



A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

Promising Technologies

- ◆ Production of high quality organic peaches 1
- ◆ *In-vitro* propagation of pointed-gourd 2
- ◆ Screening wheat for drought tolerance 3
- ◆ Plasma nanotechnology for value-addition of cotton textiles 3
- ◆ Hydroponics technology for fodder production 4

New Initiatives

- ◆ High phytase wheats for improving nutritional quality 5
- ◆ Bioinformatics software to locate priming sites of RAPD, ISSR primers 6

Natural Resource Management

- ◆ Resource conservation through organic input management 7
- ◆ Arka microbial consortium for vegetables production 7
- ◆ First generation interspecific hybrid of *Cymbidium* 8

Profile

- ◆ National Research Centre on Yak, Dirang 10

Spectrum

- ◆ Multi-cob maize selection – MCM-11/ 01 14
- ◆ New late-sown malt-barley cultivars 14
- ◆ Cut-flower of commercial importance – GLADIOLUS 16
- ◆ Blended squash: A new product from sweet-orange 16
- ◆ Ovsynch protocol for improving fertility in buffaloes 17
- ◆ Novel protein/vaccine carriers for fish designed 18
- ◆ Agricultural growth and reduction in rural poverty 18

- ◆ Way Forward 20

PROMISING TECHNOLOGIES

Production of high quality organic peaches

For producing good quality organic peaches from the limited land resource, high-density peach plantations were established under the organic cultivation module. Peach cv. Red June was planted at a spacing of 4 m × 1 m and was trained on the modified flat-training system. For nutrient requirement, organic sources such as farmyard manure, Nadep compost, vermicompost and mycorrhiza were applied. Maximum yield of good quality marketable peaches was recorded with vermicompost + mycorrhiza. The interspaces between the trees were utilized for growing intercrops, preferably leguminous crops such as soybean, lentil and pea. After the harvest of the leguminous crops residues were left in the field itself to cover soil. To enhance scope for biological control and to minimize incidences of pests in the orchards, repellent crops like rosemary, chamomile, pyrethrum, gypsophylla, chive and garlic were grown on the borders of the terraces. Likewise, marigold and sunflower were also planted as trap-crops along the field borders.



Peach high-density planting under organic module during spring
(Inset: Heavy fruiting of organically grown peaches)

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PROMISING TECHNOLOGIES

The peach (*Prunus persica*) is one of the most important fruit-trees grown in the Uttarakhand. It is gradually replacing apple-trees, which do not fruit properly in the state due to the lack of sufficient chilling (required by the apple-trees), owing to global warming. Thus the area under peach cultivation is increasing steadily in the state. Peaches are also being preferred because of their higher antioxidant content, and due to popularity of their value-added products among consumers such as dried, canned, candied peaches. To contain incidences of diseases and insect-pests on peaches, synthetic pesticides are intensively used; this causes many negative consequences such as resistance development, detrimental effect on the non-target natural predators and also environmental pollution. Thus, indicating a need for development of eco-friendly alternatives for pest management in peaches.

For peach leaf-curl management, trees were sprayed during dormant season with tree spray oil, followed by Bordeaux mixture. Similarly, for peach leaf curl aphid, neem oil at 1.5% and leaf extracts, prepared by fermenting leaves of stinging nettle, walnut, marigold and *timur* in cow-urine and water, were used.

The organically grown peaches, besides with improved shelf-life of fruits, were found to contain higher content of sugars, vitamins and antioxidants than the conventionally grown peaches.

This holistic production system grew peaches organically, involving minimum resources.

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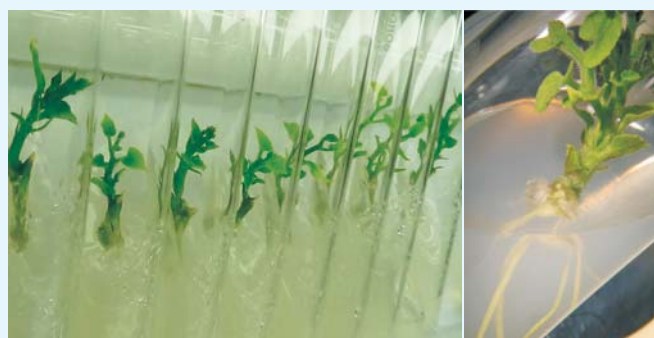
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In-vitro propagation of pointed-gourd

Pointed-gourd (*Trichosanthes dioica*) is one of the potential vegetables of Odisha, which bears fruits round-the-year. However, availability of quality planting material is a major limitation in its cultivation.

Different plant parts – nodal segment, terminal shoot, leaf and root – were taken for explants. They were surface sterilized with 70% ethanol and 2% sodium hypochlorite solution under aseptic conditions, and were cultured on the solidified MS medium supplemented with kinetin (2-10 mg/litre) and BAP (0.5-2.5 mg/litre), and were maintained in the growth room at 25 ± 1°C with 16 h photoperiod (40 mmol.m²/s). The best initial micro-shoot response was observed with basal nodal segment on the medium containing kinetin 8.0 mg/litre. And the sub-culturing medium with



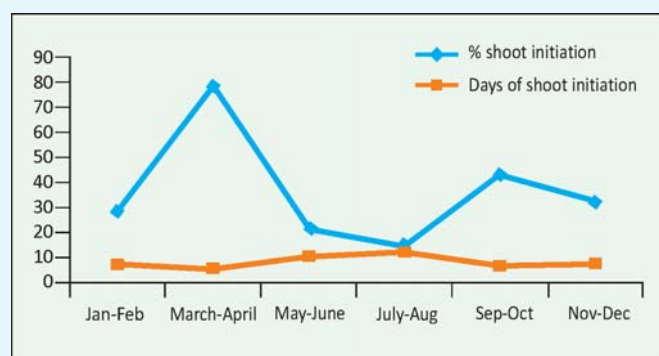
Rooted plantlets of pointed-gourd

4.0 mg/litre produced maximum regenerated shoots with good shoot growth. Terminal shoot and root segments could not produce shoots. In BAP, shoot proliferation was not significant. *In-vitro* rooting was optimized with 0.4 NAA mg/litre; which gave highest root initiation percentage (58.5) and also number of roots (4.2). However, *in-vitro* roots were produced without NAA also. Interestingly, shoot initiation and days to shoot initiation showed temporal variations. Maximum percentage of shoot initiation and minimum days for shoot initiation were recorded during March-April. Optimization of *in-vitro* plantlets development can be a tool for large-scale propagation and conservation of this elite germplasm.

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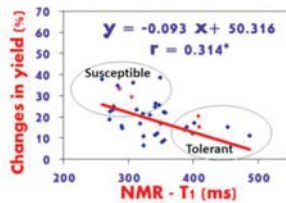


Temporal variations in shoot initiation in pointed-gourd

Screening wheat for drought tolerance

Drought remains an important stressor to crop-plants in many regions of the world. There are predictions by the current climatic global circulation models that there would be further increase in warming and drought in the coming decades. The drought tolerance of crops is generally characterized by leaf-water content, relative water content, leaf-water potential and canopy temperature. But these characteristics do not allow rapid analysis, and are not appropriate when many cultivars are to be screened (high-throughput screening) for tolerance.

The challenge of the high-throughput screening of wheat cultivars tolerant to drought can be met by Nuclear Magnetic Resonance (NMR) spectrometry. Pulsed NMR measurements of longitudinal and transverse relaxation times (T_1, T_2) have been extensively used to assess water status and its interaction in many biological systems, including its physiological compartmentalization and variations under stress. Investigations were carried out using the NMR relaxation times related to tissue water status to characterize drought tolerance in wheat lines of unknown tolerance. Forty lines of wheat cultivars (36 of unknown tolerance and four internal checks of known tolerance to drought) were grown under irrigated and rainfed conditions.



Relationship between changes in wheat yield under rainfed conditions and NMR spin-lattice relaxation time – T_1 . (♦ – Tolerant check; ◆ – Susceptible check)

Observations on the NMR measurement of longitudinal relaxation time (T_1) and other water-stress parameters like relative water content (RWC), leaf-water potential, osmotic potential, moisture content, leaf temperature, rate of transpiration and diffusion were made.

Longitudinal relaxation time (NMR- T_1) at 8th leaf stage was found superior in characterizing drought tolerance. Significant correlations of relaxation time (T_1) with other leaf-water status parameters, RWC, leaf-water potential, osmotic potential and moisture content were observed. By characterizing NMR-longitudinal relaxation time measurements, the wheat genotypes with unknown drought tolerance could be categorized as tolerant or

susceptible. These results were substantiated by correlation of NMR-longitudinal relaxation time (T_1) with reduction in yield of wheat-crop grown under water-stress conditions. The present study indicates quick and non-invasive technique for screening drought-tolerant wheat genotypes.

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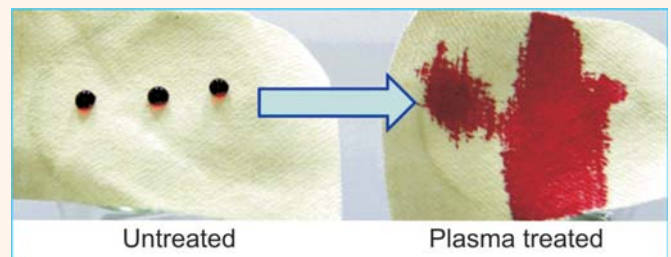
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Plasma nanotechnology for value-addition of cotton textiles

All types of plasmas are not suitable for value-addition of heat-sensitive polymeric materials such as cotton, jute, silk, wool, polyester, nylon etc. Only cold plasmas, where the temperature of the plasmas is close to the ambient temperature, can be used for nano-scale surface engineering of polymeric and textile substrates; and this will be environment friendly too.

Plasma can be generated under low pressure or at atmospheric pressure by ionizing a gaseous molecule with sufficient discharge voltage. It is easy to generate plasma at a low pressure. However, this process technology has not been commercialized in textiles



Transformation of hydrophobic surface to hydrophilic with plasma treatment

due to its inherent limitations of batch process and high cost of operation. And atmospheric pressure cold plasma can overcome these limitations; hence research

Plasma is a partially ionized gas consisting of positive and negative ions, neutrals, electrons, excited molecules, photons and UV light. Lightning bolt and solar corona are examples of plasmas present in the Nature. Man-made plasmas are fluorescent lamps, television, neon signs and welding arcs.

community is more interested in this for value-addition of textiles at a low cost.

Surface modification of textiles with a desired functionality can be achieved by selecting appropriate process parameters and precursor molecules. A few atmospheric pressure cold plasma machines are commercially available for treating textiles. However, design and process technology of these machines were not found suitable for carrying out *in-situ* plasma reaction on various textile substrates using varieties of liquids and gaseous precursors.

So, a proto-type of atmospheric pressure plasma reactor was developed at the institute. This reactor is suitable for processing and finishing different types of fibres, yarns and fabrics in a batch as well as in a continuous

method. The effects of plasma treatment on textiles at present were investigated by treating natural fibre-based textiles to improve their surface hydrophilicity. Atmospheric pressure cold plasma was generated in the environment of He and He/air gases. It was observed that in an untreated textile sample, a water droplet took more than 1,800 s to get absorbed by the fabric. On the other hand, in the 60 s helium/air plasma treated sample, the same water droplet took only 3 s to get fully absorbed by the fabric. This indicates that 60 s of plasma treatment can significantly improve hydrophilicity of the sample. Unlike conventional textile processing, plasma processing of textiles does not create any water pollution as the process is carried out in the dry state.

This plasma reactor and the process technology can be extended further to impart other value-added functionalities such as oil repellency, antimicrobial, flame retardant and UV protection in textiles.

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Hydroponics technology for fodder production

Hydroponics technology involves growing of plants without soil. Under the Rashtriya Krishi Vikas Yojana, 11 units of hydroponics green-fodder production have been established at different dairy cooperative societies of Goa, including one at the ICAR Research Complex for Goa, Old Goa. In all the units, hydroponics green-fodder is being regularly produced in greenhouses under the controlled environment.

For maize-seeds, soaking time of 4 hours is sufficient. Hydroponics green-fodder looks-like a mat, consisting of roots, seeds and plants. About 3.5 kg and 5.5 kg hydroponics green-fodder was produced from each kg of yellow maize and white maize, respectively. Approximate cost of production of hydroponics green-fodder from white maize (₹4) was lower than yellow maize (₹5) due to more biomass production from the former. In comparison to conventional green-fodder,



hydroponics green-fodder contained more crude protein (13.6 vs 10.7%) and less crude fibres (14.1 vs 25.9%). Intake of hydroponics green-fodder by dairy animals was up to 20 kg/ animal/ day. Dry matter digestibility of the hydroponics green-fodder maize-based ration was higher than the conventional green-fodder (Hybrid Napier)-based ration in dairy cows and heifers. As green-fodder is an

integral part of the dairy ration, in situations, where fodder cannot be grown successfully or the modern progressive dairy farmer, who wants in his dairy fodder production along with elite dairy herd, green-fodder can be produced hydroponically for feeding animals.

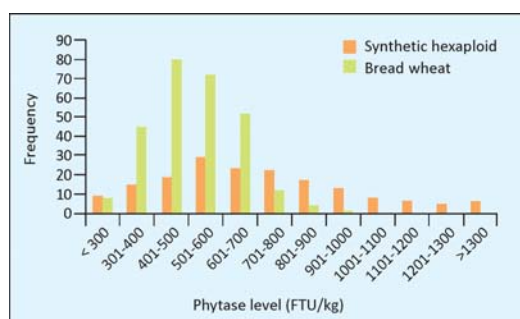
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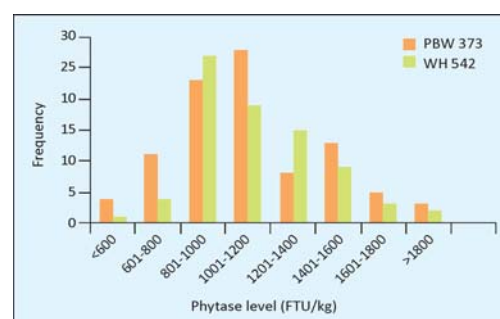
High phytase wheats for improving nutritional quality

Micronutrient malnutrition or 'hidden hunger' is a widespread problem in the developing countries of the world, including India. High incidences of micronutrients' deficiencies are in the countries where cereal-based foods represent largest proportion of the daily diet. This is because cereals generally have low micronutrient density in grains, and that also is not bioavailable. Reports indicate Fe and Zn bioavailability around 10 and 20%, respectively, in cereals, including wheat. Micronutrients bioavailability is significantly reduced by phytic acid content in grains. More than 75% of phosphorus in the grains is present in the form of phytic acid, which is not available to monogastric animals. As a result animal feeds are supplemented with P, but a large amount of phytate is excreted out by animals, and accumulates in the soil and water, causing pollution. Therefore, degradation of phytate is required to overcome micronutrient deficiency in humans and monogastric animals.

Although microbial phytases have been used in the food processing to degrade phytate; cereal phytases can be an alternative due their assumed lower allergenic potential and higher acceptance among consumers. Higher phytase activity in grains may result in extensive phytate degradation in human stomach and thus enhance micronutrient bioavailability. Little information was available about the genetic variability of phytase levels in wheat. To determine genotype differences in phytase levels, 500 wheat genotypes including synthetic hexaploids were used for investigation. For fast screening of genotypes, microlevel test was developed for estimating phytase activity utilizing 100 mg of flour. There were 3.4- fold differences in varieties developed in India and 5.9- fold variations in synthetic hexaploids. Therefore, synthetic hexaploids with higher phytase levels can be used to enhance diversity in enzyme levels in bread and durum wheats to improve micronutrient bioavailability. This is the first report of occurrence of



Phytase activity in bread wheat and synthetic hexaploids



Phytase levels in 2 populations (BC₁F₂) of cross between synthetic hexaploids and high-yielding varieties

such a large variation in phytase activity among synthetic hexaploids. High phytase lines identified of synthetic hexaploids were used in crosses with high-yielding varieties — PBW 373 and WH 542. There was normal distribution of phytase levels in BC₁F₂ populations, and transgressive segregants were observed with both low and high levels of phytase. This study showed that synthetic hexaploids can be utilized in increasing phytase levels in bread wheat, which may lead to enhanced bioavailability of micronutrients, especially Fe and Zn.

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Mega project on Aquatic Radio-Ecology launched

A mission-mode mega project, constituting four sub-projects, funded by the Board of Research in Nuclear Sciences (BRNS) and Department of Atomic Energy (DAE), Government of India, has been launched. This is first of its kind in the nuclear power era.

It aims at assessing radionuclides in the aquatic environment and also their transfer through the food chain. It conceptualizes mapping



radionuclides in the existing and the proposed nuclear power plants in and around the marine and freshwater ecosystems — Tarapur, Kalpakkam (existing), and Jaitapur and Jabalpur (proposed).

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Bioinformatics software to locate priming sites of RAPD, ISSR primers

Conventional RAPD and ISSR molecular markers work on the random process, and their success depends on the availability of the priming sites on the sequences. Hence a lot of money and time was wasted if primers purchased did not work. In the genomic era, when the sequences are available in the public domain, a scientist can analyze them using bioinformatic tools, and can use primers which are most likely to work. Expressed sequences of oilpalm covering 1.4 % genome were tested; 60% of amplifiable primers and 92 % polymorphic primers were found by comparing results with the published information on the wet-lab PCR results (Premkrishnan, B.V. and Arunachalam, V. (2012).

Here a new approach has been proposed based on the available information on sequences. A scientist can follow the steps: retrieve sequences, run software, identify specific primers, whose priming sites occur once or twice at the appropriate distance, design iSCAR (in silico Sequence Characterized Amplified Region) primers, and finally order synthesis of a specific set of the RAPD iSCAR primer. Later PCR score bands can be run to confirm results and to obtain and use successful markers with time-and- cost effective manner.

A bioinformatic software Marker Express 1.0 identifies specific primers, whose priming sites are available in the target organism, to optimize use of primers; and reagent Beta version of the software also works out base composition of the sequences, and designs iSCAR (in silico Sequence Characterized Amplified Region)

Molecular markers, RAPD (Random Amplified Polymorphic DNA) and ISSR (inter Simple Sequence Repeats), effectiveness improves by converting them into SCAR (Sequence Characterized Amplified Region) markers. Lately genomes and transcriptomes of many organisms have been sequenced, and this indicates scope for new approaches using bioinformatics.

primers. The software works by following simple steps: searches for priming sites of the given primer(s) in all the target sequences, calculates priming sites of each sequence(s), measures distance between primer annealed sites, calculates base composition of the sequences, and finally converts best amplified primers into iSCAR primers.

This software requires two input files a primer sequence file (*.txt) and a target nucleotide sequence file (*.fasta) from the user. It generates five sets of output files: Matching details of the RAPD primers; priming site location details of the matched sequences; product size details of the sequences having two or more priming sites; predicted iSCAR primers file; and a base composition file.

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Ready-to-eat fish-based extruded products

A great deal of awareness has been created among consumers about the health benefits associated with the consumption of fish and fish products. Omega-3 polyunsaturated fatty acids (PUFA), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), available in the fish oil are beneficial to human body. However use of fish oil as the functional nutritional ingredient in foods has been limited by its oxidative susceptibility.

Technology to produce ready-to-eat fish-based extruded products without using any synthetic preservatives has



been developed. The process involves utilization of fish mince/fish powder/fish oil to produce snacks rich in omega-3 fatty acids. The resulting extruded snacks possessed desirable textural properties and were with enhanced omega-3 fatty acid levels; determined by texture analyzer and GC-MS. The technology has been transferred to private industry in Mumbai.

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NATURAL RESOURCE MANAGEMENT

Resource conservation through organic input management

In a study at Dehra Dun on a gentle slope (2%), wheat yield was found higher (2.24 tonnes/ha) in T₄ treatment [farmyard manure + vermi compost + poultry manure + minimum tillage + 3 live-mulches + palmarosa as a vegetable barrier] than T₁ treatment [organic amendments + conventional tillage + panicum; 1.38 tonne of wheat/ha]. Maize yield in T₄ increased by 21.6% against 1.85 tonnes/ha of T₁.



Minimum tillage, weed-live mulch, organic amendments and palmarosa vegetative barrier for slope reduction and silt deposition

in the sub-surface layer (15-30 cm) was found lower than the critical level (0.6 ppm) in T₁ and T₂. Bulk density decreased in T₂, T₃ and T₄ (conservation agriculture treatments), which increased basic infiltration rate. Annual carbon sequestration potential (CSP) was maximum in T₄ and was minimum in T₂.

It has been observed that combination of organic amendments, minimum tillage, live-mulches and palmarosa

Maize (2011) and wheat (2010-11) grain yield, runoff and soil loss, moisture conservation, carbon sequestration potential and net returns from maize-wheat crop rotation

Treatments	Yield (tonnes/ ha)		Runoff (%)	Soil loss (tonnes/ ha)	Moisture conservation in the profile (mm)	Annual carbon sequestration potential (kg/ ha)	Fodder yield (tonnes/ha)/ Oil*(kg/ha)	Net returns from crop cycle (₹ per tonne)
T ₁	1.85	1.38	24.2	3.86	33.4	0.84	1.77	3,080
T ₂	1.48	1.67	22.5	3.12	38.6	0.76	0.37*	1,707
T ₃	1.72	1.84	20.4	2.94	45.8	1.26	4.5*	2,886
T ₄	2.25	2.24	18.2	2.46	63.8	1.34	5.2*	4,410

Soil moisture conservation up to the depth of 60 cm was 91% higher in T₄ due to organic amendments and weed-live mulches than T₁. T₄ also showed reduction in runoff and soil loss (24.8 and 36.3%) compared to T₁. Combination of palmarosa vegetative barrier with weed-live mulches has been found effective in reducing soil losses. Changes in soil properties indicated that available N and K were depleted from the initial value in all the treatments, excepting T₄. Of the micronutrients, only Zn content

vegetative barrier treatment (T₄) yielded 9% higher wheat equivalent yield and 43.2% more economic returns per tonne of soil loss from crop cycle than conventional inorganic farming (T₁) after four cropping cycles.

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Arka microbial consortium for vegetables production

This microbial consortium contains N-fixing, P- and Zn-solubilizing and plant-growth promoting microbes. It can be conveniently applied through seed, soil and water, and also through nursery-medium like coco-peat. It considerably reduces cost of vegetables production.

The synergistic effect of the formulated microbes can make vegetables cultivation sustainable. Benefits from the treatment with this microbial consortium are: (i) early germination of seeds; (ii) seedlings are ready for early transplantation (by 3-4 days); (iii) seedlings show

Arka fermented coco-peat for vegetable seedlings

Coco-peat prepared from coir-pith, a byproduct of the coir industry, was mainly used for raising vegetable seedlings in pro-trays. Nursery entrepreneurs often faced problems due to inadequate decomposition and heterogeneity of coir-pith in terms of nutrient content. To overcome this, Arka fermented coco-peat has been developed. This product has been developed through solid state fermentation of raw coir-pith by a fungal consortium. The



entire process can be completed in thirty days at the nursery-level itself. On completion of the fermentation process, material can be enriched with Arka microbial consortium.

Salient features of the product

- Reduction in the cost of production by 50 % over the existing practice.
- The process requires only one-third of the time.
- No need of washing raw coir-pith; hence is environment-friendly.
- Dispenses need for sterilization of growth medium.



Tomato seedlings 21 days old inoculated with microbial consortium (left); uninoculated (right)

increased vigour; (iv) rhizosphere of the seedlings is with appreciable PGPR bacterial population; (v) reduced requirement of N and P fertilizers (by 25-30 %); (vi) increased yield of different vegetables (10-16 %).

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First generation interspecific hybrid of *Cymbidium*

In 2005, cross PBX 05-56 between *Cymbidium lowianum* (female parent) and *Cymbidium tigrinum* Parish (male parent) was attempted. After *in-vitro* multiplication, progeny of F_1 s flowered during the mid- April 2012. The typical new taxon from this cross is found similar to grex category developed *Cymbidium*, 'Lowgrinum', reported by R.I. Measures in 1903 from the United Kingdom and to a natural hybrid between two species *Cymbidium* × *C. baoshanense* from Yunnan province in China. The pedigree for this re-invented *Cymbidium* hybrid conforms to the records of the 'International Orchid Commission' (IOC), maintained at the Royal Horticultural Society (RHS), UK, as per the 'International Code for Nomenclature of Plants'. The derived new species (grex) is characterized by the combination of both parental lines (species) along



Flowering PBX-05-56/2012-01

with distinct novel features. Its characteristics are as follows—height medium, size medium, medium-sized pseudo-bulbs, spike with a few flowers, flower size, 6.5cm × 6.6 cm (larger than male parent), petal colour yellow-green (RHS-151A) with size 4.9cm × 1 cm, lip size 3.1cm × 2 cm with glabrous texture and a narrow red-purple (RHS-59A) central lining on the apical lobe. The hybrid progeny resembles typical oriental *Cymbidium* hybrids. Its male parent *C. tigrinum* belongs to rare and endangered species, listed by the 'Convention on International Trade in Endangered Species' (CITES, known as Washington Convention). The female parent *C. lowianum* is endemic to Sikkim and the north-eastern India, which was used extensively by European explorers for development of the modern *Cymbidium* hybrids during 19th century.



Flower configuration of *C. lowianum* (left) PBX-05-56/2012-01 (middle) and *C. tigrinum* (right)



Flowers of PBX-05-56/2012-01

These first generation primary hybrids will help understand genetic control of traits and flow of genes between the species. They will also serve as the new genetic stock/clone for future breeding programmes. The use of wild and endangered species in breeding

programmes will also indirectly bring down threatening pressure from their natural habitats.

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Eco-friendly cups from bamboo

Bamboo is grown in 9,883 km² area, and it occupies an important place among the forest bio-resources of Andhra Pradesh.

In certain bamboo varieties, bamboo sheaths (bracts) are formed at each node. Size of the sheath is up to 14 inches in length and 3 inches in width, depending upon the variety and age of the plant. These sheaths were usually dumped as waste.

For cup-making, these dry bamboo leaf- sheaths are cleaned and processed with hot-water and are kept



under weight to remove wrinkles and folds, and then they are pressed in the machine.

Cups of 3-4 inches diameter with gold shining were prepared by using either pedal- or hand-operated devices. Similarly 5 inches diameter plates could

Bamboo-sheath cups	
Production capacity	: 2,000 cups /day
No. of persons	: Two
Production cost (₹0.20 ps/cup) (Raw material collection + Electricity charges + wages)	: ₹400
Market price (₹0.40 ps/cup)	: ₹800
Net income	: ₹400/ day



also be produced.

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PROFILE

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Yak, considered “ship of the plateau” is the most ecologically sustainable genetic resource of Indian Himalayas, which provides livelihood and nutritional security to highlanders

Yak is an important animal resource of high altitudes and snow-bound areas of India, Bhutan, China, Mongolia, Nepal, and other parts of the Central Asia. It provides milk, meat, fibre and hide. And it is also used as a pack animal for transportation of household goods and for riding. In spite of its usefulness, not much attention was paid to this animal in the past that led to dwindling of its population from 132,000 in 1977 to 30,000 in 1987 (as was reported by Pal in 1994). In 1989, a National Research Centre on Yak was established in Arunachal Pradesh for in-depth study on overall improvement and sustainable development of yak husbandry in India. As per the year 2007 census, yak population increased to 83,080.

Initially, the Centre was started at the premises of the Regional Temperate Fodder Station, Animal Husbandry and Veterinary Department, Government of Arunachal Pradesh. In 1995, its own campus was established at the heart of Dirang town, measuring 11.32 acres; 1,500 m above the mean sea level (msl). A yak farm was established at Nyukmadung at 2,750 m above msl, 31 km away from Dirang; keeping in view the extremely cold- climate requirement of yaks. And on 19 April 2009, state-of-the-art laboratory-cum-office building was also established.

At present, the farm is of 67 ha; out of which 11.71 ha have been cleared for cultivating grasses and tree fodders. The total numbers of sheds at the farm complex are 19 —1 bull shed, 1 metabolic shed, 2 milking sheds, 2 female sheds, 4 calf sheds, 5 general animal sheds, 2 quarantine sheds, 1 experimental shed and 1 parturition shed. The farm complex also has a laboratory-cum-animal clinic, an andrological laboratory, a feed-milling unit and a farm implement unit. Total yak population in



Yak farm at Nyukmadung



Newly constructed office-cum-laboratory

the farm is 186 , comprising 123 females (adult - 83, young (heifers) - 17, calf-23) and 63 males (adult-14, young-32, bull-17).

MANDATE

- To conduct survey for genetic resources, management practices, production level and problems associated with production.
- To establish a small herd of pure yaks to carry out observations on the performances under range and semi-range systems of management.
- To conduct research on the improvement of yak through selection and breeding with exotic frozen semen.
- To conduct research on nutrition, physiology, production and management aspects under the semi-range and confinement.
- To conduct research on fodder crops and development of pastures at mid and high altitudes for yaks.
- To provide complete health coverage through proper therapeutic and prophylactic measures based on the clinical and laboratory findings on the prevalent yak diseases.

INFRASTRUCTURE

The Institute has well-equipped central instrumentation laboratory and separate subject- specific laboratories to conduct research on reproductive biotechnology, molecular signatures of biomolecules, pathways of nutritional interventions and management and detection of yak pathogens through antibody fingerprinting. The institute is enriched with commercial software that provides support for *in silico* analysis of sequence information. It also has yak-product technology unit that produces organic yak products.

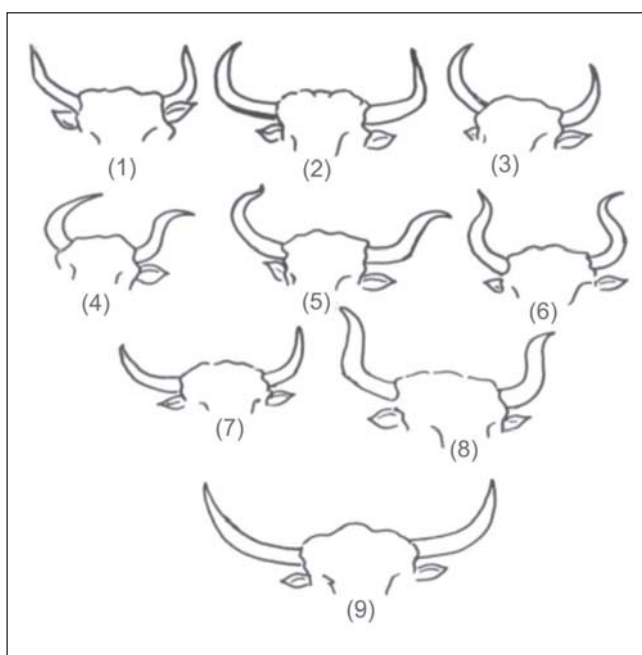
RESEARCH ACHIEVEMENTS

Nutritional Interventions

- Grazing grounds for yaks during winter usually had sparse cover of green palatable foliage due to extensive growth of unpalatable ferns and herbs. Hence, exotic grasses (*Phleum pratense*, *Dactylis glomerata*, *Lolium perenne*, *Trifolium pratense* and *T. repense*) that remain green and palatable to yaks during snow-fall have been introduced in the yak tracts.
- Fifty-one varieties of suitable and palatable fodder species, received from Food and Agriculture Organization, were tried under different altitudes and for seed-setting. *Dactylis glomerata*, *Vicia*, and *Agrostis* sp. showed signs of adaptability.
- When soil samples from fourteen yak-inhabiting pockets revealed deficiency of copper, area-specific mineral mixtures were prepared. Mineral mixture of zinc, copper, cobalt and manganese in 40:20:2:1 is essential for yak production, health and immunity.
- During winter, yaks migrate to mid-altitudes, and also show nutritional deficiency. To alleviate deficiency, low-cost complete feed blocks (CFBs) have been prepared using locally available crop residues and tree leaves as yak feeds. CFB feeding results in optimum weight gain among growing calves and increased milk production in lactating yaks.

Genetic Interventions

- Physical appearance of yak has been found polymorphic and polytypic in terms of colour and horn characteristics, respectively. A total of nine different horn types have been observed in yak tracts of Arunachal Pradesh.
- Uniformly black coloured, sans other coloured patches, was observed only in 30.7% animals. Animals with predominantly black colour along with some stray white patches accounted for 58.7%. Light brown and beige accounted for 4% and 6.6%. This research intervention was an initial fingerprinting on the survey of the genetic resource of the yak.
- For the first time, yak types were differentiated based on the physical conformation. Five categories of yak have been identified: Common type (used for milk and meat), Bisonian type (for draught), Bare back yak (for milk and draught), Hairy forehead yak (milk and draught) and White yak (for milk).
- Knowledge of chromosomal profiles of male and female animals and their effects on the economic traits are helpful in planning animal-breeding strategies.



Polymorphic horn types of yaks of Arunachal Pradesh



White yak



Hairy forehead



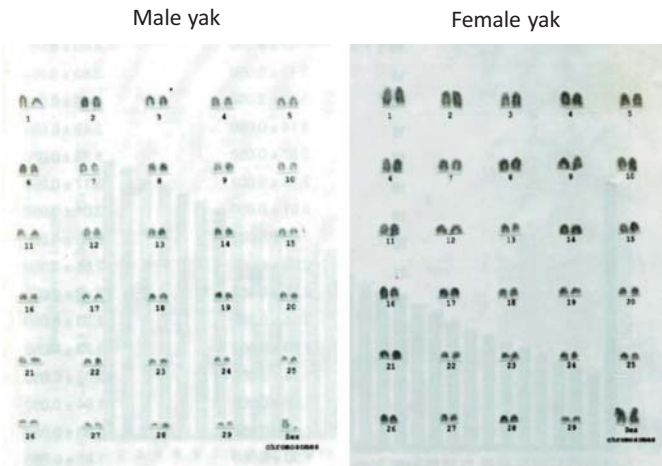
Bare back type



Bisonian type



Common type



Karyotypes of male and female yaks

Infection and Immunity

- Colostral immunity is important for passive transfer of maternal antibodies to neonates. Effects of colostral immunity on the experimental basis were explored for the first time through biochemical mining, which is the base-line information for disease management in yak-calves.
- An ovum of the parasite *Mammomonogamus laryngeus*, which affects ruminants and human beings as well, was identified for the first time in the Indian yak during coproscopy. Such identification and characterization of the causative agent helps formulating control strategy for parasitic infection.
- First global report of cutaneous papillomatosis in yak has been confirmed through sequence information of proviral partial gene for capsid protein.
- Cryptic stage of protozoa has been detected by standardized molecular approach, which could detect 10 pg of parasite DNA.

Toxicant and Eco-toxicology

- Alkaloid-containing poisonous plant like *Senecio crisanthomoides* has been identified through pro-inflammatory, oxidative and pro-apoptotic signaling. It is fatal for yak, and is thereby posing a major problem in the region.
- Average arsenic concentrations in water at various pockets of West Kameng District of Arunachal Pradesh were below the permissible limits as per the National standard (50 ppb) but were higher than those of the WHO standard

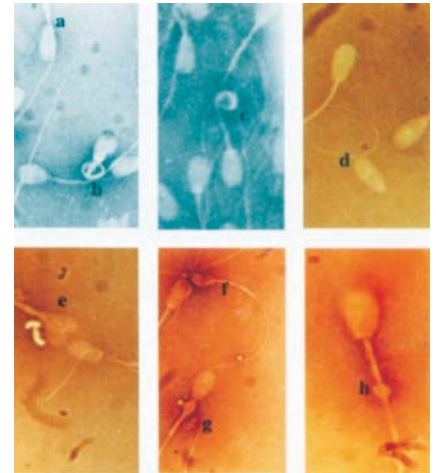


Senecio crisanthomoides: toxic plant of yak tract

(10 ppb). To study environmental pollutants in biological samples of yak, total arsenic concentrations were tested and detected from urine, faeces and wool, which are biomarkers for toxicants. Preliminary results revealed that arsenic concentration in wool was comparable to that of in cattle hair found in the contaminated zone of West Bengal; arsenic concentration in urine and faeces of yak was very low.

Reproductive Management

- Sperm abnormalities are responsible for a substantial decline in yak production. The method for identification of sperm abnormality has been standardized in yak.



Sperm abnormalities

- Conservation and genetic improvement of yak germplasm is possible only through ETT.

First yak calf was born through ETT (one female calf named MISMO was born from a recipient yak cow on 27 June 2005). This indicates the prospect of implementing



ETT for *ex-situ* conservation of yaks.

- The Ovsynch protocol for synchronizing and imbibing fixed timed Artificial Insemination (AI) has been standardized in yak. Synchronization of oestrus in yak provided an opportunity to bring majority of the animals at oestrus around the same time and also during non-breeding season. Ovsynch protocol has double advantage of fixed time AI, as yaks are shy-breeders and in them oestrus detection is difficult. Heatsynch protocol could induce oestrus and synchronization of ovulation in anoestrous yak, which addresses potentiality of technique to fixed time for AI.
- Ultrasound-guided ovum pick-up (OPU) has been standardized in yaks, and percentage recovery of A and B category oocytes was 59.09 and 22.73, respectively, with an average oocytes recovery of 1.47 per animal. Maturation of oocytes (both A and B



Jawans of army and paramilitary forces are trained for feeding yaks

categories) was found 71.43% with subsequent *in-vitro* fertilization rate of 42%, using *in-vitro* capacitated frozen yak sperm; which gave cleavage up to the stage of morulae and blastocysts. Embryos were cryopreserved and subsequently two of them were transferred to suitable recipients.

Molecular Dissection of Immune-regulatory Gene

- Two different single stranded conformation polymorphism (SSCP) phenotypes of toll- like receptor 2 (TLR2) have been identified on the basis of the band-sharing index. Presence of polymorphism in this relatively conserved domain of genome is significant because earlier studies had shown considerable monomorphism in Indian yaks in other candidate gene loci.

THRUST AREAS FOR XII PLAN

Genetic improvement

- Improvement of production/reproduction traits through the application of suitable breeding strategies.
- Assessment of novel genes which aid and assist in better production and disease control.
- Identification and characterization of genetic architecture of cold-tolerant traits in yak.

Feeding standards for different categories of yak in relation to rumen ecology

- Estimation of nutrient requirements of yak for milch animal, pack animal etc.
- Development and evaluation of suitable feeding strategies in winter for yaks.
- Exploratory trials on different grasses of high altitudes.
- Study of rumen ecology.

Developing capacities and competitiveness to screen various infectious and parasitic diseases

- Suitable immuno/DNA-based diagnostic tests for

Krishi Vigyan Kendra (KVK)

One KVK was established under this institute in Lohit District of Arunachal Pradesh in 2007. The KVK is involved in fish farming, dairy and piggery farming, integrated farming system, soil nutrient management and development of horticulture.

infectious/parasitic diseases.

- Development of DNA microchip for detection of yak pathogens.
- Detection of environmental pollutants related to abiotic stress in yak.

Studies on stress physiology and disease management

- Exchange of animals between different altitudes, i.e. 9,000 and 14,000 ft above msl and vice-versa while conducting trials on the performance of animals in respect of production and pack under the identical feeding and management conditions.
- Monitoring climatic parameters of two altitudes and comparing climatic data.
- Impending climate change and its possible effects on physiological parameters, biomolecular expression, production performance and reproductive efficiency.
- Monitoring and surveillance of transboundary and vector- borne diseases.
- Characterization of mutants during climate change.
- Elucidation of transmission modalities of emerging pathogens.
- Control measures of diseases at the source.

Assisted reproduction in yak for increasing productivity

- Hormonal and non-hormonal manipulations for improving fertility and productivity.
- AI, ETT, IVF and stem cell cloning for increasing productivity.

Development of technologies

- Preparation and commercialization of value-added products from yak milk and wool.

Capacity building of yak farmers/other stakeholders

- Organization of training programmes and extension camps for brokpas and other stakeholders.
- Impact analysis of improved yak husbandry practices and socio-economic status of yak-rearers.

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Multi-cob maize selection — MCM-11/01

A maize line (MCM-11/01) with multiple cobs (3-5) was selected from a trial plot of an indigenous maize collection (IC 524594) in 2009. The parent accession was collected from Zubja village (latitude 25°42.668"N, longitude 94°02.423"E, altitude 983 m), Kohima (Nagaland).

Selected plants were grown in isolation for two consecutive years (2010, 2011), and data were recorded for a number of agro-morphological traits.

However, grain yield/plant was not significant compared to checks, mainly due to smaller grains. The selection has dark-brown coloured husk and cream-coloured kernel. Breeding approaches can be initiated to incorporate this multi-cob trait into the improved maize varieties.



Agro-morphological characteristics of MCM-11/01, parent and checks

Traits	MCM-11/01	IC 524594	RCM 1-3	Delhi check	Local red
No. of ears/plant	3.4	1.0	1.0	1.0	1.0
Days to tasselling	69.4	70.0	69.0	68.0	65.0
Tassel texture	Medium	Medium	Medium	Medium	Medium
Silk colour at emergence	Cream	Green	Green	Green	Green
Leaf colour	Dark Green	Green	Green	Green	Green
Leaf width	Medium	Medium	Medium	Narrow	Medium
Plant height (cm)	200	348	307	268	262
Ear length (cm)	20.0	20.4	23.0	24.8	27.0
Ear width (cm)	4.8	4.4	5.2	3.4	5.8
Ear height (cm)	93.3	188	174.0	134.0	160.0
Husk cover	Good	Intermediate	Intermediate	Intermediate	Good
Husk colour at maturity	Dark brown	Dark brown	Dark brown	Dark brown	Dark brown
Days to maturity	114	115	112	118	115
Kernel row arrangement	Regular	Straight	Straight	Straight	Straight
Kernel colour	Dull yellow	Yellow	Yellow	Yellow	Yellow
Grain texture	Round	Round	Flat	Round	Flat
Grain shape	Indented	Indented	Indented	Indented	Indented
Grain size	Medium	Medium	Medium	Bold	Bold
100-seed weight (g)	18.3	24.2	24.9	25.3	30.0
Grain yield/plant (g)	128.4	113.4	106.2	130.5	125.4

MCM-11/01 showed higher (3.4) number of ears/plant; all checks had only one ear per plant. This is a unique trait as it has not been observed in any of the existing germplasm of the north-eastern hills region.

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New late-sown malt-barley cultivars

Barley is an important winter-cereal of India, and has to face a stiff competition from wheat, which is also a same season crop. It is cultivated over a wide range of environments in the northern India for feed, malt and forage /fodder. The demand for barley-grains for malting is on a continuous rise. Since majority of the barley produced is of the feed-grade, there is a shortage of good malt-quality barley.

Under late-sown conditions, a decline has been observed in the grain yield of the timely sown barley varieties. And there is also reduction in grain- and malt-

quality traits in such cultivars under delayed sowing. Since scope of barley cultivation is more under late-sown conditions in the semi- arid regions of Punjab, Haryana and Rajasthan as well as in the sugarcane belt of western Uttar Pradesh, the need was felt to have malt-barley varieties suitable for such areas.

Two new varieties — DWRB 73 and DWRUB 64— for commercial cultivation in the north-western plains zone under the late sown irrigated conditions have been released and notified. DWRB 73 is a two-row barley variety and DWRUB 64 is a six-row type variety. These

Crop Varieties from MPKV, Rahuri

Eight new field crop varieties have been released in the 40th meeting of the Joint Agricultural Research and Development Committee of 4 SAUs of Maharashtra, held at the Dr Punjabrao Deshmukh Krishi Vidyapeeth, Akola.

Rabi sorghum Phule Suchitra (RSV 1098/SPV 2048)

It belongs to medium-maturity group (120-125 days), and gave higher grain and fodder yields than Phule Chitra, Phule Maulee and M-35-1 in rainfed areas on the medium type of soils of western Maharashtra. Its grains are medium-bold of pearly white colour. The variety showed tolerance to drought, shoot-fly and charcoal- rot disease, and better tolerance to leaf rust and leaf blight. The variety is proposed for replacement of existing *rabi* sorghum variety Phule Chitra.



Pearl millet (ICTP 8203 FE10-2) Dhanshakti

Its iron content is higher than check variety ICTP 8203. It is an early- maturing (78 - 83 days) variety, found resistant to downy mildew and blast disease. It has been recommended and released for drought-prone areas of Maharashtra.



Sugarcane VSI 434

It is an early- maturing (10 months) sugarcane variety that gave higher cane yield and higher sugar (CCS) yield than check variety CoC 671. It has good ratooning ability and showed tolerance to drought. It was found moderately resistance to smut, grassy shoot, pokkah boeng and red rot (plug method) and was less susceptible to internode borer. Variety is suitable for early period of crushing season. It has been recommended and released for commercial cultivation in pre-season and *Suru* seasons in Maharashtra.



Paddy Phule RDN 6

It is a high-yielding (4.4 tonnes/ha), mid-late maturing (125-130 days) rice variety with long slender grains. It showed resistance to bacterial leaf blight and was found moderately resistant to leaf blast



and it has been recommended and released for cultivation in the western Maharashtra.

Pigeonpea Phule Rajeshwari (Tur 12)

This recorded higher yield than check Vipula and ICPL-87 in rainfed areas. It matures within 133 days. Its seeds are bold (11.3 g/100 seed weight) with higher protein content than Vipula. It showed moderate resistance to *Fusarium* wilt, sterility mosaic, pod- borer, pod-fly and nematodes. It has been recommended and released for cultivation in *kharif* in Maharashtra.



Groundnut Phule Unnati (RHRG 6083)

It recorded higher dry pod yield during summer and *kharif* than JL 501 and TAG 24, respectively. The variety has been found resistant to leaf spot, stem rot, rust, *Spodoptera* and thrips. It has been recommended and released for cultivation in summer and *kharif* in Maharashtra.



Safflower Phule SSF 733

This recorded higher yield than national check A-1. It has 28.2 % oil, and matures in 120-125 days. This variety gives good response to fertilizers and showed resistance to aphids. It has been recommended and released for drought-prone areas of Maharashtra.



Grass Phule Marvel 06-40

It recorded higher green forage yield and dry matter yield than Marvel. It showed resistance to leaf spot and rust and was less susceptible to jassids. It has better fodder nutritional quality (crude protein- 6.41%), and high leaf: stem ratio, and has high tillering ability. It has been recommended for rainfed pasturelands of Maharashtra.



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varieties have performed better for grain (bold%, thin%, hectoliter weight, husk %) and malt (hot water extract, malt friability, diastatic power and wort viscosity) quality traits .

To have acceptable malting quality even under the late-sown conditions is opening up possibility for the major

Indian brewing and malting companies to further extend *Contract Farming* in the areas.

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Cut-flower of commercial importance – GLADIOLUS

There is a constant demand of gladiolus varieties with novel floret colours. Hence, a need arose to develop varieties in a spectrum of colours with improved spike quality to cater to the requirement of flower-growers. Three new gladiolus varieties have been recommended for release by the institute variety identification committee.

Pusa Manmohak: It is a selection in the progeny from the cross of Mayur × Hunting Song. Its plants are healthy, medium green and straight; it is a mid-maturing variety, flowering in about 100-105 days. Its florets are saffron-red (40B) with thin whitish stripes on the throat of two oppositely placed lower tepals. And its inter-florets distance is less, which results in compact arrangement of florets on all sides of the spike. About 5-6 florets remain open at a time.



Pusa Manmohak

Pusa Red Valentine: It is a selection from the open-pollinated population of variety Regency. It is a mid-maturing variety; flowering in about 95 days. Its spikes are straight and long with good rachis length. And its florets are brick or blood-red (53B) with sun-ray like small lines on the lower tepals which make them attractive and very good for vase decoration as well as for bouquet preparation. This variety produces on an average 2.33 corms and more than 28 cormels from each mother corm. Its floral arrangement lasts for more than 9 days.



Pusa Red Valentine

Vegetative and flower characteristics of new varieties

	Pusa Vidushi	Pusa Manmohak	Pusa Red Valentine
Plant height (cm)	107.19	108.55	127.22
Number of shoots per corm	2.11	2.33	2.33
Days to flowering	80.00	104.66	94.11
Spike length (cm)	90.00	92.00	117.88
Rachis length (cm)	51.33	56.00	58.44
Number of florets per spike	15.11	19.99	19.11
Number of florets remaining open at a time	5.44	5.22	7.11
Floret diameter (cm)	9.19	10.57	9.76
Stem thickness (cm)	1.95	1.90	1.75
Spike longevity on plant	13.00	12.00	13.00
Number of corms per plant	2.33	2.22	2.33
Number of cormels per plant	37.44	49.33	28.11

Economics of cultivation

Particulars	Cost (₹/ha)
Total cost of operation (A)	300,330
Corms and cormels (90q/ha @ ₹2,000/q) (B)	180,000
*Production of spikes (132,000/ha @ ₹2.5/spike) (C)	330,000
Total gross income (B+C)	510,000
Net income {(B+C)-(A)}	209,670

*Net income depends upon the prevailing market price

Pusa Vidushi: It is a selection in the progeny obtained from Melody × Berlew. It is an early and mid-maturing variety; its first floret opens 80-85 days after planting. Its spikes are straight with good rachis length; and per spike, it has about 15-16 florets. The florets are purplish-white with greyed-purple spots on the base of the throat. Compact arrangement of florets is on the one side of the spike; and 5-6 florets remain open at a time.



Pusa Vidushi

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Blended squash: A new product from sweet-orange

Sweet-orange (*Citrus sinensis*) cv. Malta occupies a predominant place in the fruit industry of Uttarakhand. Its juice is a curative for jaundice and its refrigerant qualities make it indispensable for treating fevers. Its excellent quality fruits are generally available for only two months —December and January. However, owing to its poor shelf-life and non-climacteric nature, fruits cannot be stored for longer periods under ambient conditions or transported to distant places.

An attempt was made to prepare squash from Malta juice and ginger. The extracted juice was blended with ginger juice comprising 25% Malta juice (control), 22.5% Malta juice +



Malta in Uttarakhand

Physico-chemical characters of different squashes during storage

Treatments Character	T ₁			T ₂			T ₃			T ₄		
	0	3	6	0	3	6	0	3	6	0	3	6
TSS (°Brix)	46.6	47.2	47.4	46.0	46.5	46.8	46.4	46.8	47.0	46.4	46.6	46.8
Acidity (%)	0.650	0.636	0.630	0.623	0.603	0.600	0.620	0.603	0.600	0.616	0.603	0.600
Ascorbic acid (mg/100g)	27.27	26.36	25.50	25.45	24.54	24.15	23.64	22.73	22.50	21.82	20.91	20.50
Reducing sugars (%)	6.67	6.25	6.20	6.25	5.88	5.80	5.88	5.55	5.50	5.56	5.26	5.23
Total sugars (%)	40.00	41.67	42.10	39.21	40.00	41.25	40.00	40.82	41.04	40.00	40.82	41.00
Antioxidants (mMTE/L)	4.233	4.105	3.992	4.300	4.245	4.175	4.365	4.332	4.290	4.442	4.392	4.356
TSS: acid ratio	71.69	74.21	75.24	73.83	77.11	78.00	74.83	77.61	78.33	75.32	77.28	78.00

T₁- Control 25% Malta juice, T₂- 22.5% Malta juice + 2.5% Ginger juice, T₃- 20% Malta juice + 5% Ginger juice

T₄- 17.5% Malta juice + 7.5% Ginger juice

2.5% Ginger juice; 20% Malta juice + 5% Ginger juice and 17.5% Malta juice + 7.5% Ginger juice. The TSS of the final products was ameliorated to 45° Brix with sugar syrup. The blended squash was packaged in glass-bottles after adding 250 ppm potassium metabisulphite (KMS). These products were evaluated at regular intervals for various physical and biochemical characteristics.

Among the different treatments, Malta (20%) and Ginger (5%) was found the best in sensory evaluation (score out of 25) at the time of preparation and also after 3 and 6 months of storage. During storage, there

was reduction in acidity, ascorbic acid, reducing sugars and antioxidants and an increase in total soluble solids and total sugars. The cost of production, after adding 40% profit, of one litre bottle was ₹95; the similar products are available in the market at more than ₹150 per litre.

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Ovsynch protocol for improving fertility in buffaloes

In India, buffalo is the principal milk-producing animal, contributing to more than 50% of the total milk production in the country. However, a major limitation with this species is its poor reproductive efficiency due to its late maturity, long post-partum period to cyclicity and poor estrus expressivity. Anestrus in buffaloes is one of the most serious reproductive problems, affecting 30-40% of the buffalo population.

In cattle, a new estrus synchronization protocol (Ovsynch Protocol) was developed. It used combination of GnRH - PGF_{2a}-GnRH injections, which narrowed down ovulation time considerably to a range of 24 hours to achieve maximum conception rate with set-time artificial insemination. This protocol was experimented with in two trials on buffaloes also.

In Ovsynch protocol, anestrus/repeat breeding buffaloes are injected with 2.5 ml of GnRH analogue (Receptal) on any day intramuscularly; seven days later, 5 ml of lutalyse is administered, two days later, a second dose of 2.5 ml of Receptal is given. All animals are then subjected to fixed time AI at 12 and 24 h post second Receptal administration.

In the first trial, 60 anestrus buffaloes (ranging from 6 months up to 3 years) were selected from villages around Karnal. The animals were subjected to Ovsynch protocol for induction of estrus, followed by set time AI at 12 and 24 hours after the last GnRH injection. Animals which returned to estrus after treatment were bred either by natural mating or AI; 24 buffaloes were declared pregnant (40%), another 28 buffaloes became cyclic (47%). The success rate of this technique was 87%.

Another trial was conducted on 131 buffaloes. The overall incidence of pregnancies recorded was 67/131 (51.1%); either at fixed time AI or at subsequent estrus. This trial included 53 anestrus animals and 14 repeat breeders. And another 38 anestrus buffaloes also responded to treatment by returning to cyclicity; giving an overall success rate of 80%.

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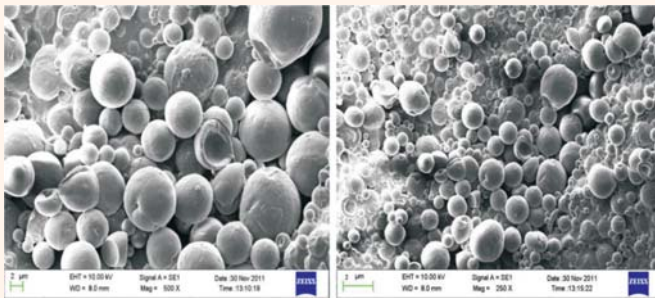
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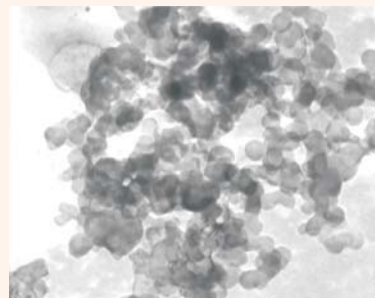
Novel protein/vaccine carriers for fish designed

The new generation therapeutics and vaccine components mainly contain purified proteins, recombinant proteins and peptides, which are poorly immunogenic. Therefore, the search for harmless and effective adjuvants and carriers was carried out for designing suitable delivery systems for augmentation of response of protein/vaccine molecules in fish.

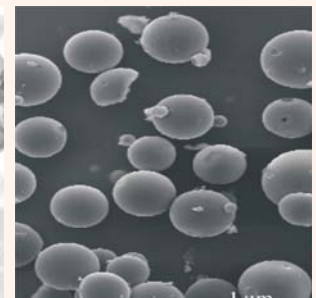
layer proteins adsorbed calcium phosphate nanoparticles; extracellular proteins (ECPs) encapsulated chitosan-coated lecithin-based liposomes; and outer membrane proteins (OMPs) encapsulated Poly D, L-lactide-co-glycolic acid (PLGA) microparticles— of two different bacterial strains *Edwardisiella tarda* and *Aeromonas hydrophila* was studied through



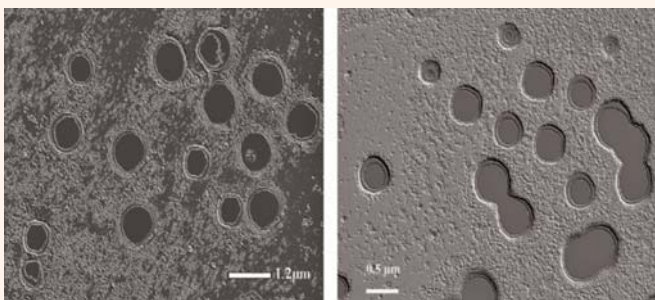
Scanning electron micrograph OMVs adsorbed chitosan-PCL microspheres (left) and OMVs adsorbed alginate - PCL microspheres (right)



Transmission electron micrograph of S-layer protein adsorbed calcium phosphate nanoparticles



SEM of outer membrane proteins loaded PLGA microparticles



Transmission electron micrograph of ECP encapsulated liposomes (bar = 0.5 μm) (left); ECP encapsulated chitosan coated liposomes (bar = 1.2 μm) (right)

Immunogenicity of four different protein preparations — outer membrane nanovesicles (OMVs) adsorbed with surface modified poly-caprolactone microspheres; S-

parenteral immunization in *Labeo rohita*. These delivery systems stimulated both adaptive and innate immune responses, which persisted up to 9 weeks post-immunization and protected fish from infections. This suggests that the above delivery systems would be safe novel adjuvant/antigen carriers for parenteral immunization in fish.

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Agricultural growth and reduction in rural poverty

Agricultural growth is positively related to annual rate of decline in rural poverty at the national level and also in majority of the states. However, in Arunachal Pradesh, Bihar, Karnataka, Kerala, Madhya Pradesh and Tamil

Nadu, there seems to be a disconnect between agricultural growth and poverty reduction. In these states, agricultural growth does not translate into commensurate decline in rural poverty.

Compound annual growth of AgNDP, NDP and decline in rural poverty

Period	(% per annum)		
	AgNDP	NDP	Annual rate of decline in rural poverty
1993-94 to 2004-05	2.3	5.9	0.8
2004-05 to 2009-10	3.9	8.9	1.6
1993-94 to 2009-10	2.6	6.6	1.0

Different sets of determinants can be critical to influence poverty at different points of times. Agricultural productivity, farm wages, and rural literacy have been found main drivers for rural poverty reduction.

The significant negative coefficient of AgNSDP per capita suggests that improvement in agricultural performance is associated with substantial reduction in rural poverty, indicating that benefits of the agricultural growth have

Relationship between agricultural growth and reduction in poverty

State/UT	Compound annual growth rate in Ag NSDP (%)	Annual rate of decline in rural poverty (%)
1993-94 to 2009-10		
Andhra Pradesh	3.78	1.58
Arunachal Pradesh	0.53	2.11
Asom	1.36	0.94
Bihar	2.46	0.44
Chhattisgarh	0.51	-0.01
Gujarat	3.50	1.03
Haryana	2.40	1.34
Himachal Pradesh	2.78	1.73
Jammu and Kashmir	3.13	1.53
Jharkhand	5.30	1.52
Karnataka	1.31	1.91
Kerala	-1.43	1.37
Madhya Pradesh	1.95	0.44
Maharashtra	1.78	1.86
Manipur	3.10	1.06
Meghalaya	4.34	1.42
Odisha	1.63	1.49
Punjab	2.28	0.36
Rajasthan	2.30	0.90
Sikkim	2.67	1.09
Tamil Nadu	0.62	1.86
Uttar Pradesh	2.36	0.72
Uttarakhand	1.30	1.36
West Bengal	2.77	0.86

trickled down to rural poor, and the growth has been inclusive. The agricultural productivity, an indicator of real agricultural growth, has played an important role in poverty reduction in rural areas, as is indicated by its higher elasticity for reducing poverty. For increasing agricultural production and accelerating productivity, especially the total factor productivity (TFP), the need for raising public investment is well documented. There is an urgent need for substantial increase in public investments in irrigation, rural infrastructure (roads and power), research and development, and due emphasis need to be given on the development of horticulture, livestock, and fisheries etc. Further, the spread of agricultural growth to the less-developed regions would lead to an overall increase in agricultural growth as well as reduction in rural poverty in the country. Policy measures like land reforms, enhanced rural credit, and greater public investment are important instruments to promote agricultural growth in less-developed regions. However, agricultural growth alone will not be sufficient to reduce rural poverty. Wages are major source of rural households income, and improvement in wages will significantly reduce poverty. Therefore, the rural development programmes that have direct or indirect influence on the living conditions of the farming and the landless labour households should be accorded

considerable importance in planning process to ensure inclusive growth. Appropriate education and capacity development enables individuals to take advantage of the labour market opportunities and income-generating prospects. It also enhances awareness level and skills to explore opportunities in the lucrative sectors, and thus may help in alleviation of rural poverty. A significant negative association between poverty and literacy indicates critical role of education in poverty reduction; asserting for greater investment on human resource development in the rural areas.

Determinants for reduction in poverty of farming and agricultural labours households

Dependent variable: Farmers' poverty (%)		
Exploratory variable	Coefficient	Standard error
Agriculture NSDP per person (₹)	-0.3857***	0.147938
Rural literacy (%)	-0.6062**	0.157547
Rural wages (₹)	-0.3470*	0.068741
Constant	12.90185	1.285675
R ²	0.7152	

* Significant at 5 % level, ** Significant at 10% level.

Source: Authors' estimates based on the data from the NSSO and CSO, Gol

There have been serious attempts in the recent years, through a series of flagship programmes to address these issues, and an encouraging progress has been achieved in some parts of the country.

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WAY FORWARD

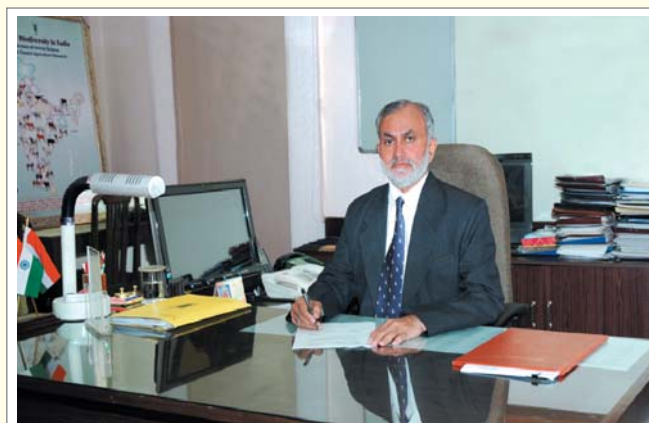
IMPORTANCE of the health-promoting foods is steadily increasing with the health concerns of the people across the globe, the researchers, the academicians, and the consumers. Changing lifestyles, eating habits, irregular working durations, increasing costs of medicines and medical-care, and decreasing resistance of the body to fight diseases, have forced all to think for easy, effective and better alternatives for maintaining physical and mental well-being. There is no strict definition for 'Health Food'. In general, it is used to describe foods that are beneficial to human health, besides providing basic nutrition. The term is widely used as an umbrella term, covering functional foods, probiotics, prebiotics, natural foods, organic foods, whole foods, nutraceuticals, designer foods, dietary supplements, etc.

In India, production of various food items has increased many folds during the last five decades. However, a substantial part of the Indian population still faces challenges of malnutrition and of undernutrition related chronic diseases, which are acute among infants, children and women. India, being a country in the developmental transition, faces dual burden of pre-transition diseases like undernutrition and infectious diseases, as well as post-transition, lifestyle-related degenerative diseases such as obesity, diabetes, hypertension, cardiovascular diseases (CVDs) and cancer.

According to the most recent estimate released on October 2010 by the FAO, 925 million people are undernourished all-over the world. According to the National Family Health Survey (NFHS) and UNICEF Reports (2006), 46% of the pre-school children and 30% of the adults in India suffer from moderate to severe protein-calorie malnutrition, as judged by the anthropometric indicators. Adequate nutrition is essential for both men and women. However, women nutrition assumes additional importance due to its association with the implications on the health and the well-being of the neonatals and infants.

About 25-30% Indian population is below poverty line, and lacks economic access to good quality nutritional food. Hence, it is essential to develop foods which cater to the needs of the undernourished population. Some of the health foods need to be developed to overcome micronutrient deficiency of the target population such as infants, children, women and elderly people.

Malnutrition has been identified as one of the most crucial issues to be addressed in the XII Five-Year Plan



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by the Government of India. It is widely recognized that the long-term solution to malnutrition must rest on the provision of adequate quantities of all the nutritional components in the traditionally accepted food itself. Food-based approaches are most effective in addressing existing protein-energy malnutrition and micronutrients deficiencies. These approaches must include strategies to assure dietary diversification, improved food availability, food preservation, nutrition education, food fortification, and development of equipment(s) and processes.

Presently available health foods or nutritional supplements in the country are expensive and beyond the reach of the common man. Under such circumstances, there is a need to develop foods for health promotion from the locally available raw materials. These foods when routed through public distribution system will reach masses and will resolve for a long-term the prevailing problem of malnutrition and food-related health issues. Prior to promoting the developed health foods, it is important to conduct clinical trials to ascertain their safety and efficacy, and for that an appropriate regulatory framework needs to be established in the country. Taking into consideration all these facts, the ICAR, for the XII Five-Year Plan has contemplated to undertake research on the development of health foods through consortium- mode by networking related institutes and departments. It is expected that research efforts would help development of safe and cost-effective health foods to strengthen national nutritional security at the household level.

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