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ICAR NEWS
A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Pusa Anmol chrysanthemum for year-round flower production

Chrysanthemum photo-and thermo-insensitive varieties for commercial cultivation are very few. Ajay chrysanthemum is one such thermo-and photo-insensitive variety that produces three flushes of flowers in a year; as against one by the majority of the cultivars. Rooted top-cuttings (10-12- cm long) of this cultivar were irradiated with different doses (10-50 Gy) of gamma rays; variability obtained through this has commercial significance. M_1 population of the variety was screened for variations in terms of altered flower colour or altered flower form or both. A large number of chimeras (existence of two

Pusa Anmol

genetically different tissues in the same vicinity) were formed in the mutated population. The chimeras were partial (half of the flower was of the parent colour and the other half was with the novel colour) or complete (complete flower was with the novel colour). Since these chrysanthemums cannot be propagated conventionally through flowers, plant-tissue technology was used to regenerate plantlets from such complete chimeras. The regenerated plantlets from ray-florets were established in the greenhouses, and were evaluated for

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altered flower colour for 3 consecutive years to establish stability. Further propagation was done by top-cuttings and suckers to maintain clonal fidelity. One such a novel mutant with salmon colour was isolated, established in the field, and was recommended for release in 2009 as Pusa Anmol.

Chrysanthemum is a typical short-day plant, requiring long dark period and short day light for blooming; and therefore, it usually blooms during winters. Its year-round production can be achieved only by manipulating light-and-dark cycles in the greenhouses, which is an expensive proposition. Hence availability of varieties that are photo- and thermo- insensitive, which can bloom in off-season, will be of great advantage.

Pusa Anmol is a floriferous bushy variety, producing as many as 50-60 flowers/branch. It's short-to-medium stature bushes produce 10-12 branches, which terminate into flower-buds, and which trigger further branching and flower-bud formation. The variety possesses strong stems with multiple flower-buds arranged in different heights, and opening in a sequential manner. The yellowish pink-coloured buds are oval-to-round and they unfurl into double flowers.

Pusa Anmol takes 85-90 days to bloom after trans-planting in July. It is a relatively thermo-and photo-insensitive type and flowers during October, February and May, when chrysanthemums availability is limited in the market. It has good suckering ability, and can be easily propagated through vegetative means. It equally responds to *in-vitro* propagation techniques.

In the northern plains, top-cuttings are raised in nursery during May-June in mist chambers. Cuttings root in 3-4 weeks time, and rooted plants are transplanted in the main field at 30cm × 30 cm apart during July. The variety comes to flowering during the first fortnight of October; and farmers can catch the market early and could command a premium for flowers. After October blooming, the plants are pruned and allowed to produce vegetative flush; they bloom in February. The plants are pruned again after February blooming to promote vegetative growth for flowering in May.

Parent Ajay in the foreground and Pusa Anmol in the background

This chrysanthemum can flower in peak summer when maximum temperature hovers around 40-44°C and minimum around 32-35°C. This is recommended for cultivation throughout the country in plains and hills. Its cultivation during summer months in hilly states and in places with milder climate is advantageous owing to its better colour retention. Market surveys have indicated that blooms of Pusa Anmol produced in peak summers may fetch a premium price of ₹10-12/stem.

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Nutraceuticals from corn waste

Production of nutraceuticals began with the identification of xylan-rich materials, followed by xylan extraction, and its hydrolysis into polymerized products, i.e. XOSs.

A protocol has been developed to convert corn-cobs into xylo-oligosaccharides. Xylo-oligosa-ccharides (XOSs) are sugar oligomers that have multidimensional health benefits of lowering cholesterol, increasing mineral absorption and immunity, and also in reducing enteric pathogens in poultry and pigs.

Corn-cobs are rich in hemicelluloses (mainly comprising xylan), and can be an ideal raw material for XOSs production. Out of the several methods applied for xylan extraction, sodium hydroxide coupled with autoclaving resulted in the highest (85%) recovery of xylan from ground corn-cobs. In the alkali-extracted xylan, reducing sugars were less than 1% and there was no glucose. The chemical identity was confirmed by Fourier Transform Infra Red Spectroscopy (FTIR) and Thermogravimetric Analysis (TGA). XOSs were produced successfully by chemical as well as enzymatic hydrolysis. Combination of 40°C, *p*H 4.0, incubation time 8 hours

Corn waste (Cob) Corn-cob xylan Xylo-oligosaccharides

and enzyme dose of 2.65 units yielded highest concentration of xylobiose (1.025mg/ml) and xylotriose (0.604 mg/ml); as was analyzed using High Performance Liquid Chromatography (HPLC). Similarly, acid hydrolysis of corn-cob xylan yielded 0.47 mg/ml xylobiose and 0.402 mg/ml xylotriose. XOSs generated through acid hydrolysis were tested for prebiotic potentiality and were found to stimulate growth of proven probionts. XOSs production process from corn-cobs is ready for industrial application.

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Indigenous technologies standardized for virgin coconut-oil production

Virgin coconut-oil is obtained from fresh coconuts by mechanical or natural means with or without heating. In this, no chemical refining, bleaching or deodorizing is done; thereby it maintains natural coconut aroma and nutrients. Commercial coconut-oil is prepared from dried coconut kernel, known as copra, by mechanical or chemical extraction process.

Virgin coconut-oil (VCO) is a high-value coconut product of commercial importance, and is becoming popular globally due to its medicinal and nutritional properties. It is called "virgin" as the oil obtained is pure, raw and pristine. VCO is unique among other vegetable oils because of its high lauric acid content, tocopherol content and antioxidant properties. Lauric acid is used by the body to make disease-fighting fatty-acid derivative monolaurin; babies make that from lauric acid they get from mother's milk. Monolaurin is reported to have antibacterial, antifungal, antiviral and anti-protozoan properties.

Technologies have been standardized for VCO production by hot-process and fermentation methods, and the choice of the technology depends to a great extent on the scale of operation, degree of mechanization, amount of investment available and on the market demand.

Hot-process involves extraction of coconut-milk, and then controlled heating of this in a specially designed

cooker- the VCO Cooker. And the fermentation method comprises extraction of coconut-milk and its fermentation to produce VCO. VCO produced by hot-process contains 5% capric acid, 5% caprilic acid, 51% lauric acid, 21% myristic acid and 6% oleic acid.

Testa remover, grating machine, hydraulic milk extractor, VCO Cooker and fermentation unit have also been developed. Efforts are being made to commercialize technologies through the ITMU.

VCO meal, the partially defatted coconut-gratings obtained as a byproduct, is very good dietary fibre. Several edible products using VCO meal such as fortified *atta*, biscuits, *ladoo*, compressed bar, porridge and *burfi* have also been prepared.

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Mass-scale propagation of spotted scat

Spotted scat (*Scatophagus argus*), a brackishwater ornamental fish, which can be maintained in freshwater, brackishwater and marine aquaria, is a suitable candidate species to be promoted as an ornamental fish.

Captive-land based broodstock of scat (48 – 254 g) was developed in ponds and tanks, and then fishes were provided with required environment for accelerating maturation under captivity. *Successful spawning of the captive broodstock was achieved for the first time* in India using brood fishes developed under the controlled environment.

A female fish weighing 200 g with ova diameter of 426 µ was selected and administered with Human Chorionic Gonadotropin (HCG) hormone as a prime dose, followed by Luteinizing Hormone and Releasing Hormone (LHRHa), as a resolving dose. Male fishes were also administered with the same hormones. Forty-eight hours after the treatment, fishes responded and ovulation was observed.

Ovulated eggs and milt were stripped from fishes and fertilization was facilitated externally. Larvae hatched out after 19 hours of fertilization, and average size of the larva was 1.62 mm. They were fed with rotifers from day 3, up to day 10, and afterwards with brine shrimp, *Artemia* nauplii up to day 25, till they reached 7-9 mm size. Later, fry were weaned to formulated feed and reared further. The hatchery produced juveniles were supplied to entrepreneurs for further propagation.

Two-inch(5.08 cm) size scat can be sold at ₹ 30/pc in the local markets, and it fetches US $ 2 /pc in the international market.

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Bucket-drip system for vegetables production in backyards

A cost-effective, low-head bucket drip system costing ₹750-1,000 per unit has been designed for small farms and backyards (area: 25 to 50 m^2) of village-houses. This system operates through gravity from a bucket of 25-litre capacity, placed at 1 to 1.5 m height. The system can be operated easily by anyone and about 25 to 50 plants of vegetables can be irrigated using a single system, which can produce 150 kg bottlegourd, 90 kg bittergourd, and 75 kg okra in a season (March to June). Sixty-five women-farmers of Rajasthan and Uttar Pradesh have already adopted this technology.

Farm woman of Rajasthan using bucket kit for ridgegourd cultivation

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Sorghum hybrid CSH 16 cultivation in rice-fallows

In the changing climate scenario, sorghum is emerging as a potential alternative food, feed, fodder and bio-energy crop. In the rice-fallows of the coastal Andhra Pradesh, sorghum cultivation is gaining popularity among farmers. It is now grown in more than 5,000 ha in rice-fallows with an average productivity of 5.7 tonnes/ha, which is the highest in the country. The farmers have now shifted from urdbean (blackgram) culivation to maize (in assured irrigation) and sorghum (with limited irrigations).

Five public and private sorghum hybrids—CSH 16, CSH 23, NSH 27, Kaveri 6363 and Sudama 333—were evaluated in rice-fallows under the zero-tillage during *rabi* 2010-11 on 10 hectares in farmers' fields at Nallapadu, Sripuram and Athrota villages of Guntur district of Andhra Pradesh. Private hybrid Mahalaxmi was used as a check; as it was commonly grown by farmers. After the harvest of *kharif* transplanted rice, sorghum varieties were sown during 25-28 December 2010 under zero-tillage to utilize residual soil moisture. Sowing was done manually in rows (40cm × 20cm) at 4-6-cm depth by making a hole with wooden-stick and placing 3-5 seeds in each hole. In almost all demonstrations, for effective weed control, tank-mixed application of Paraquat + Atrazine (1.0+0.50 a.i. kg/ha) was done one day after sowing. No fertilizer was applied at sowing. However, 30 days after sowing (just before first irrigation), 75 kg N and 60 kg P_2O_5/ha were top-dressed in rows. At 60 DAS (just before 2nd irrigation), 75 kg N/ha and 75 kg K_2O/ha were applied. Endosulfan 35 EC at 2 ml/litre of water was sprayed at 2 weeks after germination to reduce incidence of pests. Crop was harvested at physiological maturity (110 days after sowing).

Sorghum hybrid CSH 16 in rice-fallows

Among all the hybrids, CSH 16 (8.61 tonnes/ ha), followed by Kaveri 6363 (7.61 tonnes/ ha), Sudama 333 (7.11 tonnes/ ha), NSH 27 (7.04 tonnes/ ha) and CSH 23 (6.86 tonnes/ ha) yielded better than Mahalaxmi 296 (6.63 tonnes/ ha). The highest fodder yield was also recorded from CSH 16 (11.78 tonnes/ ha). Sorghum hybrid CSH 16 indicates huge potential for increasing sorghum productivity in rice-fallows.

Hybrid	Plant population/ m row	Plant height at harvest (cm)	Panicles/ m^2	Panicle length (cm)	Grains/ panicle	Grain weight/ panicle (g)	100-grain weight (g)	Grain yield (tonnes/ ha)	Fodder yield (tonnes/ ha)
CSH 16	12.6	174.2	12.6	31.6	4503	75.0	1.90	8.61	11.78
Kaveri 6363	10.4	183.2	10.4	35.6	3043	76.8	2.52	7.61	10.70
Sudama 333	11.4	171.8	11.4	30	2309	64.6	2.85	7.11	9.75
NSH 27	11.4	183.0	11.4	35.4	2544	68.8	2.71	7.04	8.39
CSH 23	11.4	187.2	11.4	36.8	3159	70.4	2.23	6.86	9.40
Mahalaxmi 296	12.80	170.8	12.8	32.40	2378	55.2	2.31	6.63	10.35
LSD (P=0.05)	2.05	8.50	2.05	4.27	1201	11.85	0.45	1.71	2.37

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Insect-proof net-house for cultivation of high-value vegetables

An insect-proof net-house, designed and fabricated for the northern plains of India in the form of a naturally ventilated greenhouse, but costing much less (₹ 350-380/m^2) with high benefit: cost ratio (2.5-3.0), has been found suitable for safe and virus-free cultivation of high-value vegetables such as parthenocarpic cucumber, coloured capsicum, cherry-tomato.

Insect-proof net-house fabricated in a greenhouse design

Tomato, cherry-tomato and capsicum can be grown for 8-9 months, and two crops of parthenocarpic cucumber can be grown for 7-8 months, excepting during peak winters.

During the peak summer (April-June), net-house can be covered with a 40-50% shade-net and during the peak winter (December-February), it can be covered with a transparent plastic on the roof.

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Innovative technology for large-scale farming of pearlspot

A technology has been developed for easy propagation of pearlspot *(Etroplus suratensis*) by breeding it under controlled conditions.

Captive broodstocks from diverse genetic pools (from Pulicat and Muttukadu in Tamil Nadu and Kumarakam in Kerala) of the fish in cages were established at Muttukadu Field Centre, and an average of 1,200 juveniles could be obtained from a pair of parent fishes.

"Matsya Keralam" Scheme has taken up a massive programme for farming brackishwater fishes on a large scale; and due to this, demand for the quality pearlspot fish juveniles has increased. Efforts are also being made to promote pearlspot fish culture in derelict inland saline wetlands of Karnataka.

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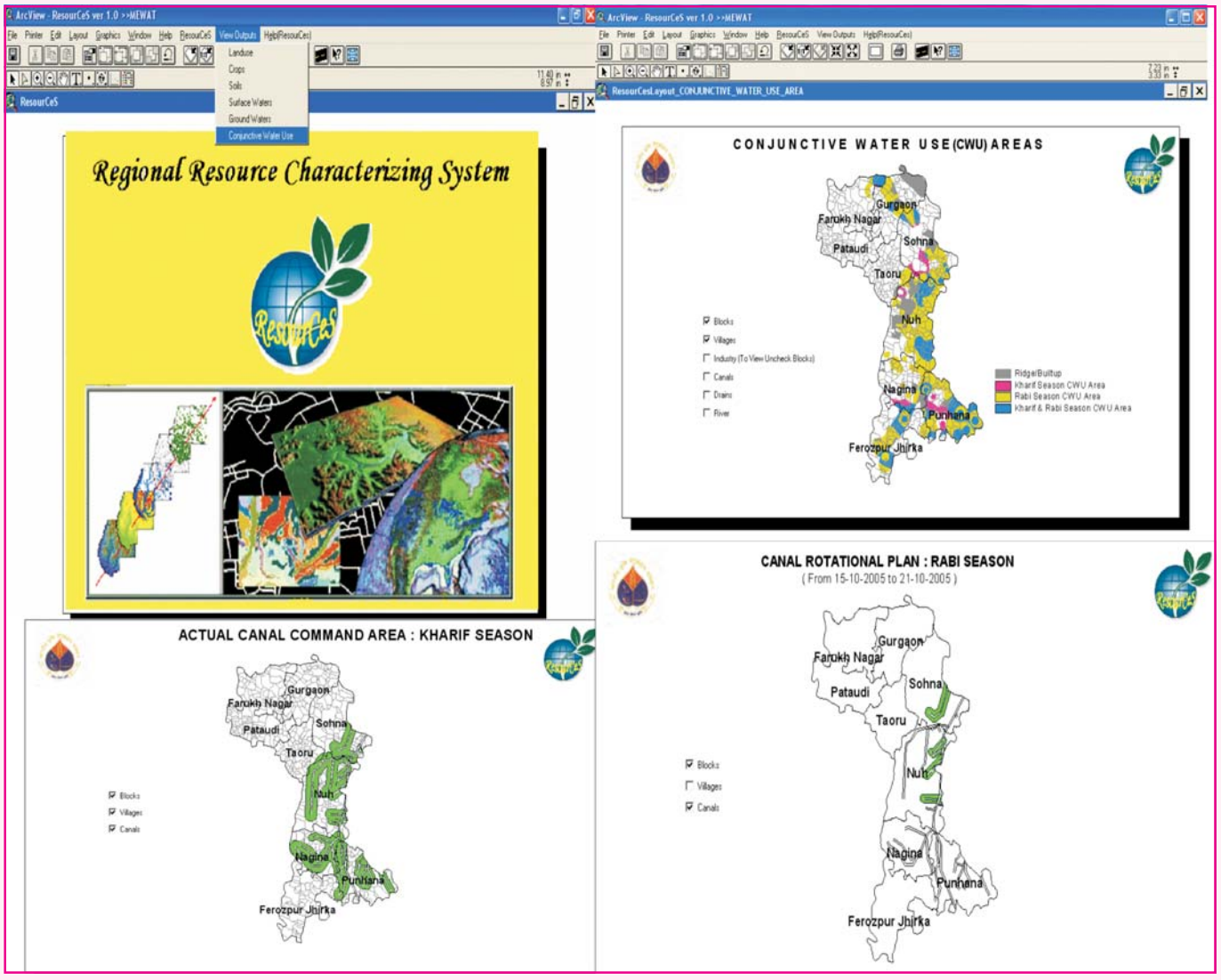
ResourCeS© – Regional Resource Characterizing Spatial Decision Support System

Regional perspectives and analyses of agricultural systems are becoming increasingly popular. This is possible only with the conjunctive growth of the digital analytical and display techniques and with the consistent data at the similar scales. In India, however, acquisition of resource specific data required for such an analysis, and hence regional policy-making, is confronted with 2 major problems—(i) non-availability of environmental data in uniform formats and (ii) no centralized data providing centre(s). This tool, ResourCeS©—an Arc-View GIS customized regional Resource Characterizing System—helps in overcoming problems by integrating all non-uniform and decentralized resource data at one place in a uniform format. This can, thereby, assist a policy-maker in assessing water use, water productivity, and soil, water and vegetation health of any region and also for targeting vulnerable areas in a customized menu-driven environment. The tool can even be used for delineating actual canal command areas and benchmarking/ assessing canal irrigation performance and canal water rotational plans. *The generated technology has been applied across the National Capital Region, and is of immense use to several governmental agencies involved in resource management and planning.*



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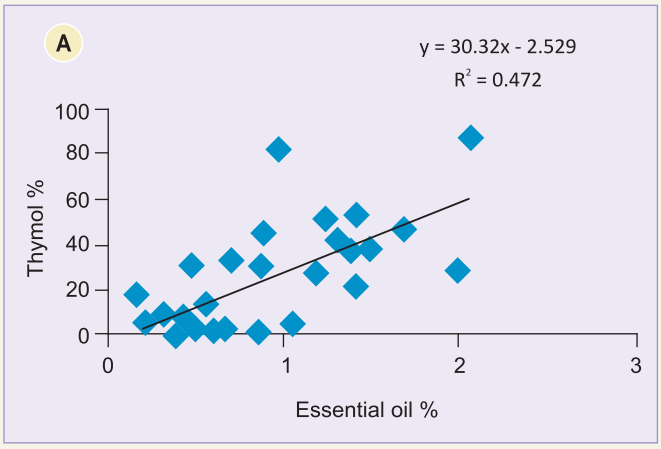
Oregano superior genotypes on the basis of chemotypic variations

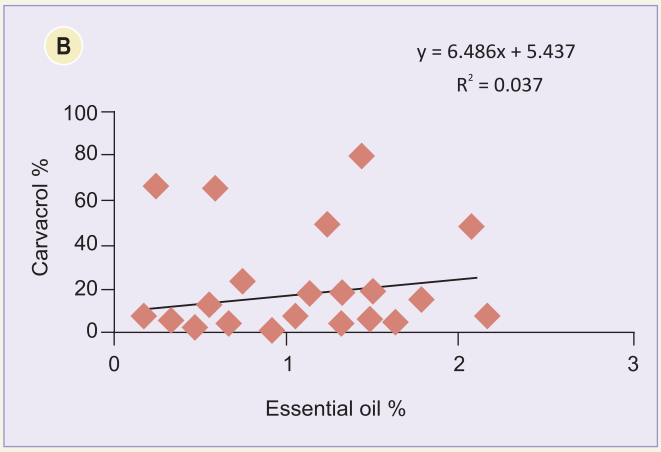
A study was undertaken to collect superior genotypes of oregano from the Central Himalaya; and 34 oregano accessions were introduced or acclimatized in the field gene bank/herbal garden of Bhowali Regional Station (NBPGR).

Aerial parts of all the accessions were subjected to Clevenger Hydro-distillation; and essential oils 0.16 to 2.07 % on the dry weight basis were found in different accessions as compared to reported value of 0.15 to 0.41%. Gas chromatography samples of these oils revealed presence of aroma constituents, particularly major phenolic compounds, Thymol and Carvacrol; they can be used in perfumery, cosmetics, pharmaceuticals, and food and beverage industry. On the basis of the major phenolic compounds, following two chemotypes have been identified.

Chemotype 1: Thymol-rich (85.87%) IC 589087 from 3,300 m asl in district Chamoli, Central Himalaya. The plant has purple flowers.



Linear correlation between essential oil and Thymol



Linear correlation between essential oil and Carvacrol

Chemotype 2: Carvacrol-rich (63.6%) IC 589079 from 2,300 m asl in district Bageshwar, Central Himalaya. The plant has white flowers.

The percentage of Thymol and Carvacrol is found increasing towards higher elevations of the Central Himalaya. Generally chemotypes form biochemical varieties or physiological forms in a particular genotype, each with a specific enzymatic property. These genotypes are genetically codified and direct their biosynthesis to preferential formation of a definite compound.

Oregano often pronounced as wild marjoram, called in local parlance as van-tulsi, sathra, jakham booti, basloo ghas and jonk-jari, and in Latin as *Origanum vulgare* belongs to Lamiaceae family. Lately some therapeutic properties—antibacterial, antimicrobial, anti-septic, antiviral, antifungal, anti-helminthic, antioxidant, preservative, energetic action, insect-repellent— have been established by the industrial community. The genus includes 39 species, widely distributed in the Mediterranean region; in India only one species is available from the sub-tropical to alpine zones of Himalaya.

As per the local folk medicine, oregano is an acute herb against cold and cough, influenza, digestive disorder, fever, menstrual flow, hysteria and urinary problems. Fresh juice of leaves and tender stems relieve itching problem in heal and feet, ear-ache, pustules and carbuncle. Due to antioxidant property, leaves are being used for the preparation of herbal tea.

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Parthenocarpic pointed-gourd

A pointed-gourd (*Trichosanthes dioica*) germplasm has been identified, which sets fruits without pollination and fertilization. For cultivation of this, planting of male-plants is not required; only female plants are grown by root-cuttings during December – January at a spacing of 120 cm × 150 cm. Fruits, thus developed, are seedless with only unfertilized ovules and without solid seeds.

Pointed-gourd is an important vegetable-crop of the Gangetic plain of India. It is mainly grown as a *rabi*-summer-crop through root-cutting or vine-cutting. Vegetative method of propagation is followed to accommodate female and male plants in 10:1 ratio in the field to ensure pollination and fertilization. In case of poor fruit-set due to lack of pollinator insects, manual pollination is required, which demands huge labour cost.

Immature fruits

Mature fruits

Advantages of this selection are: it reduces production cost, incurred for manual pollination; no land is occupied by unproductive male-plants; and seedless fruits get better market price. And its only disadvantage is shorter shelf-life of its fruits.

Further studies for its characterization and performance trial to other cultivated varieties are required for releasing the germplasm as a variety.

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Purple-podded Frenchbean with high antioxidant content

A unique Frenchbean line (MZFB 44) having attractive and colourful purple pods, may be a mutant, has been collected from Sherkhan, Kolasib, Mizoram. Unlike green-podded genotypes, the line has dark-purple flowers, purple pedicels and petioles, and also purplish leaf venation.

The pods are green for the first 6-8 days, and then turn completely purple in the next 8-10 days. Immature, tender, fresh pods are rich in anthocyanin content (7.08 mg/ 100g fresh weight); 16 times higher than the normal green-podded genotypes. This pole-type purple podded line flowers at 35-40 days after sowing (DAS) and pods are ready for first harvest at around 60-65 DAS with a crop duration of 95-105 days. On an average, the weight and the length of each tender pod is 16.5 g and 17.1 cm, respectively; containing approximately 8.1 seeds. Seeds are kidney-shaped, light-brown and 100 seeds weigh approximately 25.0 g. This line bears 10-12 pods/ plant and yields 170-185 g fresh pods/ plant in a total of 6-7 pickings during the rainy season (April-July). On an average, 5-6 seeds are sown in each hill at a spacing of 60cm × 75 cm during 2nd week of April, and vine is supported on bamboo-sticks or dried branches. The yield potential (tender pods) of MZFB 44 is 13.5-15.0 tonnes/ ha. Other than being with high yield potential and health benefits, the line has penetrated into Metro markets, especially hotels, for decorating salad and food items.

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Directorate of Mushroom Research, Solan

*It has emerged as the **Centre of Excellence** for mushroom research and development in India*

This institute was established at Solan in 1983 as the National Centre for Mushroom Research and Training (NCMRT) under the auspices of the Indian Council of Agricultural Research, and in 1997,it was renamed as the National Research Centre for Mushroom (NRCM), and then was upgraded as the Directorate of Mushroom Research in 26 December 2008.

All-India Coordinated Research Project on Mushrooms

This came into existence during the VIth Five-Year Plan (1 April 1983). The Director, DMR, functions also as the Project Coordinator. The AICRPM had started with six centres ; and at present, it has two cooperating centres (Dr Y.S. Parmar University of Hort. & Forestry, Nauni, Solan (Himachal Pradesh) and HAIC Agro R&D Centre, Murthal) and 14 AICRP centres.

INFRASTRUCTURE

National Mushroom Gene Bank. This has cryopreservation, freeze-drying and safe-deposit facilities for mushroom cultures; and at present, number of accessions in the bank are 1,900. Accessions of commercial strains, *Agaricus bisporus, A.bitorquis, Pleurotus* spp., *Lentinula edodes, Volvariella* spp., *Calocybe indica, Ganoderma lucidum* and *Auricularia* spp., besides economically important wild mushrooms, are available in the bank.

Spawn Production Facility. A commercial spawn production facility has also been established, which sells mother-spawn and planting-spawn of different strains of popular cultivated mushrooms.

Research Laboratories. The institute has two Centralized Lab Facilities and three well-equipped research laboratories for Crop Production, Crop Protection and Post-harvest Technology.

Mushroom Production Facility. This facility comprises 13 climate-controlled growing rooms and a modern composting unit with indoor bunkers and bulk chambers. In addition to this facility, four low-cost structures for indigenous mushroom cultivation are also available.

MANDATE

- Mission-oriented and innovative research on all aspects of mushrooms.
- To act as the centre of academic excellence and as repository of mushroom germplasm and information.
- To coordinate network research on location-specific problems of national importance, and to achieve higher production and productivity.
- To promote human resource development and transfer of technology and to provide technical support to mushroom industry as well as to rural masses for poverty alleviation.

Trainers' Training Centre. This is equipped with LCD display, interactive white-board and audio-visual system.

Library. It has a documentation centre, and the DMR Library Server is linked to CeRA and provides CD ROM data search through HORT-CD to users.

RESEARCH AND DEVELOPMENT

Mushroom Improvement

- Three varieties of *Agaricus bisporus*, including the *first hybrid in the country*, and two varieties of *A. bitorquis* have been released for commercial cultivation.
- DNA fingerprinting of all the commercial edible strains *Pleurotus, Lentinula, Volvariella, Flammutina, Calocybe indica* has been done.
- Molecular characterization of important competitors/ myco-parasites *Trichoderma, Hyohmyces perniceous, Sepedonium, Verticillium fungicola* has been done.

Mushroom Production

- A simpler and low-cost substrate preparation technique named as the chemical sterilization technology (CST) has been developed for oyster-mushroom cultivation. This has been adopted by growers all-over the country.

The Directorate has a well-developed Agricultural Knowledge Management Unit (AKMU). All sections are connected with the AKMU through LAN and facilities for Internet search, especially for scientific literature through J-Gate. It maintains database on mushroom production and consumption from different parts of the country.

Nature's Bounty

Oyster mushroom: With high protein, highly medicinal; antihypertensive, anticholesterol and anti-diabetic

Calocybe indica: Mushroom of Indian origin. It is similar to button mushroom, and can be grown at a higher temperature of 35-40°C

Lentinula edodes: Highly nutritious and with medicinal properties; anticancerous, antihypertensive and immunomodulator

Grifola frondosa: Enhances immune system, regulates blood pressure, glucose, insulin, and both serum and liver lipids

Ganoderma lucidum (Reishi): Known as mushroom of immortality, Highly medicinal; anti-cancer, anti-AIDS, anti-aging, hepatoprotective, nephroprotective, antiplatlet aggregation

Hypsizygus ulmarius (Blue oyster mushroom) Its cosmetic use is for skin antitumor activity

Cordyceps sinensis: Cures lung infections, has hypoglycemic activity, is anti-depressant

Morchella esculenta: Highly priced mushroom of the world, so far not cultivated artificially

Organic/chemical-free button-mushroom production technology has also been developed.

- For button-mushroom cultivation, an indoor composting technology developed uses thermophilic fungi for better quality compost production in the environment-friendly manner and in the shortest possible time.
- Cultivation technology has been standardized for *Lentinula edodes, Pleurotus eryngii, Agaricus bitorquis Calocybe indica, Flammulina velutipes, Agrocybe aegerita, Macrolepiota procera, Ganoderma lucidum, Hericium erinaceum, Macrocybe giganteum, Auricularia* spp., *Hypsizygus* spp.
- Indoor cultivation technology based on the cotton-ginning-mill-waste compost has been standardized for paddy-straw mushroom that gives double yield compared to traditional technology.
- Technology for utilization of spent-mushroom substrate (SMS) as manure and bioremediation has been developed.

Mushroom Protection

- Chemical pasteurization technology has been developed for controlling yellow mould; a dreaded competitor of button-mushroom compost.
- Residue analysis of recommended pesticides has been done, and safer waiting periods have been worked out.

Post-harvest Technology

- Extended shelf-life of fresh mushrooms through modified atmosphere packaging (MAP).
- Various value-added products such as mushroom biscuits, jam, candy, *murabba*, soup, nuggets etc, have been developed.

Nutritive value of common edible mushrooms (dry weight basis; g/100g)

Mushroom	Carbohydrate	Fibre	Protein	Fat	Ash	Energy K cal
Agaricus bisporus	46.17	20.9	33.48	3.10	5.70	499
Pleurotus sajor-caju	63.40	48.6	19.23	2.70	6.32	412
Lentinula edodes	47.60	28.8	32.93	3.73	5.20	387
Pleurotus ostreatus	57.60	8.70	30.40	2.20	9.80	265
Volvariella volvaceae	54.80	5.50	37.50	2.60	1.10	305
Calocybe indica	64.26	3.40	17.69	4.10	7.43	391
Flammulina velutipes	73.10	3.70	17.60	1.90	7.40	378
Auricularia auricula	82.80	19.8	4.20	8.30	4.70	351

Impact of technologies

- CST developed has almost eliminated costly and cumbersome hot-water/ steam- pasteurization technique.
- Chemical sterilization technique has helped growers in eliminating yellow mould infection from compost, thereby saving on crop failures.
- Tropical mushrooms such as oyster and milky mushrooms are grown in the plains of Punjab, Haryana and Jammu, thus mushroom portfolio of these states has been diversified.
- Indoor composting technique has been adopted by many commercial units.

Mushroom Products

Mushroom Engineering

- Various low-cost machineries for mushroom cultivation such as compost turner, compost conveyor, substrate-mixing drum, portable pasteurization chamber have been developed.

Thrust Areas

- Collection, long-term preservation and characterization of mushroom genetic resources, and their utilization in breeding for improvement in yield and quality.
- Domestication and commercialization of newer wild mushroom species.
- Characterization of mushroom genetic resources using advanced biotechnological tools.
- Morphogenesis studies on the important cultivated mushrooms.

Medicinal values of some important mushrooms

Mushroom	Compounds	Medicinal properties
Auricularia auricula	Acidic polysaccharides	Decrease blood glucose
Flammulina velutipes	Ergothioneine, proflamin	Antioxidant Anti-cancer activity
Trametes versicolor	Polysaccharide-K (Krestin)	Decrease immune system depression
Cordyceps sinensis	Cordycepin	Hypoglycemic activity, anti-depressant activity, cure lung infections

- Identification of bioactive molecules from mushrooms for industrial use.
- Diversification in mushroom portfolio—domestication of promising wild species, use of diversified and location-specific agro-wastes for mushroom production, popularization of newer cultivated species.
- To develop liquid spawn technology for high productivity and for shorter crop duration.
- Recycling of spent-mushroom substrates as feed, biofuel, organic manure and for soil remediation, bioremediation of industry effluents and pollutants, and as bioagents for control of insect-pests and diseases.
- Refinement in cultivation technology for indigenous edible mushrooms.
- Development of IPM packages for major pests and diseases of cultivated mushrooms.
- Development of expert system for mushroom cultivation, forecasting and management of insect-pests and diseases.

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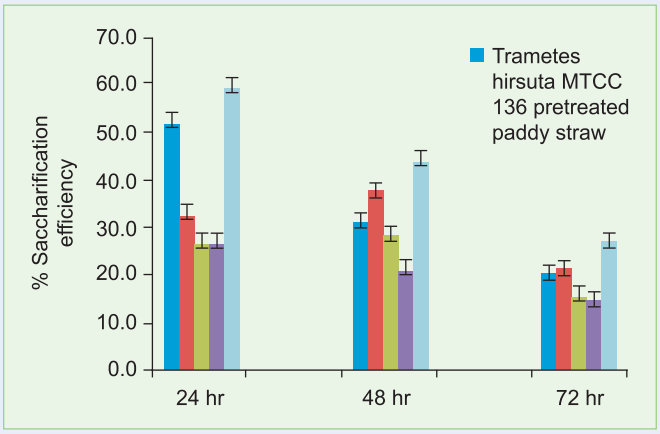
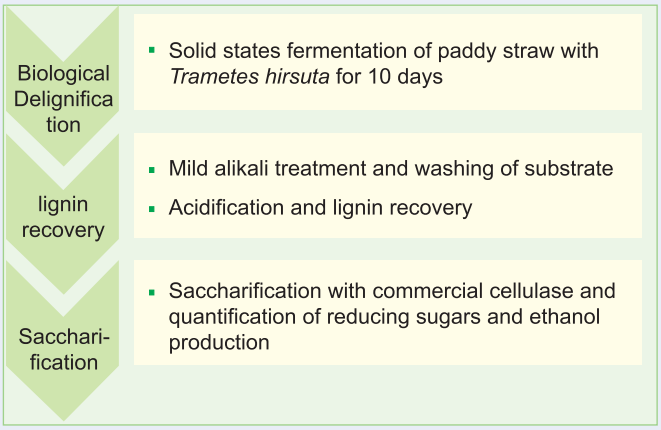
Paddy-straw biodelignification for improved saccharification and ethanol production

Sheer enormity of lignocellulosics makes them potential feedstock for biofuel production but their conversion into fermentable sugars has been a major hurdle. Most of the chemical pretreatment methods employed were resulting in the release of chemical inhibitors that affected subsequent saccharification and fermentation process. One of the environment-friendly approaches of microbial pretreatment has received renewed attention that enhances enzymatic saccharification of lignocellulosic biomass. This method employs micro-organisms, mainly white-rot fungi, which degrade lignin.



Saccharification efficiency of paddy-straw in different treatments



Biodelignification of lignocellulosic biomass

Preliminary screening of several white- rot and coprophilus fungi revealed superiority of *Trametes hirsuta* in production of lignin-degrading enzymes. *Trametes hirsuta* MTCC 136 showed high ligninase activity (on tannic acid, ABTS, and Azure B incorporated plates) and low cellulase activity (on CMC and swollen cellulose plates). Specific activities of cellulolytic enzymes after 7 days of growth on Reese's mineral medium with 1 % paddy-straw as the sole carbon source under submerged cultures were low and those of lignolytic enzymes were high. Solid state fermentation of paddy-straw with *T. hirsuta* enhanced glucan content of the substrate by 11.1% 10 days after pretreatment. High extent of lignin break-down by the fungus was evident from high absorbance values at 205 nm, exhibited by alkali extracts of pretreated paddy-straw. The amount of lignin recovered as value-added acid-precipitable polymeric lignin (APPL) from the pretreated paddy-straw samples 10 days after incubation was 3.8 times from autoclaved, uninoculated control and 6 times of the yield from uninoculated, unautoclaved samples, respectively. Furthermore, enzymatic hydrolysis of the fungal pretreated paddy-straw yielded much higher sugars, that increased till 120 hours of incubation. After 72 hours of incubation with a potent cellulase enzyme, saccharification efficiency of biologically pretreated paddy-straw was 52.69%, which was 10.6 and 3.2 times of the autoclaved, uninoculated and unautoclaved, uninoculated paddy-straw samples. This indicates potential of biological pretreatment process for delignification of lignocellulosic substrate and facilitating efficient enzymatic digestibility of cellulose. This biological delignification process will serve as a model for efficiently treating different lignocellulosic substrates as feedstock for indigenous bioethanol production.

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Wheat yellow rust resurgence in the northern hills and *tarai* regions

Containment of the yellow-rust epidemic for the past several years in India has been through rust- resistance breeding. However, during *rabi* 2010-11, its sudden outbreak was recorded in the northern parts of the country. The disease appeared on the majority of the areas in mid-February; and in the last week of March, severity reached up to 80S.

In Uttarakhand hills, severity reached up to 80S (susceptibility)with high prevalence on the local wheats and around 40S on the non-recommended improved varieties. Recommended varieties like VL Gehun 804, VL Gehun 829 and VL Gehun 907 showed good resistance;but VL Gehun 738 was susceptible. In the *tarai* region on the Haridwar-Delhi and Haridwar-Haldwani road, the crop was at the grain-filling stage and yellow-rust prevalence was 80-100% with 60-80S severity in PBW 343, PBW 373 and PBW 154; and fields of PBW 226 were having 5-10MR (moderate resistance) yellow rust. Late-sown crop showed relatively lesser incidence than timely sown crop. At Nagina, Uttar Pradesh, yellow rust was recorded up to 20-40S in PBW 343 and in PBW 590 with 80-100% prevalence. VL 829 and VL 892 showed resistance. In Udham Singh Nagar district, the grain bowl of Uttarakhand, most of the farmers planted PBW 343, PBW 550 and PBW 502. Since most of the farmers are seed producers, they had already sprayed Propiconazole. In PBW 343 and PBW 502, average of 30-40% incidence was seen with a severity of up to 30-40S. Unsprayed fields showed yellow rust severity up to 30-40S on DBW 17.

In Himachal Pradesh, yellow rust was observed from 10 to 80S in parts of Kangra, Hamirpur, Bilaspur and Mandi districts. Yellow rust was observed on PBW 343, PBW 502, PBW 373, Raj 3765, UP 2338, HS 240, HS 295 and HS 420 during the first week of March. However, low severity up to 5-10S was observed on VL 829. HPW 184, HPW 42, HPW 155 and VL 907 were free from the disease.

In Jammu and Kashmir, in Jammu, Sambha, Kathua and Akhnoor areas, prevalence of yellow rust was observed in majority of the farmers' fields with the intensity ranging from 5 to 80S, and varieties PBW 343, PBW 550, PBW 502 and DBW 17 were most affected with 30-60% prevalence. PBW 175 and RSP 561 were found moderately susceptible with severity up to 30MS. Raj 3077 and Raj 3765 were affected less by yellow rust (10S). Other affected areas were Chatha, RS Pura, Ghaghwal, Mathura Chak, Gial band, Merheen and Udaywala, with severity up to 60S.

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A potential underutilized vegetable – water mimosa

Water Mimosa (*Neptunia oleracea* Lour. syn. *N. prostrata* Baill, Family : Fabaceae) is one of the potential underutilized vegetable crops of Manipur. It is locally known as Eshing ekaithabi in Manipuri (Layalu in Hindi). The crop is native to Tropical Asia, South America and Africa. It is widely used as a vegetable in Thailand and China. It grows well in ponds and ditches; where it floats on water due to its white spongy structure. But when it is grown under terrestrial conditions, this structure does not develop.

Water mimosa large-scale cultivation with farmyard manure or compost application has been started in the puddled fields in Manipur. Its slips as well as seeds are used as the planting material. In the case of seeds, wet nursery is raised in March-April, and one-month-old seedlings are transplanted at a spacing of 0.5 m × 0.5 m. Normally, tender leaves, shoots and green pods are used as a vegetable in curies, fried items, boiled or fresh chutney known as Iromba and Singju. First picking starts after about a month after transplanting, and then is at 10-15 days interval. Its cultivation has been taken up by the farmers mainly in Imphal West, Imphal East and Bishnupur districts of Manipur, particularly adjoining villages of the Loktak lake. The vegetable is available in the market at ₹100 per kg; mainly during the rainy season (2nd week of June-September). During off-season, shoots can be successfully nurtured in low-cost polyhouses for early production of crop. From a



Water mimosa is a warm-season crop, growing actively during rainy season, and remains dormant in winter. It is quick-growing aquatic plant. It shows seismonastic movements similar to *Mimosa pudia*, which is responsive to a touch or to a knock stimulus. In the earlier time, it grew as a wild plant in ponds and ditches in Manipur. It is reported to have medicinal properties and is used in the treatment of nose bleeding, sores in tongue, diarrhoea with blood, white discharge, epilepsy etc. Its nutritive value per 100 gram (fresh weight basis) is 87.5% moisture, 17.3% crude fibre, 13.4% crude protein, 1.4% crude fat, 5.6% total ash and 5.2 mg ascorbic acid.

pond of 1,650 sq. ft, a farmer can earn a net profit of approximately ₹20,000. The crop is ideal for poor and marginal farmers to fetch a good profit within a short time. Water mimosa can be easily included in the integrated farming system with fishery as a component; this vegetable can be grown successfully with most of the fishes, excepting grass carp. But, the complete package of practices for growing this vegetable on the scientific lines has yet to be developed.

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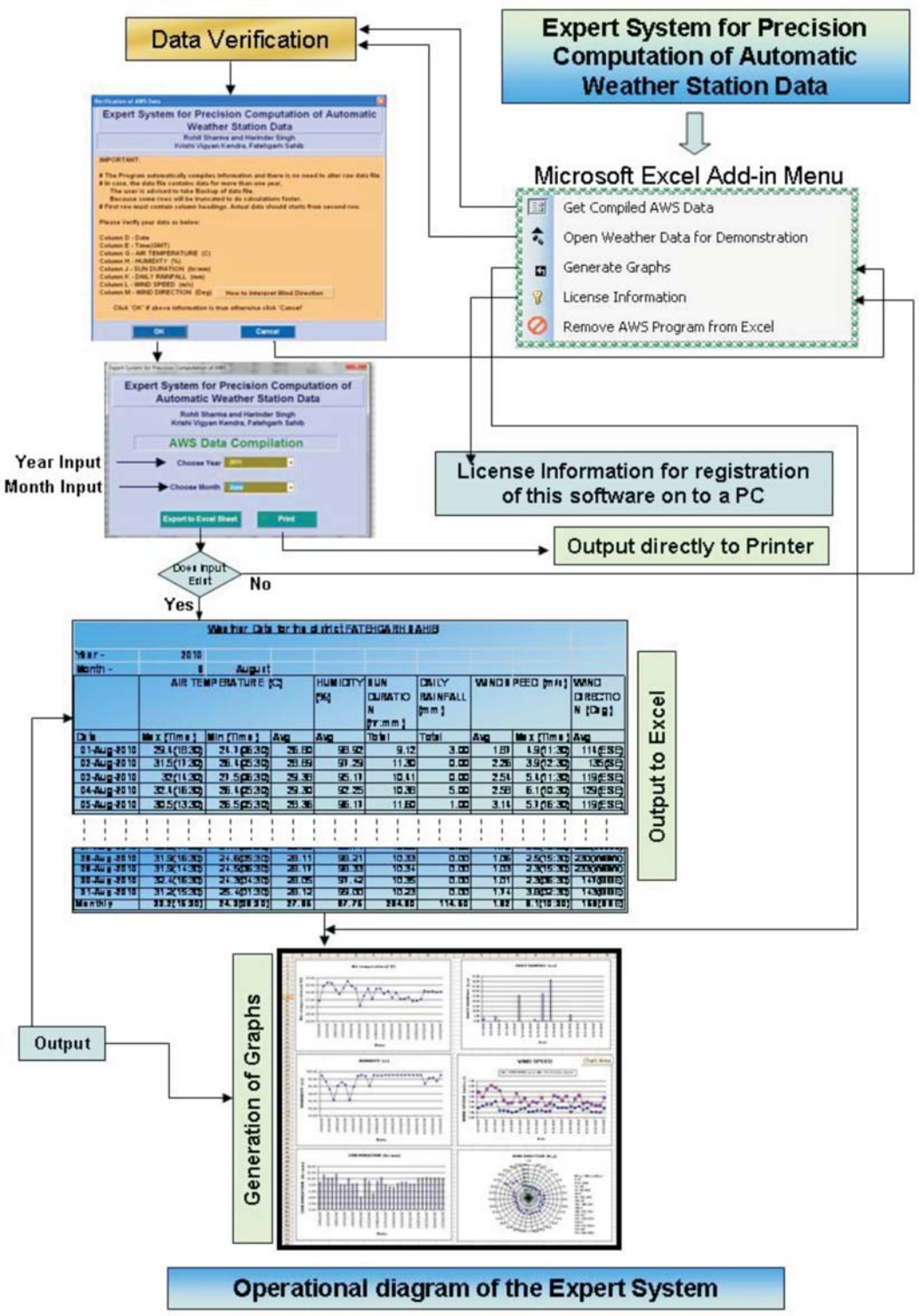
Expert system for precision computation of automatic weather station data

An Expert System for Precision Computation of Automatic Weather Station Data (a database management tool) has been developed using 'Visual Basic for Applications' embedded in Microsoft Excel in which various user defined and Excel in-built functions are incorporated into the spreadsheet. This menu-based programme takes only month and year as the input data from the user and gives compiled daily and monthly weather data that includes maximum, minimum and average air temperatures, average humidity, cumulative Sun duration, cumulative daily rainfall, maximum and average wind speeds and average wind direction. The expert system automatically adds a time difference of 05:30 hours to raw data for converting into the Indian Standard Time (IST) and compute values for all parameters automatically which saves lot of time and condenses whole weather data into readable format along with advantage of 100% accuracy.

A total of 550 Automatic Weather Stations (AWS) are being installed by the Indian Meteorological Department at various locations, and many of them are functional. Weather data generated by these AWS is in Greenwich Mean Time and on the hourly basis format for all weather parameters (air temperature, humidity, Sun duration, daily rainfall, wind speed and wind direction). Most of researchers, statisticians and extension workers require weather data on the daily basis. To obtain results on the daily basis from this raw data, a time difference of 05:30 hours need to be added to each time cell to convert it into Indian Standard Time (IST), as the weather data is available only in GMT format. It is very cumbersome to get results for all parameters; errors are bound to occur due to manual calculations or by using computer which takes so many man hours. This change of time will also cause change of dates for calculations for all parameters.



Operational diagram of the Expert System

The graphs for all the six parameters can also be generated automatically in no time by clicking sub-menu option 'Generate Graphs'. The software has been verified by the Department of Agrometeorology, PAU, Ludhiana, for its accuracy and acceptability, and the copyright for this software has already been applied with Govt of India, New Delhi. The software is user friendly and even a non-computer user can operate this programme.

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Initiated service-oriented computing services

Service-oriented computing consists of computing techniques that operate on the software-as-a-service. For providing a service-oriented computing to Indian NARS users, a Portal has been established under the NAIP Consortium on Strengthening Statistical Computing for NARS, which is available to NARS users through IP Authentication at http://stat.iasri.res.in:8080/sscnarsportal. Any researcher from the Indian NARS can obtain user name and password from the nodal officer of their respective NARS organization; list is available at www.iasri.res.in/sscnars. Analysis of the data generated from any block design (complete or incomplete) and split plot design is available on this portal. The module for combined analysis of the data generated from the block designs across the environments is being developed.

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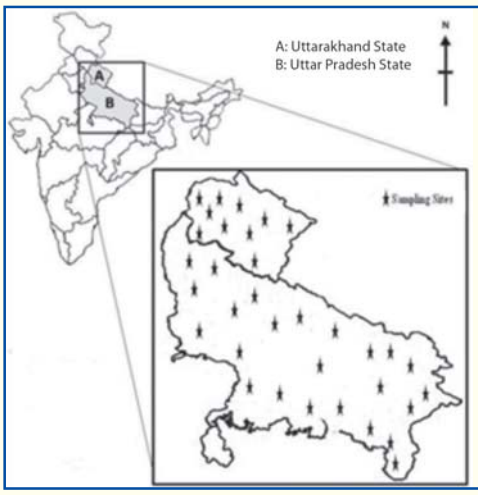
Actinomycetes diversity from Indo-Gangetic plain

Random, stratified soil sampling method from wheat-cropping system of different regions of the Indo-Gangetic Plain (IGP) was employed and 145 streptomyces were isolated from among 238 morphotypes that were showing wide variations in colony morphology. Plant-growth promoting attributes of all the isolates revealed that a total of 57.2% were ammonia producers, 8% were siderophore producers and 34.4% were phosphate solubilizers. All isolates were assayed for salinity tolerance (2, 4, 6, and 8% NaCl), antimicrobial assay against plant pathogens, *Macrophomina phaseolina, Rhizoctonia solani, Fusarium ciceri* and *Bacillus subtilis*, and for cyanide production. Extracellular enzymes recorded showed that 11.7, 13.7 and 42% isolates produced amylase, protease and cellulase respectively. Diversity analysis of *Streptomyces* using molecular tools revealed isolates belonging to *Streptomyces fumigatiscleroticus*, *S. variabilis*, *Streptomyces* sp., *S. flavidofuscus*, *S. rubrolavendulae*, *Streptomyces* sp., *S. coeruleorubidus*, *S. thermocarboxydus*, *Streptomyces* sp., *S. labedae*, *S. aureofaciens*, *S. althioticus*, *S. poonensis*, *S. albus*, *S. acrimycini*, *S. avidinii*, *S. ambofaciens*, *S. saprophyticus*, *S. variegatus*, *S. koyangensis*, *S. fradiae*, *S. thermoluteus*, *Streptomyces* sp., *S. bacillaris*, *S. humidus*, *S. atrovirens*, *S. viridis*, *S. vinaceus*, *S. globisporus*, *S. pseudogriseolus*,



Coordinates	Location	Soil Type	pH	Total number of colonies/ *Streptomyces* count (×10²)
30.33°N 78.06°E	Northern Indogangetic plain	Alluvial soils	7.5-7.8	35/23
29°23°N 79°27°E	Northern Indogangetic plain	Loamy to sandy loam	6-6.5	29/14
29.96°N 78.16°E	Northern Indogangetic plain	Loamy to sandy loam	7-7.5	31/14
29.59°N 79.65°E	Northern Indogangetic plain	Loamy to sandy loam	6-6.5	32/19
26.50°N 80.50°E	Upper Indogangetic plain	Saline-alkaline alluvial	7.8-8.5	47/32
27.57°N 80.68°E	Upper Indogangetic plain	Saline, alluvial	7.5-7.8	36/23
27.58°N 81.60°E	Upper Indogangetic plain	Saline, alluvial	7.3-7.7	38/22

Details of soil samples for diversity analysis of actinomycetes

S. griseoflavus, *S. albogriseolus*, *S. carpaticus*, *S. rochei*, *S. spiralis*, S. *macrosporeus*, *S. griseorubens*, *S. albogriseolus* and *S. viridodiastaticus*.

The distribution and abundance of microbial population is restricted to nutrient availability, temperature, ecological habitat and availability of oxygen as well as sunlight. In conclusion, the results provided further evidence that species diversity of actinobacteria is higher in the Indo-Gangetic Plain of India. And these have promising potential for plant-growth promoting and various other attributes.

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New composting process with reduced nutrient losses

The traditional methods of composting are costly, requiring huge manpower to handle bulky material, and to make permanent structures like trenches, pits, etc. Also in these methods, duration of decomposition ranges from 90 days to 250 days or more.

In the new method, windrows of residue are prepared using different ratios of residues and fresh cow-dung with the help of a tractor-mounted loader. Windrows are approximately 2.0-m high and 2.5-m wide according to the turning- and-mixing machine, which is very effective in mixing and turning unchopped residues with cow-dung and microbial consortium, thus saving on manpower and time.

Adequate space between the windrows is left for movement of the turning equipment. Microbial consortium in powder form or in liquid form is sprayed evenly on the windrows before turning and mixing. Thorough turning of the compost material ensures uniform mix of the material throughout the windrow. It also reduces uneven spots in the heap; having overheating or high moisture material that reduces microbial activity. Moisture and temperature is managed by frequency of turning. Turning at regular intervals during the initial 2-3 weeks of composting is required to reach and maintain temperatures above 55°C for 15 days to kill most of the pathogens and weed seeds. In this method, decomposition period is reduced to 75-90 days. Shortened period also reduces nutrient losses from the compost.

Change in colour and texture of compost in subsequent turnings and mixings (from A to B)

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Pre-sowing irrigation to winter-season crops at 5-cm depth increased yield

Early cessation of monsoon in certain years adversely affects germination and establishment of winter-season rainfed crops in the south-eastern Rajasthan (Kota) due to inadequate soil moisture in the surface layers. As a result, moisture stored in the deeper layers is also not efficiently utilized by the crops.

There is ample scope of runoff harvesting in the region for maximizing production, as 19 -33% rainfall during rainy season goes as runoff from arable lands. In such a situation, a pre-sowing irrigation with harvested runoff water may ensure adequate moisture for proper germination and early establishment of the crops.

Study conducted with 3 depths for pre-sowing irrigation – 0, 5 and 10 cm – on yield and water-use efficiency (WUE) of chickpea, linseed and mustard indicated 50, 61 and 80% and 63, 69 and 92% increase, respectively, with 0, 5 and 10 cm irrigation. Mustard showed average highest water-use efficiency (16.5 kg/ha/mm) and linseed the lowest (10.2 kg/ha/mm).

Effect of presowing irrigation on yield and WUE of chickpea, linseed and mustard

Pre-sowing irrigation (cm)	Grain yield (kg/ha)			WUE (Chickpea equivalent kg/ha/mm)		
	Chickpea	Linseed	Mustard	Chickpea	Linseed	Mustard
0	1,176	606	1,203	10.6	8.0	12.1
5	1,760	973	2,162	14.1	11.3	18.7
10	1,911	1,022	2,314	13.7	11.3	18.8

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Cobia bred using land-based pond-reared domesticated broodstock

Black king fish, cobia (*Rachycentron canadum*) is one of the candidate species suitable for farming, owing to its fast growth rate and high value in the domestic and international markets. Its breeding was usually carried out using broodstocks maintained in the open-sea cages in most of the places in the world and also in India. Recently, its breeding using land-based domesticated broodstock maintained in the pond ecosystem has been achieved for the first time. This achievement would be a landmark for seed production of cobia under controlled conditions and with an easy investment.

Fishes of 4.0 to 20.0 kg were maintained with proper feeding, health-care and water management in a viable land-based broodstock in the pond system and they attained maturity under the captivity. Matured females with ova diameter around 550µ were selected and maintained in the Recirculation Aquaculture System (RAS) for a month and were administered with HCG hormone (when the ova dia. was around 680µ) intramuscularly @ 300 IU/kg body weight for females and half of the dose for males. Successful spontaneous spawning was obtained after 34 hours of hormonal administration and fertilization was effected. About 1.40 lakh larvae hatched out (2-4mm size) after 18 hours, and are being reared following standard protocols.

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WAY FORWARD

FROM about 50 million tonnes of foodgrains production in 1950-51, harvest in 2010-11 reached over 241 million tonnes, highest ever, along with high production of fruits, vegetables, milk, eggs and fish. These food-production increases in the country have mainly been achieved through productivity gains, as the net-sown area has remained static for the last four decades. By 2020, India would require more than 280 million tonnes of foodgrains, 66 million tonnes of oilseeds, 95 million tonnes of fruits, 150 million tonnes of milk and 11.5 million tonnes of fish. The foremost challenges of alleviating malnutrition, enhancing productivity and crop diversification can be met through better resource management and by developing more productive, more nutritious, less input-demanding crops as well as livestock and fish breeds.

Advances in modern biology, especially biotechnology, offer many advantages in conjunction with traditional techniques to develop breeds with desirable traits of crops and animals. In early seventies, with the advent of genetic engineering techniques, natural barriers for gene exchange and transfer were removed. Genomes of rice, *Arabidopsis*, Medicago, sorghum, tobacco, etc. have been unraveled to provide better opportunities to manipulate crops for desirable traits.

The ICAR has initiated a network programme aiming at the development of transgenics of major crops. The crops are rice, sorghum, maize, chickpea, pigeonpea, soybean, cotton, mustard, tomato, papaya, brinjal, banana, cassava, castor, groundnut and potato for resistance to insect pests, viruses and drought tolerance. The transgenics of cotton, potato, castor and tomato are being field-tested. In 2002, Bt cotton was the first GM crop approved by the Government of India for commercial cultivation after biosafety and environmental safety testing as per the guidelines. Subsequently, other Bt cotton events, 'Bollgard II', 'GFM-Cry1A', 'Event -1', 'BNLA 601' and 'Event 9124', were subjected to biosafety tests; as of now, 619 Bt cotton hybrids are available for cultivation. Bt cotton hybrids are at present cultivated in more than nine million hectares; record production of 33.5 million cotton bales in 2010-11 is a testimony to power of GM cotton. In near future, GM crops, which have been modified for better availability of vitamins, iron, micronutrients, quality proteins and oils, would ensure nutritional security for masses.

The Government of India has been very supportive for the efforts to develop transgenic crops, and has invested liberally through the Department of Biotechnology, Department of Science and Technology and the Indian Council of Agricultural Research.

The programmes of developing GM products are also receiving due attention for systematic assessment of their potential impacts on the food, feed and environmental safety. The major consideration related to introduction of such GM products comes from the consequences of genetic manipulation, which may pose risk to human-beings and environment; as the location of the introduced gene in the host genome is not controlled. The future of the GM crops needs to be carefully crafted, and each transgenic event requires thorough testing for biosafety and environmental safety. A Joint FAO/WHO Expert Consultation on Biotechnology and Food Safety in 1996 elaborated on the compositional comparison as an important element in the determination of substantial equivalence. The Department of Biotechnology and the Department of Environment of the Government of India have constituted committees (Review Committee on Genetic Manipulation-RCGM and Genetic Engineering Approval/Appraisal Committee-GEAC) to critically assess applications from various institutions for conducting testing of transgenic plants and then only issue permits. Various aspects pertaining to biosafety of GM crops and their products towards different organisms, environment and biodiversity are being evaluated. Many compositional equivalence studies have been completed with GM crops (e.g. corn, cotton, soybean, wheat, rice, potato) over the last decade, and composition reported for the GM crops was found equivalent to that of their non-transgenic counterparts, only with the exception of intended changes. To meet basic food demands, and in a short span of time, it is imperative to harness full potential of biotechnology in a responsible way, wherein role of GM products will become increasingly important. It is, therefore, necessary that while we make precious investments in research for promoting GMOs in agriculture, we must simultaneously address concerns of human, livestock and environmental safety, and also make efforts to educate the users about this modern technology.

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