-straw fields after combine harvesting. Seven rotary slit openers with trapezoidal shaped blades are mounted on a shaft powered by tractor PTO for cutting surface straw and opening narrow slits in the soil. Secondary furrow openers with small shoe and delivery boots for seed and fertilizer are positioned right behind the rotary slit openers. Spring-loaded press wheels are provided in front and positioned in the space between two rotary slit openers. The press wheels keep loose straw pressed for effective cutting of surface straw and slit cutting. Seed-cum-fertilizer box with standard fluted roller metering system is mounted

on the main frame. Metering mechanism is powered by ground drive wheel through sprocket chain transmission.

The zero-till slit drill is drawn by a 45 hp (33.6kW) tractor. Its field capacity is 0.40 ha/hr, and a field efficiency is 85%. The estimated cost of the machine is Rs 60,000.

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Self-propelled riding-type interculture-cum-spraying machine

A self-propelled riding-type machine has been developed powered by a 7-kW (9.5 hp) single cylinder, water-cooled diesel engine with operator's work place, controls, steering system, transmission system and adjustment of rear and front wheel track width for use with interculture-and-spraying equipment.

Weeding operation is carried out at various crop stages after sowing. The mean forward speed, effective field capacity, hourly fuel consumption, weeding efficiency and plant damage are 2.6 km/hr, 0.25 ha/hr, 1.33 litres/hr, 64 % and 5.5 %.

Spraying equipment consists of three spinning discs, powered by 12 V batteries. The discharge from individual disc varied from 269 ml/min. to 292ml/min. with an average value of 278 ml/min. The total width of coverage was 514 cm at disc spacing of 145 cm. The variations in discharge per disc were (–) 3.24 to (+) 5.04% with respect to mean value.

The mean droplet size is in the range of 116 to 128 microns in disc speed range of 6,500 to 7,000 rev/min. About 95% of droplets are of size smaller than 200 microns.

The machine, in soybean sown at 35 cm row-to-row spacing gave an effective field capacity of 0.55 ha/hr at a speed of 1.80 km/hr. The fuel consumption was 1.10 litres/hr. The rate of discharge of liquid under actual field condition was 61.0 litres/hr (110.9 litres/ha).

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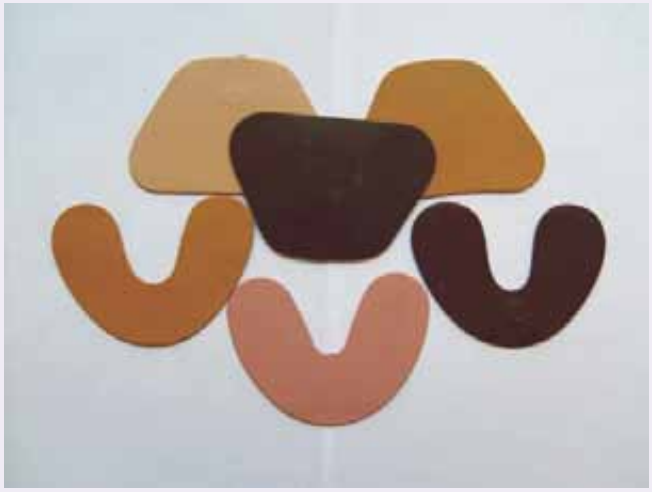
Shellac-base plates for dental use

Dental-base plates are used to replace missing teeth, just like false teeth. The plates are used as an intermediate in prosthesis. They are plastic compositions comprising shellac, fillers and colouring matter. The plates can be easily softened over a flame and moulded to a desired shape. Upon cooling, base plate retains its shape to form a strong and dimensionally stable intermediate base for prosthesis.



These plates were developed by a firm in Delhi, and twenty-three tests related to heat stability, colour stability, solubility, resistance to climatic changes, strength of the plates, plates softening, mouldability were carried out. These plates properties were found very good in comparison to the existing formulation. Storage stability test (shelf-life) of the plate samples is being studied.

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Seed delivery of 'High Volume Seed' Crops

The Indian seed system had started with public seed corporations, which ably met objective of delivering seed to commercial farmers and catering to seed needs of small subsistent farmers. Privatisation of seed system steamed up with the implementation of the New Seed Policy in 1988 and economy-wide reforms introduced by the Government in 1991. A nation-wide survey conducted by the National Sample Survey Organization (2005) showed that nearly half of the farmers bought seed from various sources and the remaining used farm-saved seed or seed exchanged with fellow farmers. Nearly two-thirds of farmers usually replaced seed every year or alternate year. Two-thirds of the farmers classified quality of the seed as "good" and the remaining found it "satisfactory." Although survey provided a broad scenario of availability, acquisition and replacement practices of seeds by farmers, questions still remain about seed quality and ability to meet seed requirement of small farmers in marginal areas. In particular, questions are asked about viable options for delivering seed of groundnut and potato (having high seed rate) often referred to as 'high volume seed' crops.

Role of public and private sectors

Survey conducted in Andhra Pradesh for groundnut and in Uttar Pradesh for potato showed that more than half of the seeds were acquired off-farm. There is not much incentive for private sector in these crops. Public seed corporations should take lead in seed supply to farmers. The seed corporations can very well identify seed-producing areas and farmers, and help them in use of improved seed production and handling practices.

In comparison of other crops, seed cost is very high for these crops, and farmers in marginal environments with low and unstable yield do not have adequate resources and incentive to invest in seed. AP government policy to subsidize groundnut seed has no doubt improved farmers' access to commercial seed, but it discouraged small local seed producers, who find it hard to compete with public seed agencies selling subsidized seed. Therefore, private groundnut seed producers should be identified and encouraged by suitable incentives, or should be provided benefit of subsidy, as is for other crops.

Local seed producers, with little extra investment and efforts to maintain seed quality, can play a significant role in augmenting seed supply. Supply of source seed and training them in use of improved seed management practices would go a long way in improving seed supply.

Another major opportunity for private sector's participation is provided by expanding markets for quality products. This is clearly noticed in potato. For groundnut, these markets are kernels for table-purpose in domestic and export markets, high-oil content, and export of groundnut-cake. Since these markets enjoy considerable price premium, there is incentive to maintain product quality. In the event of supply chain becoming stronger for these markets, input companies may enter in seed business and integrate with supply chain. This has happened in rice, potato and vegetables, and can be replicated in groundnut also. Entry of APOILFED in seed business is another example of this process of diversification of seed system.

Partnership. There is some success in partnership in potato for developing varieties suitable for processing. It is very unlikely that such partnership will emerge in groundnut seed provision in near future. This is because there is no private seed company dealing with groundnut seed; only example of a formal seed company was found in Gujarat. The company also claims to have "developed" three varieties, which are in seed production. It is quite likely that such companies may be looking to public plant breeding programmes for improved germplasm or varieties for seed multiplication and sale. Thus, private sector, for profit and non-profit, can prove to be a useful partner in testing and promotion of new varieties. However, much scope and success for partnership is in developing decentralized seed system. Initially, public research system has to take a lead in developing such partnerships. If required, government should support partnership through appropriate funding mechanism, or some form of monetary incentives and necessary institutional changes.

Technological imperatives. The public research system should accelerate research efforts in development of improved varieties suitable for different production environments and purposes. High oil and fodder yield and tolerance to moisture stress are most preferred traits for groundnut. Addressing problem of aflatoxin through crop improvement or crop-management practices is another. To improve seed multiplication rate and to ensure seed quality

is another challenge. This is major particularly for seed technologists. Potato also faced this problem, which was successfully addressed through tissue-culture technique. This reduced in investment and seed cost, and markedly improvement in seed quality. But this needs effective quality control system. The problem associated with crop management in seed plots and handling of seed during storage and distribution are major concerns. Easy-to-use, low-cost techniques will go a long way in improving quality of seed produced by the decentralized seed system.

It is very unlikely that groundnut and potato will attract private investment in plant breeding even under new IPR regime. Therefore, public research system should continue to shoulder responsibility of plant breeding, and develop partnerships with private sector to strengthen decentralized seed activities. The state seed corporation should also strengthen their seed business with focus on better seed multiplication and quality management. Co-ordination among public seed agencies may provide opportunities for cost reduction, augmenting supply in deficit regions, and offering greater choice to farmers. The government should look for linking marginal production regions with national and global markets. This would help develop value chain, especially for premium market, which may eventually attract corporate sector in product, as well as seed market.

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Solar dryer for silk-cocoons

A solar air-heater-based forced-convection-type dryer was designed and developed for drying 50 kg silk-cocoons per batch. Solar dryer set-up consists of a cabinet-type drying chamber, drying trays, solar air-heaters, hot-air ducts, blower and electrical back-up.

Drying chamber with trays is provided for loading cocoons to avoid direct UV-light exposure to silk-cocoon shells. Thirty drying trays (0.57 m x 0.82 m) are provided in the chamber. Eight solar air-heater panels (1m x 2 m) having total collector area of 16 m^2 are arranged in series and parallel combinations. The solar air-heater is provided with absorber of selective surface coated copper sheet. Two panels in series are connected to duct to achieve desired temperature. The heaters are installed facing south at 20° inclination with respect to horizontal plane. The drying

chamber and ducts are suitably insulated to reduce heat loss. A centrifugal blower is provided to suck hot-air from panels and to push it into drying chamber. Electrical back-up of 4 kW is provided to supplement heat during cloudy periods and night-time. The solar cocoon dryer was installed and tested at no-load at the Silk Reeling Centre, Hoshangabad. The temperatures at inlet and outlet of the solar-heating panel were 25-27°C and 65-80°C. The air temperature near entry of the drying chamber was 55-62°C. Air flow rate to the drying chamber was 300-330 m^3/hr. Solar insolation and ambient temperature during testing were 550-600 W/m^2 and 25-27°C.

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Indian gene centre is one of the world's 12 mega-centres of biodiversity. India hosts about 49,000 species of flowering and non-flowering plants; about 19% of the 260,000 species described the world over. And out of 90,000 animal species of the country, representing 7.28% of the total global faunal species, over 68,000 are insect species. About 2,200 fish species occur in the country, out of 27,800 reported globally.

On a changing time-scale, an accelerated and effective use of genetic resources will determine the extent of improvement in productivity, profitability, quality, sustainability, and finally the well-being of the mankind in the changing environment.

Dr Mangala Rai, Secretary (DARE) and Director-General (ICAR)

The dwarfing genes in wheat and in rice, and rust resistant genes in wheat are testimony to the power of genes that laid sound foundation for green revolution, and subsequently sustaining productivity gains. *Bt* cotton clearly depicts how genes from evolutionary distant organisms can bring revolution in agriculture. In the wake of the new challenges of rising population, malnutrition, declining arable land, reduced availability of water and global climate change, there is an urgent need to search for new genes and novel alleles.

Abiotic stresses are the primary cause of yield losses worldwide. In most of the major crops, reduction in yield is nearly 50%, owing to abiotic and biotic stresses. Under changed climate, emergence of new races of pathogens pose far greater challenge. Some of the important biotic stresses and genes conferring tolerance to such stresses would be addressed in a long-term perspective.

A substantial number of high/low temperature, drought, salinity and submergence tolerant species are available, which can be used to unravel additional stress-associated resources (genes and mechanisms). Antarctic bacteria, archaea, lichens, cyanobacteria and crop species such as *Lathyrus*, moth-bean, *Zizyphus*, *Eleusine* and *Pennisetum* are some systems that can yield invaluable genes, imparting tolerance to abiotic stresses.

It is a very fortunate situation for Indian agriculture to possess a large germplasm of crops, animals, fishes and microbial species of agricultural importance. Long-term conservation of these ensures their availability at the time of necessity. However, efficient utilization of the germplasm resources would be possible only if these are characterized, catalogued and understood much beyond their passport data. The crops in which existing diversity is less and/or one wishes to create alleles other than those available in the germplasm, it is possible to create large mutant populations and use them, in addition to the germplasm lines, for allele discovery. Allele-mining identifies new alleles of known or candidate genes for traits of importance in germplasm lines, including induced mutants, which can be used for direct transfer of the target allele to desirable agronomic background through conventional breeding. Alternatively, the novel allele, when available across sexual barriers, can be cloned and transferred through genetic engineering. This however requires massive efforts supported by liberal funding so that raw materials for future crop improvement become readily available, and in the process, we safeguard our food and nutritional security.

The ICAR has embarked upon an ambitious multidisciplinary programme 'Bioprospecting of Genes and Allele-Mining for Abiotic Stress Tolerance under the National Agricultural Innovation Project (NAIP). The project will be in a network mode focusing on important crops, animals, fishes and micro-organisms adapted to extreme environments. The programme aims to provide a well characterized germplasm resource and core sets of germplasm in different crop species; Elite germplasm lines with agronomic traits for future; New information on the SNP/haplotype structure in different known/candidate genes for drought tolerance and disease resistance; Novel alleles of known/candidate genes for target traits ; and more importantly a pool of trained human resources and infrastructure to handle large-scale genotyping of germplasm. This endeavour will go a long way in developing efficient strategies for abiotic stress management in rice and wheat. And will also broaden the window of optimal growth conditions for cultivated crops under adverse climates, thereby increasing yield under changed environment.

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