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ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Sustaining soybean system in Central India with pulses

Soybean has been the most important rainy-season crop of the Central India. However, many farmers in Madhya Pradesh, who usually planted soybean during kharif, decided to switch over to other crops as soybean no longer appeared remunerative, mostly owing to lower prices and higher production cost. Despite the fact that soybean has an access to best marketing practices, the crop lost its shine as its production and productivity had gone down over the years, resulting in a rare possibility of covering its cost of cultivation.

Thus, there arose an urgent need to manage natural resources |of the soybean-growing regions, particularly rainfall, to contain soil erosion and to improve efficiency of rainwater-use by switching to improved land configurations and appropriate soil cover. Rainwater stored by improved agronomic approaches can suitably be recycled for crop growth and development and thereby would enhance scope for another crop during *rabi* (fall). For example, low water requiring pulses like chickpea and lentil can be very well integrated with (after) soybean under rainfed agro-ecologies. Short-duration pigeonpea, urdbean and some compatible cereals are found most promising and remunerative if selection of suitable varieties is made and the necessary crop environment is altered through modification of existing sowing windows. The current series of investigations were undertaken to fulfill twin objectives of: Enhancing crop productivity and sustainability in *soybean-based intercropping system* (*kharif*): and Enhancing system productivity of *soybean-lentil system* under the rainfed agro-ecology of the Central India (*kharif* + *rabi*).

Keeping in view of the proven advantages of intercropping, extensive studies were made during 2014-16 to screen crops/varieties for their performance and adoption in the soybean system. While assessing and refining most remunerative intercropping systems, short-duration pigeonpea and urdbean have been found most compatible for sustainable bio-intensification of soybean system.

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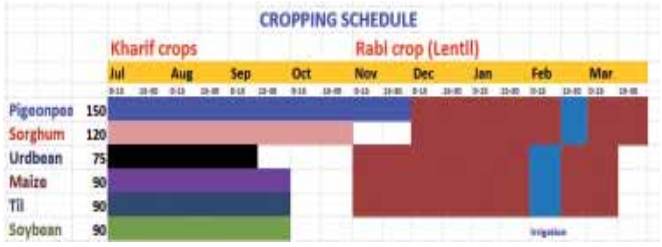
a. Soybean + pigeonpea (2 lines of soybean: 2 pigeonpea); **b.** Pigeonpea (after harvest of soybean); **c.** Lentil in *rabi*

Strategies for bio-intensification of soybean system

- Sowing short-duration pigeonpea with soybean by mid-June or June (possible with 1st few pre-monsoon showers)
- Switching to more appropriate pigeonpea variety (TJT 501, TT 401, JKM 189 and other short-duration varieties)
- Managing crop optimally under rainfed conditions (with restricted crop growth and dry matter) on broad- bed furrows (BBFs)
- Relatively narrow spacing for pigeonpea (by maintaining row spacing of 50-70 cm)
- Planting *rabi* pulses; lentil by 1st week of December under residual moisture
- Provision of one supplementary irrigation, if possible during *rabi,* for realization of higher lentil yield

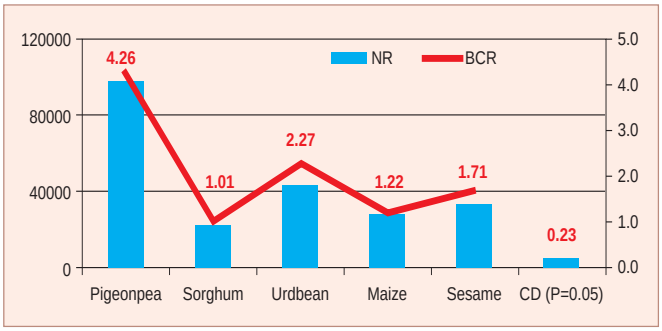
Technological Interventions: Soil of the experimental site was normal with clay-loam (Vertisols) texture and 7.87 *p*H, low N (198 kg/ha) and SOC (0.42%), medium P (15.5 kg/ha) and high K (368 kg/ha) at the surface depth (0-15 cm). Five intercrops — short-duration pigeonpea TJT 501, maize RASI 4242, sorghum MGSH 55, urdbean IPU 2-43 and sesame or til Western were taken along with soybean RSV 2001-4 in 2:2 replacement series both in the flat bed and broad-bed furrow (BBF) land configurations. These crops were followed by lentil IPL 316 during *rabi* with or without supplementary irrigation. The study indicated soybean highly compatible with short-duration pigeonpea. The slow growth of pigeonpea during initial period facilitated soybean growth as a parallel cropping. After maturity of soybean (around 3 months from sowing), pigeonpea occupied total space, and in fact, performed as *a pure or monocrop* and gave higher soybean equivalent yield (SEY, 3,556 kg/ha) compared to other intercropping situations (SEY, 544-707 kg/ha). BBF had a distinct advantage for both *kharif* and *rabi* crops as significant enhancement in crop productivity to the tune of 19.2, 16.6, 18.5 and 16.7 % in soybean alone, lentil alone, total productivity during *kharif* and *rabi*, respectively, was recorded over flat planting.



Cropping scheme inclusive of *kharif* crops (soybean + intercrop) and *rabi* crop (lentil) with their duration in days

BBF (with BBF planter) is advantageous over flat bed for drainage of excess water and conservation of soil moisture

When comparison was made on total system productivity of both *kharif* + *rabi* (soybean +intercrop - lentil), significantly higher total soybean productivity was recorded with soybean + pigeonpea - lentil (SEY, 4,691), followed by soybean + urdbean - lentil (SEY, 2,425 kg/ha) under heavy soil conditions of the Central Zone. Both pigeonpea and sorghum were harvested late in the



Soybean + pigeonpea-lentil system economics in Central India (₹/ha/yr)

Importance of Pulses

- Pulses typically contain 20 to 30 g of protein per 100 g; about **twice the amount of protein** found in **whole grain-cereals such as wheat**.
- Pulses have a unique profile of low digestible carbohydrates including several healthy prebiotic compounds: raffinose-family oligosaccharides (RFO), fructooligosaccharides (FOS), sugar alcohols and resistant starch. **With a low glycemic index, low fat and high fibre content, pulses are suitable for diabetic people**.
- **Pulses are good source of B vitamins**, such as B9 or folate, which reduce risk of neural tube defects (NTDs) like **spina bifida** in newborn babies.
- Pulses contain more potassium than sodium which is important for the management of hypertension and may **reduce risks of coronary heart disease. Pulses high iron** content make them a potent food for **preventing iron deficiency anaemia** in women and children, especially when combined with food containing vitamin C to improve iron absorption.
- Pulses are rich in bioactive compounds such as **vitamin E, selenium, phenolic acids and phytic acids**.
- Pulses contain small quantities of **phytosterols and saponins**. Plant sterols, stanols and saponins are found to reduce blood cholesterol levels.
- Pulses **are gluten-free**.
- Pulses contain more calcium than cereal-grains – **promote bone health**.
- Pulses also contain compounds that can cause **bloating as well as flatulence** and lower nutritional value by lowering digestibility/bioavailability of nutrients. Bloating and flatulence can be overcome using traditional cooking techniques such as soaking, germination (sprouting) and fermentation.

Land configuration and soybean+ intercrop (2:2)-lentil system

Land configuration/ Cropping system	Soybean yield* (kg/ha)	Intercrop yield during *kharif* (SEY, kg/ha)	Lentil yield (kg/ha)	Total system productivity (SEY, kg/ha/yr)	Net return (₹/ha/yr)
Land configuration					
Flat	421	1,110	693	2,363	39,567
BBF	502	1,312	808	2,785	49,857
C.D. (0.05)	68	96.4	63.5	108	2,776
Intercropping system					
Soybean+pigeonpea-lentil	432	3,556	584	4,691	97,238
Soybean+sorghum-lentil	465	565	604	1,756	22,599
Soybean+urdbean-lentil	481	684	1,049	2,425	43,128
Soybean+maize-lentil	483	544	765	1,945	27,390
Soybean+sesame-lentil	445	707	750	2,053	33,207
C.D. (0.05)	NS	274	82.5	192	4,921
C.D. (0.05) for Interaction	NS	388	117	272	6,960

*Soybean area is 50% of total area; SEY: Soybean Equivalent Yield (kg/ha)

season (end of November), and thus there was delayed lentil sowing, which affected adversely *rabi* crop (of lentil) and total productivity. Yet, because of very high productivity of pigeonpea, the losses were fully compensated in the lentil yield. As a result, net returns per hectare went up to ₹ 97,238 and BCR (net returns over cultivation cost) to 4.26 (the highest, and doubled over other systems).

In addition to the pertinent effect of BBF and soybean + pigeonpea system, supplementary irrigation once to lentil could also enhance its productivity over rainfed crop. Thus significantly higher (27.4%) lentil yield (and its soybean equivalent yield) was obtained following irrigation even though scanty rainfall was received in monsoon season; total productivity of soybean-lentil system was not influenced by irrigation. This study confirmed sustainability of soybean system with pulses.

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Pigeonpea yield enhanced with protected cultivation

India is the largest producer of pigeonpea, and contributes to more than 80-90% of the world's pigeonpea production. Cultivation of pigeonpea by providing appropriate drainage techniques along with protection of crop with insect- proof net would result in avoiding or minimizing use of plant -protection chemicals, and would maximize crop production. A field experiment was carried out on Vertisols of Bhopal (at 23° 19' N latitude and 77° 24' E longitude and at altitude of 490 metres above mean sea level) to evaluate performance of pigeonpea. The pipe-less drained area was covered to a height of 3 m with the insect-proof net, and drained water was collected in a sump first and then pumped to a storage tank kept at an elevated platform at 1.2-m height. The crop was grown under insect- proof net with silver black plastic mulching and without mulching as well as in the open field with and without plastic mulching. Drip irrigated laterals were installed to meet crop water requirement after rainy season. Pigeonpea was sown at a spacing of 60 cm between row-to-row and 45 cm between plant-to-plant on the raised beds 15 - cm high and 90 - cm wide. Same crop cultural practices were adopted in all treatments. The crop growth parameters and yield parameters were estimated for 16 randomly selected plants under insect-proof net with mulch and without mulch and of open field. During rainy season, no irrigation was given; however, during September to December, drip irrigation was given in all the treatments equally.

Pigeonpea-crop in insect-proof net and in open field

Plant height and average number of branches per plant were high under plastic mulched fields in both the environments. Insect and pest populations under insect- proof net and in open field were also monitored. The adult population per ha was almost double in the open field as compared to the insect-proof net house.

During the experimental period, a total of 698-mm annual rainfall was received; of which 47-mm water was drained from the root zone of the plant with pipe-less drains; installed earlier. This drained water was stored in a water- storage tank and was used after withdrawal of monsoonal rains. However, in the open-field area, where no such drainage facility was available, root zone was saturated with excess water for over five to six days during rainy season, and resulted in crop damage. Average yield of pigeonpea per ha under the insect-proof net with silver-black plastic mulch and without mulch was 2.17 tonnes and 1.40 tonnes, and in open field under plastic mulching, yield was 1.31 tonnes and in un-mulched,it was 0.85 tonne. The improved technology of the insect-proof boundary, pipe-less drainage, drip irrigation with plastic mulching increased income to ₹1.30 lakh over un-mulched open field cultivation.

Insect population in different treatments

Parameter	Under insect-proof net	In open field
Adult per m^2	1,540–3,100	3,200–6,220
Adult per ha	32 million	62 million

From the study, it can be concluded that by providing appropriate drainage to drain temporary waterlogged soils and installing insect-proof net at the periphery with silver-black plastic mulch, farmers can have higher productivity and good returns. The plant morphological parameters as well as yield were found highest under plastic mulching over unmulched conditions.

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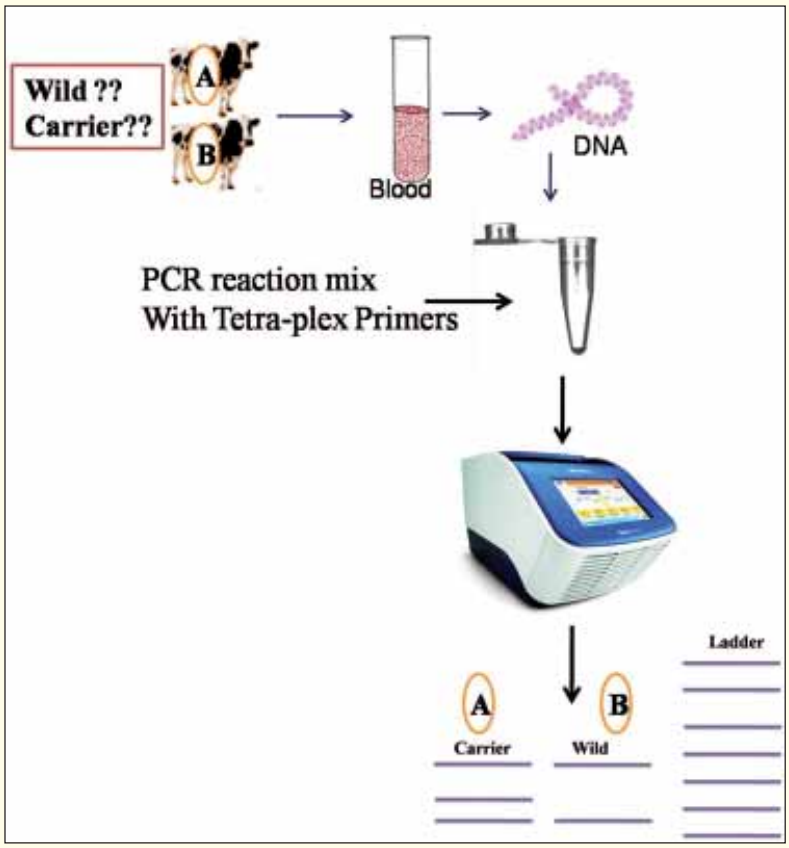
Rapid user-friendly diagnostic tool for detecting Bovine Leukocyte Adhesion Deficiency

Fast and economical means of assaying SNPs are important in diagnostic assays, especially when a large number of animals are to be screened for a genetic disease. Of the different genetic diseases reported in Cattle, Bovine Leukocyte Adhesion Deficiency (BLAD) is the most important one, and it is reported worldwide. BLAD is an autosomal recessive disorder, where carriers are responsible for transmitting mutant allele to the next generation, as they don't show clinical disease symptoms. The situation can be alarming if carriers are bulls to be used for artificial breeding programme. Clinical symptoms such as recurrent bacterial infections, oral ulceration, pyorrhea, chronic pneumonia, chronic diarrhea and death in calf stage are due to the inability of the leukocytes to perform cell surface adherence functions. Normally, leukocytes express β2 integrin (CD11a, b, c/CD18) glycoproteins, which are mediators for the cell to cell and cell to extracellular matrix interactions. A point mutation (adenine to guanine) at 383rd position of the *CD18* gene causes aspartic acid to glycine substitution at 128th amino acid position (D128G). This substitution impairs glycoprotein, leading to dysfunction of adherence dependent leukocyte functions. Cattle suffering from BLAD die within a year of age; while survived cows show low production and reproduction performance. Advances in molecular biotechnology enabled fast and reliable methods for accurate diagnosis of mutations responsible for different genetic defects; and these assisted breeders to identify carriers at an early stage. Different techniques — allele-specific PCR (CN101899511 B, patent 2010), PCR-RFLP and real time PCR — were used to identify BLAD carrier animals. But these assays were either time consuming or expensive. Therefore, a rapid and economical test for routine screening of the animals for BLAD has been the need of the hour.

A tetra-primer single- tube PCR-based assay for detection of BLAD carriers in the cattle has been developed. This assay utilizes four primers — two outer primers and two inner primers. In a single- tube reaction, outer forward (OF) and outer reverse (OR) primers amplify a specific amplicon of the target gene, irrespective of the allele at the SNP position. The inner forward (IF) and inner reverse (IR) primers with OR and OF primers, respectively, generate allele-specific amplicons. These amplicons are of different sizes, and hence can be easily discriminated on an agarose gel as homozygous or heterozygous. While two outer primers (OF, OR) ensure gene specificity and PCR efficiency; inner outer combination (OF/IR, IF/OR) ensures allele specificity. This method rely on different amplicon sizes, generated by inner outer primer combination (OF/IR, IF/OR) and increased specificity created *via* deliberate mismatch inserted to inner primers. The assay has been tested over DNA of 200 bulls and results have been verified using PCR-RFLP and sequencing.



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Cadalmin™ antidiabetic extract from seaweeds for type-2 diabetes

Type-2 diabetes receives more attention than type 1 because it is considered to be a preventable disease. Post-prandial hyperglycemia plays an important role in development of type-2 diabetes. Controlling plasma glucose level is essential for delaying or preventing type-2 diabetes. While synthetic drugs are efficient in attenuating rising blood glucose levels in many patients, their continuous use is often associated with undesirable side effects such as liver toxicity and adverse gastrointestinal symptoms. It is for this reason that there is a need for natural alternatives.

Cadalmin™ Antidiabetic extract (ADe), a nutraceutical product, with activity against type-2 diabetes contains 100% natural marine bioactive ingredients from selected seaweeds. The bioactive ingredients in Cadalmin™ ADe competitively inhibit dipeptidyl peptidase-4 and tyrosine phosphatase 1B, thereby hindering type-2 diabetes. Type-2 diabetes and obesity are characterized by resistance to hormone insulin; possibly due to attenuated or diminished signaling from receptors. A large body of data have identified protein tyrosine phosphatase 1B (PTP1B) as a major negative regulator of insulin signaling. Pharmacological agents capable of inhibiting negative regulator(s) of signaling pathways like PTP 1B would supposedly potentiate action of insulin, and therefore would be beneficial for treatment of type-2 diabetes. The Antidiabetic extract (Ade) developed inhibits tyrosine phosphatase 1B (PTP1B). Another mode of action of Antidiabetic extract is inhibition of dipeptidyl peptidase-4 (DPP4), which is an antigenic enzyme, expressed on the surface of most of the cell types, and is associated with immune regulation and signal transduction. DPP-4 inactivates incertins GLP-1 and GIP by removing amino acids from these peptide hormones. GLP-1 and GIP are essentially required for insulin secretion from β-cells of pancreas.

The bioactive ingredients in the nutraceutical product have the ability to interfere with release of simple sugars from the gut, which in turn, reduces postprandial (after eating) hyperglycemia (high blood sugar level).

The active ingredients have been encapsulated in hydroxypropyl methylcellulose shells (hypromellose), replacing animal-derived gelatin in an attempt to improve their greater *in-vivo* dissolution compared to hard gelatin capsules. The hydroxypropyl methylcellulose has been adopted due to drawbacks associated with cross-linking of gelatin and drug incompatibilities and strict regulations regarding use of animal-derived gelatin, which require absence of bovine spongiform encephalopathy/transmissible spongiform encephalopathy.

Cadalmin™ ADe has a promising consumer appeal and market potential, especially for the large vegetarian population in India and abroad. The unique biochemical engineering technique adopted to retain antidiabetic activities in the preparation of Cadalmin™ ADe assures its higher shelf-life.

Time-dependent shelf-life studies conducted to identify oxidative changes of the product revealed no significant reduction of anti-diabetic activities and the content of the active principles of the formulation after the end of the study period. Large-scale extraction of active principles from raw material was optimized in a factory unit. The total yield of the active principle from raw material in the factory was greater than 20%; demonstrating commercial feasibility of the product.

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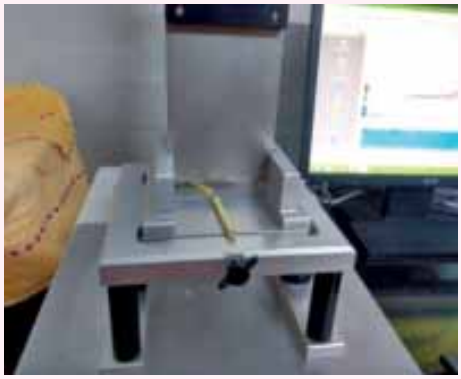
Wheat-shoot shearing characteristics for its lodging-risk assessment

Knowledge of plant physical and mechanical properties is important for understanding plant material reactions to cutting forces and deformation. Cutting often is accomplished by shearing plant material between a stationary counter-shear and a moving knife. Lodging involves falling over of the crop under the influence of complex interactions of surrounding environmental factors, thus it becomes necessary to study physico-mechanical properties of shoots and also underlying characteristics differentiating lodging in different cultivars.

Lodging in wheat reduces crop yield and quality, besides increasing duration of grain drying. Lodging during early stages results in severe economic losses, and at the time of ear emergence may result in about 75% yield reduction. In general, lodging during later stage of crop may not affect yield but may affect bread- making quality of wheat in terms of Hagberg Falling Number.

Wheat nodes

Shear test set-up



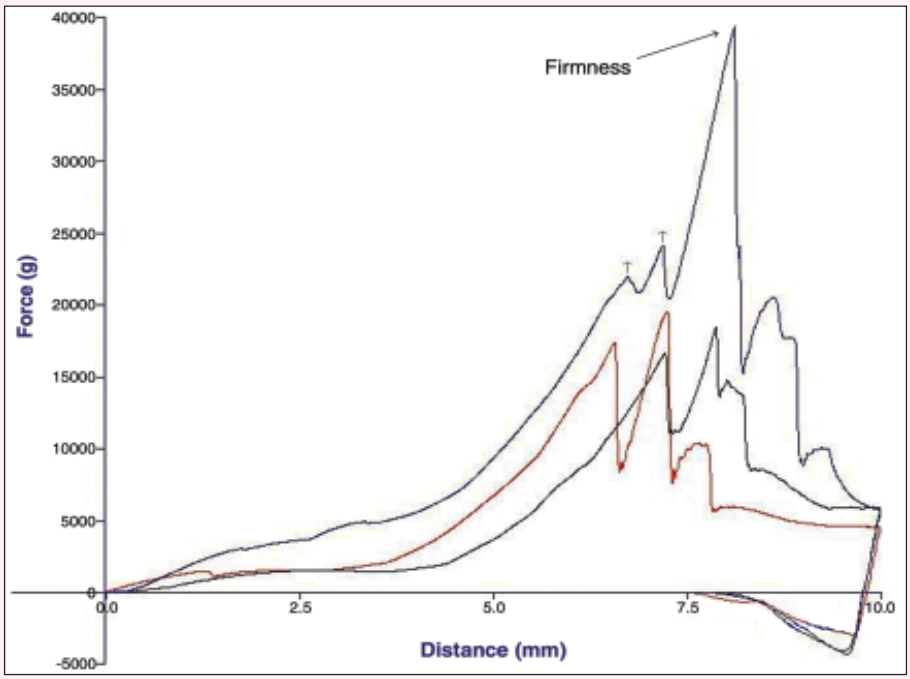
Shear testing at load 500N

Lodging results in grain shrivelling and decreases in test weight of grains due to reduced supply of assimilates. In spite of the introduction of semi-dwarf wheats during green revolution, in India, wheat genotypes that were grown at 120 kg N/ha used to lodge when grown at 180 kg N/ha. Lodging is often attributed to poor stem strength. Regardless of semi-dwarf character of the present-day wheat varieties, varietal variations in lodging often have been reported. Previous studies identified wheat genotypes like PBW 343, UP 2338 and Seri 82 as tolerant and WH 542 and HD 2329 as susceptible. Losses due to lodging, as much as 30%, can be reduced by delaying sowing of wheat by 2 weeks.

An effective technology to determine lodging in wheat cultivars based on shearing characteristics has been developed. Samples of ten wheat cultivars in replicate were collected from IARI fields; raised under irrigated and moisture stress conditions (IW/CPE ~ 0.6) and prior to any treatment or measurement, their leaf blades and sheaths were removed. Three lower nodes were used for the study. A universal testing machine enabling shear test on wheat samples was used. It had force capacity of 500N with force resolution of 0.1g. The speed of loading varied from 0.01 to 40mm/s. During calibration and setting of instrument, contact and trigger forces were kept at 0.25 kg each for a target distance of 10 mm.Shear strength in terms of shear failure stress was calculated by dividing applied force with cross-sectional area of the node at its rupture point.

Wheat tillers were tested under 5mm/sec loading speed. Shearing force at the point of breaking or cutting of shoot along with the distance for different wheat cultivars was measured. Forces vs displacement curves were obtained and data were analyzed within exponent software available with the system to calculate shear strength as a measure of shoot capability. Shear strength was found low at higher nodes than lower nodes. This variation may be attributed to decrease in stem diameter and cross sectional area with increasing plant height.

The shearing strength of the wheat shoots showed significant correlation with the observed lodging. The coefficient of correlation among the lodging score and the obtained values of shear strength was found highest



Shear force *vs* distance graphs for PBW 343 cultivar at three different nodes

for first lower node in both control and stress conditions. This indicates that lower nodes are more prone to lodging in all ten wheat cultivars. The shear strength of wheat cultivars grown under moisture stress conditions was lower than that of control for all the tested nodes, pointing that under moisture stress wheat stalks are more brittle and hence more susceptible to lodging than their counterparts grown under irrigated conditions.

This study shows that among physio-mechanical characteristics, shear strength is the most reliable technique to characterize lodging tendency in wheat cultivars. This technology for risk assessment of lodging of wheat-crop was observed to be successful under moisture stress conditions. Given its potential and authenticity, this technology can be used to screen wheat for lodging-risk assessment.

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Dragon fruit – a potential high-value crop of Bay Islands

Dragon fruit (*Hylocereus* sp.) is a climbing-vine cactus species of family Cactaceae with the most beautiful fruits. Its flowers also are very beautiful and are nicknamed as "Noble Woman" or "Queen of the Night". Juicy flesh of the fruit is delicious in taste.

The dragon fruit is a new introduction into India, and is highly valued for its neutraceutical properties. Five collections of dragon fruit have been established. As dragon fruit is a climbing cactus, support is essential for its growth and development. Concrete poles as trellises are being used for durability of the plant; as life of the vine is around 20 years or more. The concrete pillars are supported by a square structure on the top to train vines for bearing purpose. Since Bay Islands is a high rainfall zone, soil erosion is a common problem and hence concrete square structures are made as the base for maintaining supporting medium for the vine growth. Alternatively cost- effective iron poles and waste tyres are also used as the base structures. The structures were made at a spacing of 3m × 3 m. And soil medium was enriched with organic inputs like FYM, coir compost and vermicompost along with biofertilizers.

The rooted cuttings of dragon-fruit accessions were planted in June 2015 at the rate of 4 cuttings around each concrete pillar. The growth of dragon-fruit vines was very fast; an average growth rate of 8.2 cm was observed per week. The reported rainfall requirement of the dragon fruit is 1,145-2,540 mm/year. Since the rainfall is distributed for eight months in the Islands, irrigation is not needed but in dry season, the growing medium is kept moist through drip system on alternate days. Weed control is an important operation in its cultivation; use of weed-mat reduced efficiently weed growth and along with aided soil moisture conservation. In about 8 months after planting, dragon fruit forms a thick dense mass of vines on the top of the trellises, which lie drooping to ground.

Flowering was initiated in red-fleshed and white-

fleshed dragon fruit types in March 2016 (nine months after planting). And the fruits were ready for harvesting in 25-35 days after flowering. The maturity index of the fruit is colour breaking stage, from bright green colour to red. Exact time of harvesting is 3 to 4 days after colour change for the local market. But in long distance transport/export, fruits are harvested when colour break is noticed. Initial establishment cost is little high especially for the construction of trellises but once the plants are established, fruits can be harvested continuously up to 20 years. After establishment of the crop, only minimum expenses are required for maintenance of the plantation. The fruit is packed with excellent health benefits and has a good demand in local as well as international markets. In the Islands too, the fruits have good demand; imported fruits are marketed at ₹200 to 250 per kg. Dragon fruit cultivation in the Islands could be a viable option for farmers and entrepreneurs of medium to large scale plantations. It is a fast return potential fruit crop with production starting second year onwards of planting.

Though initial establishment cost is high; substantial profit can be achieved within five to six years after planting.

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Agri-IPRs pricing in India: Viewing from two divergent cases

In the past, technologies generated by the ICAR were provided free- of -cost to poor farmers or only by charging nominally of their market price.

In the process of economic development, role of industry and business enterprises in Indian agriculture has also increased on the pattern of the developed countries. Individuals and organizations involved in agri-businesses used free services such as intellectual properties (IPs) of the ICAR, for fetching profits.

During the course, it has been realized that the Council invests a lot of time and money for developing knowledge- and -skill base, and it should not be free for business or profit ventures. Hence, emphasis has been laid on protecting intellectual properties of the organization.

Mechanism of protection of IPRs in ICAR: In 2014, the ICAR formulated *"ICAR Rules and Guidelines for Professional Service Functions (Trainings, Consultancy, Contract Research and Contract Services)"* ,which presents a clear-cut scheme on how to value its services. In 2006, ICAR prepared guidelines for agri-IPR management and commercialization. Setting-up Institute Technology Management Units (ITMUs) in all ICAR institutes and Zonal Technology Management & Business Planning and Development (ZTM&BPD) Units at the IARI-New Delhi, IVRI-Izatnagar, CIRCOT-Mumbai, NIRJAFT-Kolkata and CIFT-Kochi under the overall administration of the Intellectual Property & Technology Management (IP&TM) unit was an important step of the Council. This infrastructure helped in kick starting the mechanism of commercializing salable technologies at appropriate prices, which included value of intellectual input invested in developing the technology. Many technologies in the ICAR set-up have already been commercialized.

***Valuation of technologies and IPRs*:** Computation of cost or investment in developing a particular technology

Potato – Aeroponic technology

becomes a pre-requisite for fixing price of that technology when no evidence of market price exists. However, it is cumbersome owing to absence of project- based budget in the ICAR institutes. The situation is further complicated when the concerned technology is a partial outcome of one project or more than one projects or even multiple of institutions. There may be some degree of subjectivity in the process, but ITMUs need to compile production cost of a particular technology in consultation with the concerned principal investigator, in-charge ITMU and director of the institute. Such an exercise would make ex-ante profitability analysis and valuation of technologies possible. Director of the institute and in-charge ITMU may adopt a particular strategy for obtaining required cash-flow to make the process of commercialization of that technology profitable. Institutes may solicit opinion from experts at the ICAR level, though ICAR issues periodical guidance or supply latest information on the related developments to its institutes.

Pricing under imperfect market conditions: The IPRs create essentially imperfect market conditions, and thus fixing prices of technologies under imperfect conditions is a real tedious exercise.

Different approaches are adopted by different ITMUs and there has always been varying opinions on the appropriateness of a particular price fixation mechanism. In India, agri-innovations range from one extreme situation where cent per cent physical and financial efforts are invested by the innovator institute and scientist(s) for developing the IP to the other extreme where IPs are generated out of a contract research and that research activity is cent per cent financially funded by a private agency or corporate. Seed potato production using indigenous aeroponics technology, developed by the ICAR-CPRI, Shimla, is an example of the former while portable soil-testing lab (*Mridaprikshak*), developed by the ICAR-IISS, Bhopal, represents the latter.

Case study of exclusively owned IPRs: For seed- potato production using aeroponics technology, differential price mechanisms were adopted for selling the technology to different persons/organizations at different points of time. As a guiding principal, subsequent sales were made at a higher price or benefit than the preceding one. Benefits of such sales were the resultant of license fee and future bonus(es). The first MOU for commercialization of this technology was signed in July 2013; and so far this technology has generated license fee three times the estimated cost of developing the technology. The bonus(es) would keep on flowing over the years, while there is a tremendous potential of additional sales of this technology in future. But the managers were put to a lot of scrutiny with obvious question "When there existed a potential of selling the technology at a higher price then why earlier sales were made at inefficiently lower price?"

In such cases, sale managers had to act under constraints and uncertainties. They had no provision for proper advertisement of these technologies and the challenge was also to create at least one sale for a technology so that it doesn't become part of the lot representing several non-marketed or non-marketable technologies. Advertising any product effectively is very expensive (sometimes many folds the cost of manufacturing the technology) and more often there is a risk that the small- scale agricultural technologies may not receive a price to cover even advertisement cost. Hence, making first sale at a nominal price and using that sale as a method of advertisement was in fact a smart strategy. Discussions with later stage buyers (paying higher price) clarified that at the initial stage they were not confident about the workability of the technology. When technology was found working at the level of farmers and companies, then they purchased. Hence, the method of charging differential price with a strategy of charging higher price from subsequent sales was an intelligent move. However, there exists possibility of misuse of the freedom of fixing any price by some sale managers ,and thus there is a strong need to have clear-cut price fixation guidelines or mechanism.

Case study of jointly owned IPRs: Pricing of the big hit portable (mini) soil-testing lab (*Mridaprikshak*) is an example of valuing IPRs, developed under contact research in public-private partnership. The technology

development was wholly funded by collaborating private corporate partner, hence, the technology was commercialized at a very nominal license fee to this partner on exclusive basis. A specified amount of royalty from sale of each unit would contribute to benefit stream of ICAR-IISS, Bhopal, in future. Since the technology provides exact status of soil health to the small and marginal farmers in India, the ICAR-IISS is under moral obligation to fix price of the technology in such a way that poor farmer's interest is not compromised. On the other hand, interest of the corporate private partner who funded this research activity as a contract research activity, has also to be considered. Scientists who developed the technology and concerned Institute Technology Management Committee were finding difficult to handle legal aspects of joint ownership of IPRs in the process of marketing this technology. Clearly specified guidelines on this aspect need to be formulated so that concerned institutes have a ready reference for making right decisions. While pricing such technologies, cost of showcasing and marketing technology, which really is substantial, needs to be computed separately and made part of the overall price of the technology.

There are examples of successful marketing of ICAR technologies on one hand, but there are examples of disagreements on the other. Generally, the ICAR institutes were at ease in selling technologies developed at their own with full ownership of IPRs, while, in case to IPRs with joint ownership, especially with business entities, the innovating scientists and institutes ended up in a difficult situation owing to limitations of the former in handling legal implications impeccably. There is urgent need of formulating standard guidelines for valuing agri-IPs and fixing their price(s). Such guidelines would act as a source of additional strength among Indian agri-innovators for developing path-breaking technologies and selling them efficiently.

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Jharsim — Location-specific rural poultry for Jharkhand

A dual-purpose poultry variety, *Jharsim,* suitable for Jharkhand, has been developed. The name *Jharsim* is derived from Jhar, for Jharkhand and sim, meaning hen in tribal dialect. These birds have attractive multi-colour plumage; perform better on the low plane of nutrition; and have faster growth, optimum egg production and better adaptability to agroclimate of the Jharkhand.

Birds weigh 400-500g at 6 weeks and 1,600-1,800 g at maturity under the backyard system. The age at first egg is 175-180 days and egg weight is 52-55g at 40 weeks of age. The birds have the potential to lay 165-170 eggs under the backyard system. This breed can give higher supplementary income and nutrition through egg and meat to rural/tribal population.

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Biochar for organic agriculture in Sikkim

Biochar is a carbon-rich charcoal-like substance produced by heating biomass in a limited oxygen through pyrolysis. Locally available weed biomass, which is not economically important and causes considerable crop loss, can be used as an important source of biomass for biochar preparation. When biochar is prepared from the locally available weeds then it would reduce weed population in agricultural fields; considered a serious problem in organic agriculture, especially in Sikkim, which is an organic state. In hilly areas, like Sikkim, soil loss, weathering and degradation occur at an unprecedented rate which causes imbalance in the ecosystem. Biochar plays and would play a major role in organic agriculture in Sikkim for sustainable soil health; not only by decreasing nutrient losses through leaching but also by improving soil productivity.

Biochar prepared from weed biomass and its field application

Six weed species identified are: *Ageratum* spp., *Lantana* spp., *Artemisia vulgaris*, *Chromolaena odorata*, *Bidens* spp., *Neyraridia* spp., and they were utilized for biochar preparation. Charring was carried out in a pit of 2ft×2ft×3 ft size to keep the process simple, quick and low cost with production efficiency of 13.2, 23.2, 15.1, 16.4, 14.6 and 19.6%, respectively, of the above- mentioned weeds.

The effect of weed biochar addition on the soil *p*H (clay loam) was observed for liming potential of biochar. This was done by incubating acidic soil of *p*H 5.4 with biochar up to 180 days. The biochar prepared from weed biomass and dolomite were applied at three rates (0, 2.5 and 5.0 tonnes/ha). *Lantana* spp. biochar had shown relatively higher increase in soil *p*H (initially of 5.4 to final of 6.7), followed by *Ageratum* spp. (6.5), *Neyraridia* spp. (6.3), *Artemisia vulgaris* (6.1), *Bidens* spp. (6.0) and *Chromolaena odorata* (5.9). These species can be effectively used as the potential source of biochar preparation for managing soil acidity as well as soil health.

Biochar should be applied along with the compost or manure at the same rate every year for realizing actual benefits. Application rate of organic inputs can be reduced as biochar contains some nutrients also.

Chemical properties of biochar

Sources	Volatile organic content (%)	*p*H	Moisture content	Total N (g/kg)	Total P (g/kg)	Total C (g/kg)	C:N ratio	Ash (%)	CEC (cmol/kg)	Alkalinity
Lantana spp.	15.7	9.21	10.3	7.2	1.81	735	102	25.7	29.7	121.3
Ageratum spp.	16.9	9.02	9.9	8.3	1.95	750	85	27.9	26.2	110.5
Neyraridia spp.	19.6	8.87	10.2	7.8	1.78	730	94	30.5	23.4	102.7
Artemisia vulgaris	19.1	8.53	10.1	7.7	1.81	715	93	33.2	22.7	99.7
Bidens spp.	17.8	8.11	9.7	9.5	1.92	708	74	36.4	21.6	94.7
Chromolaena odorata	18.4	8.02	10.6	8.9	1.83	727	82	39.6	20.7	90.6

Farmers in usual practice apply large quantities of lime/ dolomite to neutralize acidic soils at a greater expense. Biochar is basic in nature (*p*H > 7.0), and it can react similarly as agricultural lime does; increasing soil *p*H.

Rates between 5 and 10 tonnes/ha (0.5-1 kg/sqm) were beneficial for soil properties and crop yield. Biochar could increase/ improve soil moisture retention up to 20%, nutrient-use efficiency up to 15%, CEC up to 35% and crop productivity up to 30%. Biochar increased grain yield (≥ 15%) by decreasing leaf SPAD value at sites of upland rice with low P availability. Thus, biochar can be explored as an example of using a lesser important material, produced as a by-product of burning fuel, to benefit agricultural system through scientific technology.

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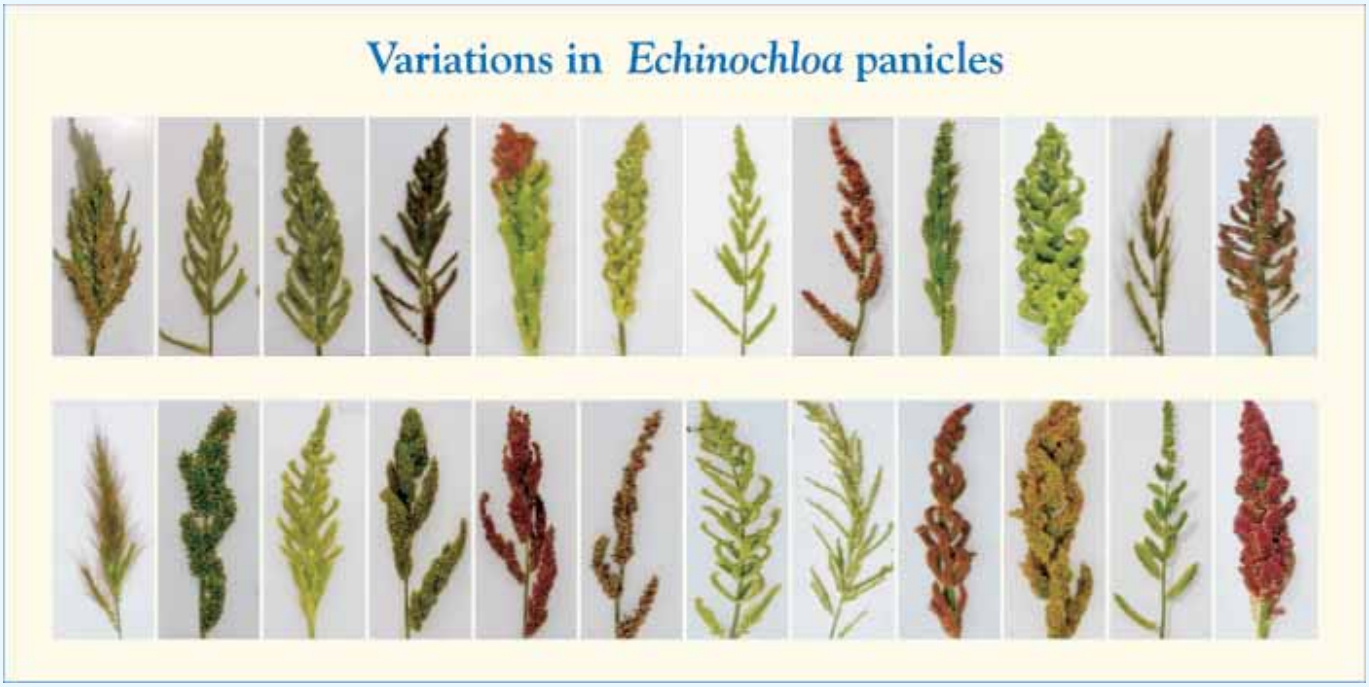
Food potential of weedy relatives of *Echinochloa*

Food and nutritional security requires a contingent plan for farming in case of delayed or a fewer rains, leading to main crop failure; for utilization of farming areas which are poor in resources i.e. water scarcity; and for growing of wild/weedy species with high nutritional value for providing better nutritional quality at a reasonable price to poor.

A study was initiated on *Echinochloa* (barnyard) as this has shorter life-cycle (which can be sown even after main crop failure), survives in harsh conditions, and has acceptable and diversified nutritional value along with fitting well with planned crops.



Seedlings of 112 entries of *Echinochloa* collected from different places across India were transplanted in micro plots (2 m × 3 m). Data were recorded for variations in different morphological characteristics — plant height varied from 45 to 158 cm at 52 days after sowing (DAS), number of tillers/plant were from 2.2 to 22.73, leaf area varied from 57.7 to 1,735.7 cm^2/plant, and root length from 9.6 to 34.3 cm. At 38 DAS, net photosynthesis varied between 12.88 and 36.37 µmoles/m^2/s. Number of panicles / plant varied from 2 to 25, while panicle length varied from 11.96 to 22.44 cm. Grain yield varied from 1.06 to 9.60 g/plant. Degree of grain-shattering was also evident among different collections, ranging from 0 to 100%.

On the basis of the results obtained, IEC 436 gave reasonable good yield (2.11 tonnes/ha) in a short duration of 58 days after transplanting with highest productivity (36.39 kg grains/ha/day). If sown early (first week of June), it took longer (72 days) and yielded 2.8 tonnes/ha. So far, no disease and insect attack has been observed in IEC 436.

Grains of 20 promising accessions representing different subspecies of *Echinochloa* were analyzed for mineral content (Fe, Mn, Zn, Ca, K, Mg, Na, P and S), which was found higher than rice and wheat; IEC 436 also showed high Fe, N, Ca and Mg and K.

Results are indicative that growing *Echinochloa* (barnyard) may provide a nutritionally sound and climate resilient option for farming with low inputs (N and water).

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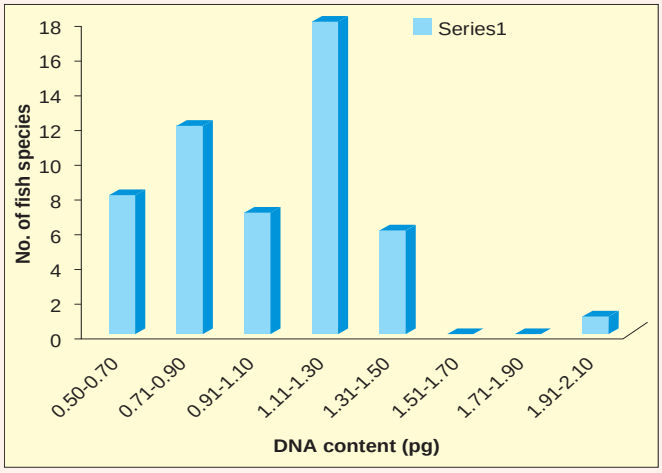
Genome size estimation of commercially important and endangered freshwater fishes

Genomic DNA content and ploidy levels of 52 economically important freshwater fishes were estimated using flow cytometry. The genome size was estimated using standard protocol, and *Gallus domesticus* (domesticated fowl) blood cells were used as the standard reference. The average genome size ranged from 0.58±0.03 pg (*Trichogaster fasciata*) to 1.92±0.04 pg (*Awaous grammepomus*). Order-wise variations in DNA content ranged from 0.64±0.07 to 1.45±0.073 pg in Cypriniformes, 0.70±0.07 to 1.41±0.02 pg in Siluriformes and 0.60±0.05 to 1.92±0.04 pg in Perciformes. Variations in nuclear DNA content between and within orders were also observed. No relationship was observed among genome size, chromosome number and organism complexity in all species. In this study, new records on nuclear DNA content of 44 species have been generated and have been revalidated for 8 species. The study would help understand genetic complexity among species and further elucidate evolutionary as well as environmental relationships for planning the future genomic studies of the species.



Haploid DNA content in 52 species

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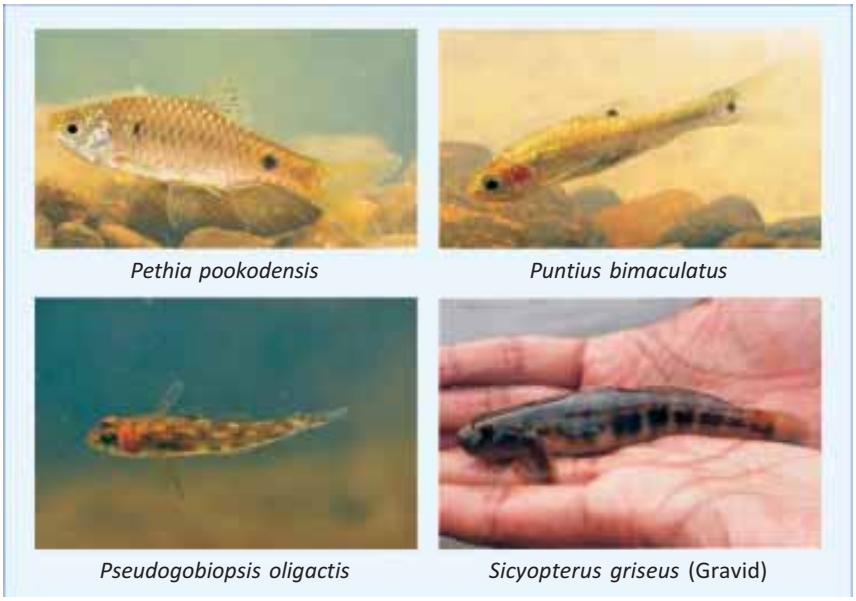
New records of fish species from Valapattanam River Basin

The Valapattanam has a length of 110 km and a catchment area of 1,321 km^2. Exploratory surveys were carried out in the River basin in Kerala and Karnataka to catalogue fish diversity. Intensive sampling was done in 13 locations, covering major tributaries of the River. The survey resulted in total yield of 49 freshwater fish species, belonging to 7 orders, 17 families and 34 genera, and 8 species of crustaceans. *Mesonoemachilus guentheri*, *Pethia pookodensis*, *Pseudogobiopsis oligactis* and *Puntius bimaculatus* represent new records from this river system. Collections indicated *Mesonemachilus guentheri* possessing wider distributional range than was reported earlier; being found throughout the middle reaches of the river basin. Specimens of *Mystus malabaricus*, *Schistura semiarmatus*, *Garra mcclellandi* and *Sicyopterus griseus* were found gravid, suggesting their spawning at the start of the monsoon.



Fish species recorded

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ICAR–Directorate of Cashew Research Puttur, Karnataka

To promote overall growth through enhancement of production and productivity in cashew

Cashew (*Anacardium occidentale*) is an exotic crop, originated from Brazil. It is said that cashew was introduced into India during the early part of 16th Century through Portuguese travellers in Goa.

In the beginning, cashew was introduced in the coastal ecosystem for afforestation of degraded hilly terrain. In early 1950s, research on cashew was initiated with the support of *ad-hoc* schemes of the Indian Council of Agricultural Research (ICAR); granted for Kottarakkara (Kerala), Ullal (Karnataka), Bapatla (Andhra Pradesh), Daregaon (Assam) and Vengurla (Maharashtra). In 1971, ICAR sanctioned an All-India Coordinated Spices and Cashew Improvement Project (AICS and CIP) with its Headquarters located at the Central Plantation Crops Research Institute (CPCRI), Kasaragod. The CPCRI Regional Station, Vittal (Karnataka), and four centres under the University (Bapatla, Vridhachalam, Anakkayam and Vengurla) were given the mandate to carry out research on cashew. During V and VI Plan periods, three more centres (Bhubaneswar, Jhargram and Chintamani) came under the fold of the AICS and CIP, and work of Anakkayam Centre was shifted to Madakkathara. In 1982, recommendations made by the Quinquennial Review Team (QRT), constituted by the ICAR ; working group on Agricultural Research and Education, constituted by the Planning Commission for VII Plan Proposals and

MANDATE

- To undertake strategic, basic and applied research for enhancing productivity, quality, processing efficiency and value-addition of cashew.
- To serve as the National Repository of genetic resources and scientific information on cashew.
- To coordinate All-India Coordinated Research Project on Cashew for addressing location- and region-specific problems.
- To promote capacity-building through transfer of technology and consultancy services to stakeholders.

Facts about Cashew

- India occupies largest area under cashew (18.2%) and contributes to 16.4% of world's cashew production; and stands at third place, after Vietnam (28.7%) and Nigeria (20.1%).
- India is the largest exporter of cashew kernel (approximate 1.5 lakh tonnes/annum), and the kernel quality of the Indian Cashew has a global repute.
- The share of cashew kernel in global tree-nut market is about 16%.
- India is the largest processor of raw cashewnut with a processing capacity of about 20 lakh tonnes.
- India produces 65 lakh tonnes of cashew-apple annually; of which hardly 4% is being utilized for processing.
- National average productivity of cashew is 706 kg/ha (2014-15) while countries like Vietnam, Madagascar, Mexico, Phillippines, Peru etc., productivity is > 2,500 kg/ha.
- In India, nearly 10 lakh people, especially women-folks, are engaged in cashew cultivation and processing.

the Task Force on Horticulture, constituted by the ICAR, resulted in the establishment of the National Research Centre for Cashew at Puttur, Dakshina Kannada, Karnataka, on 18 June 1986, which was upgraded as the ICAR-Directorate of Cashew Research (DCR) in 2009 under XI Plan. Consequent to bifurcation of the AICS and CIP, the Headquarters of the All- India Coordinated Research Project (AICRP) on Cashew was shifted to DCR, Puttur. At present, AICRP cashew is operating at 14 centres at major cashew- growing areas of the country.

Soil and Tissue Analysis Lab

INFRASTRUCTURE

The main campus is spread over 68 hectares with Field Experimental Blocks and Laboratory-cum-Administrative Building. It also has an Experimental Station of 80 hectares at Shantigodu, Puttur, 12 km away from its main campus.

The Directorate also has a well-established Library, Conference Hall, Committee Rooms, Museum, Insectory, Growing Structures, Nursery, Guest House etc. Besides, separate Project Coordinator Cell, AKMU, PME Cell, ITMU and Hindi Cell are also functioning.

Experimental Station, Shantigodu

Plant Protection Lab

The Directorate has five major research disciplines – Crop Improvement, Crop Production, Crop Protection, Post-harvest Technology and Transfer of Technology. Institution's major laboratories are Horticulture, Plant Physiology, Biochemistry, Plant Breeding, Biotechnology, Soil Science, Entomology, Pathology, Post-harvest Technology and Audio-visual Laboratory.

SALIENT ACHIEVEMENTS

Country-core collection centre for cashew: The Directorate has the largest germplasm accessions (539); conserved in the National Cashew Field Gene Bank (NCFGB) at Puttur. It is also considered as the National Active Germplasm Site (NAGS) for cashew. A total of 476 cashew accessions have been assigned with the National

Myths and Facts about Cashew

- **A crop of coastal region:** Initially, cashew was adopted as a plant for afforestation on the coastal degraded lands. But realizing the importance, it is being grown in wide agroclimatic zones of the country, except temperate region and frost-prone areas.
- **Cashew increases body cholesterol and body weight:** General believe is that cashew is rich in cholesterol and its consumption may increase body weight. But fact is that it has a desirable fat ratio 1:2:1 of saturated, monounsaturated and polyunsaturated, respectively, ideal for optimal health.
- **Cause of heart problem:** It was believed that eating cashewnuts increases low density lipoprotein (LDL) and accumulation of triglycerides, hence unhealthy to heart. But eating cashewnuts decreases LDL and triglycerides and the nuts have got cardio-protective bioactive constituents — phytosterols, tocopherols and squalene.
- **Leads to high blood pressure:** Cashewnuts are low in sodium and high in potassium, and thus keep blood pressure under check.
- **Promote stone formation:** Studies have suggested that daily intake of cashewnuts can reduce risk of developing gallstones up to 25% in healthy human-beings. In fact, cashew (roasted form) has high oxalate (262 mg/100g), and when oxalate combines with Ca forms calcium oxalate, which is one of factors for kidney stone. Hence, the kidney patients suffering due calcium oxalate-containing stones are advised to limit their intake of oxalate-containing foods.
- **Healthy for diabetics:** Cashew is mild in sugar content, and thus eating cashew and other nuts have beneficial effect on those with diabetes or at risk for diabetes.

Collection numbers (IC). The institution has characterized finger-printing of 473 germplasm accessions and brought out five catalogues, which could be a potential resource for breeders.

National Cashew Field Gene Bank at Puttur

Development of varieties/hybrids: Three varieties have been released for cultivation in the West Coast region – NRCC Selection 1, NRCC Selection 2 and Bhaskara, which are high-yielding and medium nut types. Among them, Bhaskara is less affected by tea mosquito bug (TMB) as it has mid-season flowering habit (Dec-Mar) with a flowering duration of 60 days. And NRCC Selection2 is a semi-dwarf and prolific bearing variely, suitable for high-density planting.

Popular cultivar Ullal 3

Popular cultivar Vengurle 4

Under systematic hybridization, hybrid H 126 and H 130 have been found promising for bold nut character. Notably, both hybrids have been categorized as jumbo nut types, as the average nut weight is about 11-12 g. **These hybrids are suitable for export with premium nut grade of W150.**

Bhaskara Variety

High-density planting: A high-density planting (HDP) technology with a spacing of 4m × 4m (625 plants/ha) instead of 8m × 8m (156 plants/ha) has been developed

Impact of Technologies

Varieties released by the DCR are well adopted by the farmers. Impact on adoption of DCR cashew technologies in the Dakshina Kannada indicated high adoption index (>70), scored by institute recommended varieties and planting cum initial care technologies. Farmers realized highest yield (4.73 kg/tree) and maximum productivity (737.88 and 1,882.54 kg/ha, both under normal density as well as high-density planting, respectively) from variety Bhaskara than other varieties grown in the region.

Profuse fruiting in cashew

Cashew + elephant foot yam

to increase cashew yield by 2.5 folds during the initial ten years. The nutrient and water requirements for the HDP have been standardized. Interestingly, only 50 % of the recommended dose of fertilizers (500 g N and 125 g each of P and K /tree/year) is required for HDP system.

Nutrient requirements: Besides, recommended dose of fertilizers (500:125:125 g NPK/tree/year), foliar spray of major nutrients (3% urea + 0.5% H_3PO_4 + 1% K_2SO_4) and secondary and micronutrients (0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$) indicated positive effect on the number of bisexual flowers/panicle, number of panicles/tree, number of nuts/tree and nut yield/tree. Foliar spray of major nutrients resulted in 16.1%

Application of fertilizers in circular trench

increase in nut yield, while secondary and micronutrient sprays resulted 30.5% higher yield.

Irrigation requirements: The optimal rate of drip irrigation was 36 L/day from December to January and 48 L/day from February to March to meet 60 % of the cumulative pan evaporation. Irrigating cashew at 60-80 L of water/tree once in four days through drip, after flowering till fruit-set and development, in combination with 750: 187.5: 187.5 g of NPK /tree/annum doubled yield of cashew in the West Coast of Karnataka.

Intercropping: Intercrops in cashew orchards such as pineapple, amorphophallus, turmeric, brinjal and chillies were profitable. Pineapple in cashew orchard increased cashew yield in addition to the pineapple yield (21 tonnes/ha for the first five years). Trenches for pineapple planting act as a soil-and-water conservation measure for cashew orchard.

Glyricidia as a green-manure crop during initial years of cashew contributed to 6.75 tonnes of dry matter /ha; equal to 186 kg N, 40.8 kg P and 67.8 kg K/ha. The organic carbon content was highest (0.98%) in cashew plots with *Glyricidia* and lowest (0.50%) when cashew was alone.

Recyclable cashew biomass (RCB) can be converted to enriched vermicompost in the ratio of 3:2.25. RCB can be composted initially for 20 days by adding 15% cow-dung slurry and using earthworm *Eudrilus* sp. The recovery is 65-75 % within three months.

Softwood grafting: The grafting technique was standardized for mass multiplication of quality-planting

Cashew + pineapple intercropping

Production of quality planting material

Cashew tree infested with TMB

material of cashew. Application of microbial inoculants i.e. *Azospirillum, Pseudomonas,* phosphate solubilizing bacteria 5 g each and arbuscular mycorrhizal fungi 2.5 g per poly bag containing 2 kg of potting mixture for cashew rootstocks resulted in production of healthy grafts in the nursery and their better establishment in the field.

Every year about 1.5 lakh grafts of recommended varieties are produced and distributed to farmers and other developmental agencies. The DCR, Puttur, nursery has been rated as one of the four star nurseries by the National Horticulture Board, Government of India.

Soil- and- water conservation techniques: They have direct impact on cashew productivity as most of the cashew plantations in India are on the degraded lands and in rainfed areas. Crescent bund and staggered trenches with coconut husk burial conserved soil moisture, lowered annual run off by 14 % and increased cashewnut yield by 30-40 %. Terrace with crescent bund for individual cashew- tree base was best measure for cashew grown on slopes.

Cashew stem and root borer (CSRB) management: In CSRB infestation, gum and frass start oozing out from the tree; which is the initial symptom of pest attack for taking up curative measures. As the pest incidence occurs during the period of nut collection (Feb. to May), the infested trees can be marked suitably for subsequent treatment. The infested portion should be carefully chiselled off to kill grub or pupa. Later Chlorpyriphos (0.2%) solution should be swabbed or sprayed over the portion. Trees in which more than 50% of the bark circumference is damaged and/or with yellowing of the canopy, they do not recover. Hence, they should be disposed of immediately. Regular adoption of phytosanitation by removal of dead CSRB-infested trees and those beyond recovery is essential to reduce pest inoculum.

Management of tea mosquito bug (TMB): Both adult and nymph of TMB suck sap from tender shoots, panicles and immature nuts and apples, resulting in formation of black necrotic lesions. In outbreak situations, timely spraying should be taken up to manage the pest.

The insecticides recommended are Monocrotophos (0.05% i.e., 1.5 ml/L)/Imidacloprid 17.8 SL (0.6 ml/L)/ Acetamiprid 20 SP (0.5 g/L)/L-Cyhalothrin (0.003%)/ Profenophos 50 EC (0.05%) during flushing stage and L-Cyhalothrin (0.003%)/Triazophos 40 EC (1ml/L)/Profenophos 50 EC (0.05%) during flowering/fruiting stage.

Record of pollinators and other fauna: The hymenopteran bees (*Pseudapis oxybeloides, Lasioglossum* sp., *Braunsapis* sp. and *Homalictus* sp.) are major pollinators in cashew. The predatory fauna recorded include, 115 spider species, 17 reduviid species, 49 ant species, 16 praying mantid species, 3 species of coccinellids, anthocorid bugs, Geocorid bugs, lace-wing flies, mantispid flies, pentatomid bugs, syrphids, robber flies etc. Among them, *Oecophylla smaragdina* (red ant), *Panthous bimaculatus* (reduviid), Salticidae spiders and *Euantissa pulchra* (praying mantid) are predominant ones. Occurrence of tropical tassar silkworm, *Antheraea mylitta* Ecorace KE-02, on cashew and its feasibility of rearing have also been documented.

Post-harvest machinery: *Radial arm-type cashew kernel extractor:* The machine was designed to operate while in sitting posture, thereby reducing operator's drudgery. It has 9.3 kg/ h operational capacity and 88.1% quantitative efficiency. Patent application has been filed for this (1589/CHE/2007).

Rotating drum-type roasting machine: It is a compact machine for processing raw cashewnuts. A patent application has been filed for this technology (3843/CHE/2013).

Radial arm-type cashew kernel extractor

Dual-mode dryer: It is suitable for drying rain-affected raw cashewnuts. Time required to reduce moisture from 20.44 % d.b. to safer level (8% d.b.) varied between 3.0 and 4.5 h, and energy utilized during the process worked out as 32.93 MJ/ kg for electrical power and 201.71 MJ/ kg for thermal power.

Hydraulically operated cashew-apple juice extractor: It has juice extraction efficiency of around 82%.

Concentric drum-type rotary sieve grader for raw cashewnuts: Operational capacity of grader is around 300 kg/ h and the grading efficiency is 95.2 %. Cost of grading was ₹0.70/kg of raw cashewnuts.

Rotating drum-type roasting machine

Value-addition of cashew apple: (i) After dehydration cashew-apple powder can be made and this can be blended up to 20% with cereal flours (rice, ragi and wheat) to get fibre and antioxidant-rich flour blends, which could be stored up to 4 months at ambient temperature without affecting antioxidant activity. (ii) Cashew-apple treated with sodium chloride at concentration of 2 to 10% over a period of 5 days in the presence of potassium metabisulphite (0.6 g/L) resulted in cashew-apple powder with lower tannin content. (iii) Cashew-apple Cider obtained from apple juices of different cashew varieties showed superiority over individual one; it was with 3.5-5.5% alcohol (v/v). (iv) Cashew-apple ready to serve (RTS) beverage, prepared from cashew-apple juice, blended with 3% lime juice, has been found acceptable.

Cashew products

Value-addition in cashew kernel: Organoleptic studies have revealed that sweetened cashew kernel baby-bits coated with honey and combination of cardamom flavour and apple-green colour are most preferred.

FUTURE THRUSTS

- Development of varieties tolerant to biotic stresses (major pests and diseases) and abiotic stresses (drought, salinity, waterlogging and low temperature) coupled with high yield. Emphasis needs also to be given for development of varieties suitable for high-density planting and processing (cashew-apple).
- Enrichment of cashew germplasm repository and its utilization for introgressing desirable traits in new varieties.
- Identification and utilization of molecular markers for qualitative and quantitative parameters for crop improvement programme.
- Identification of promising rootstocks and *in-vitro* multiplication of them for commercial varieties/hybrids.
- Improving productivity and quality of cashew by increasing input-use efficiency in different agro-ecological regions.
- Development of organic-farming modules for production of cashew with a view to increase demand for both domestic and global markets.
- Development of cashew-based cropping systems for better resource-use efficiency.
- Development of Integrated Pest Management (IPM) strategies for major pests of cashew, involving semio-chemicals and bio-control agents.
- Monitoring of new pests and diseases with changing climate and devising management strategies.
- Focusing on solar-based cashewnut-processing system, value-added products and biofuel from cashew-apple; enhancement of Industrial application of cashewnut shell liquid, alternate utilization of by-products of cashew industry and exploration of cashew-apple pomace as animal/fish-feed.

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Ready-to-eat green chickpea flakes

Chickpea (*Cicer arietinum*), also called as garbanzo bean or Bengalgram, is world's third most important pulse crop, next only to dry bean and fieldpea. It is considered as the best hypocholesteremic agent among legumes. Traditionally, chickpea is processed in the following ways – soaking, sprouting, steaming, roasting, flaking, dehulling and splitting, and grinding.

Chickpea-grains of cv. Pusa Green 112 remain green even after maturity. It is a high-yielding *desi* green-seeded chickpea with high resistance to *Fusarium* wilt and drought. Its average yield is 2.3 tonnes/ha; with a yield potential of 2.7 tonnes/ha. Its seeds are dark-green, uniform and excellent for cooking and culinary purposes. It can prove to be promising for marginal farmers as it has multiple stress resistance. But green colour of grains turns dark on exposure to heat,and this leads to deterioration in the quality of the product. A suitable processing strategy was explored to develop ready-to-eat flaked product with retention of green colour.

Soaked grains in water at 60°C temperature till their moisture content was 30%, which was optimum for flaking chickpea- grains with colour retention. Heat treatment of soaked chickpea- grains using 18W/g microwave power for 3 minutes exposure time was found suitable for flaking ; especially for green colour retention, least trypsin inhibitor activity and least broken grains. Roasting of soaked-heat treated-flaked chickpea at 46.1 W/g microwave power for 1 minute exposure was perfect to retain colour and for least broken content and trypsin inhibitor activity. The protein, fat and ash contents in the ready-to-eat flakes were 22.12%, 6.43% and 3.62%, respectively. Organoleptic trials have shown good acceptability of the product. The product can be made tasty with different spices as adjuvants.

Commercial production of this product can be with the initial investment (machinery) of approximately 2.5 lakh. Economic analysis of product manufacturing indicated break- even point at 5,700 kg of production and payback time of less than a year; and thus this has a potential to be a profitable venture.

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Bhura delicious apple — Kumaun region farmer's variety

In block Ramgarh, district Nainital, many varieties of apple are being cultivated in the orchards, which were introduced by Britishers, but one of them is the most popular, named *Bhura delicious*; also popularly known as D.K delecious apple.

In apples, mostly propagation is by tongue-grafting technique, but it is different for *Bhura delicious*. Five decades ago, seeds of Richard red delicious were sown in the nursery; and only one seedling germinated. After 3-4 years, the medium -sized tree fully loaded with apples in village Lodh, block Ramgarh, Nainital, Uttarakhand, was the centre of attraction. The fruits closely resembled Delicious, but were pale in colour; not true-type Red delicious. In due course of time *Bhura delicious* was acclimatized from sub-temperate to temperate climate and was better than Red delicious, Golden delicious, Richard delicious, Red golden delicious, Fenny, King David, Binoni, Early sunberry, Rymar, Hara pichola, Amri, Tom king and Backinhum.

Bhura delicious has good taste, sweet aroma, oval shape, glossy outer skin; and this apple is the best among all and fetches good price in the local market.

Bhura delicious tree: fruiting stage

Glossy and tasty fruits of *Bhura delicious*

It is called *Bhura delicious*, but basically it was named D.K Delicious (Dekar Singh and Kundan Singh) after the name of the farmers who produced and popularized it, grown in their orchards and provided grafted plants to other farmers for large-scale cultivation. Another story behind D.K Delicious (*Bhura delicious*) was that during 1965-1970 in village Khaprad, block Ramgarh, district Nainital, Uttarakhand, Dekar Singh and Kundan Singh had procured some red coloured apple-plants and had grown them in the village. Later these apple-trees bore fruits with pale-red spots or splashes on green colour fruits. These fruits had unique aroma, light sour-sweet taste and every year tree grew well with prolific fruit-bearing. After watching good growth and heavy fruiting in *Bhura delicious*, some farmers of village Lodh and Galla took scion woods of such plants and grafted on *Pore* or *Biju* plants of *Malus baccata,* locally called *moli* (a wild relative of apple). Such grafted plants started fruiting after 3-4 years. In lower submontane zone (1,200-1,800m) where snow fall was moderate in comparison to montane zone of 1,800-2,200m asl, the colour of the fruits was different and yield was higher, while the size was almost similar to as delicious. So people called it "Bhura *rang ka dana*" (brown coloured fruit), and after so many years, it is still famous as *Bhura delicious*.

The Village Chipa is located at 2,200 m above sea level. Due to high snowfall and low temperature, in this ripening of fruits is late; and in lower area (1,200-1,800m asl), where climate is cold, but amount of snowfall is low, ripening is early. It is very much suitable for submontane zone of the Himalayas. The shining colour of the fruit is the main attraction in the local market. The total amount of soluble sugar (T.S.S) was recorded between 16and18%; average weight of five fruits was 700 g; weight of one fruit ranged between 100 and 160 g. In early stage of 4-10 years, fruit production was 1.5-2.5 quintal/plant/year, and after 25-30 years fruit yield has increased to 3.5-4.5 quintal/plant/year. Plant height is between 6 and 8m. Early in flowering (flowers bloom in month of April) and self-pollinated character make *Bhura* delicious a desired choice among local farmers. Its pollination is not affected by rainfall and frost, and fruits ripen in August to September. The villages like-Lodh, Galla, Supi, Meora, Satbunga etc are producing variety in a large amount, and even the plants are also produced for sale.

In five acre of land (100 *nali*, 1 *nali*= 200 sq.m.), almost 900 plants are planted. The main developer of *Bhura delicious* is Diwan Singh of the village Lodh. This variety is totally based on Indian taste; neither sweet nor sour but full of aroma. In the past those plants, which were planted by Britishers, were sour in taste, but by Americans were sweet in taste.

On the basis of size, taste, shine or glossy in nature, shape, was aroma, yield and market demand, the *Bhura delicious* is liked by natives. It has become one of the popular farmer's varieties in Ramgarh hills of Kumaun region of Uttarakhand.

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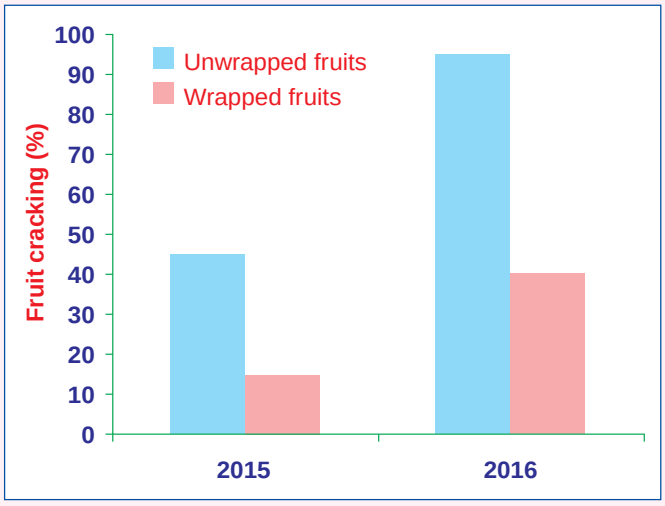
Managed fruit cracking in *bael*-fruits with cling film

Fruit cracking is one of the major problems in *bael* (*Aegle marmelos*) cultivation under arid environment. Average losses owing to fruit cracking were observed as high as 50%, depending on the environment. In general, cracking

Multiple (wider and deeper) cracks in unwrapped control fruits

occurs as the result of excessive water absorption by fruits; within the fruit, mesocarp expands but epicarp does not and so cracking happens.

To stop fruit cracking, necessity was felt to provide an external mechanical support to epicarp. 'Cling film' is a plastic packaging, very thin polyethylene film, which upon wrapping around the fruits adheres to their surface and serves as an extra covering.



Severity of fruit cracking in *bael*

Bael-fruits of cv. Narendra Bael 9 were firmly wrapped with cling film in the last week of January 2015 and 2016 at the experimental farm when fruits were still developing on the trees. Wrapping reduced fruit cracking in both the years. Occurrence of heavy hail storm also resulted in unprecedented fruit cracking in *bael*, but cling film wrapping lessened it. Almost 60% fruits were saved due to wrapping; in control fruits, cracking was noted to the extent of 95%. Severity of cracking on individual fruits was more intense (multiple cracking with wider and deeper cracks) in unwrapped control fruits.

Besides reduced fruit cracking, wrapping has several other merits over unwrapped such as reduced decay from secondary infection, delayed senescence and improved

Single and thin crack on affected wrapped fruits

Phytochemical constituents and antioxidant activities of *bael* fruits

Attributes	Wrapped fruits	Unwrapped control fruits
Soluble solid content (^{0}Brix)	33.16a*	33.79a
Acidity (%)	0.11b	0.15a
Ascorbic acid (mg/100g)	14.38a	12.46b
Carotene (IU)	1238.27a	1095.59b
Total phenolics (mg/g FW)	19.26a	15.74b
Flavonal (mg/g FW)	3.18a	2.39b
Total flavonoids (mg/g FW)	15.37a	12.61b
O-dihydric phenols (mg/g FW)	0.31a	0.23a
Total antioxidant activities (CUPRAC; µM TE/g)	98.07a	91.38b
Total antioxidant activities (FRAP; µM TE/g)	85.61a	81.53b

* Row values followed by the same letter are not significantly different.

shelf-life. Wrapped fruit could be stored for 03 months after harvest (i.e. till 3rd week July) under ambient conditions compared to unwrapped control fruits, which need to be consumed within 7-10 days of usual harvest made during mid-April. Use of cling film also improved appearance; as fruits developed uniform attractive colour within 5-7 days after removal of cling film at the ambient conditions. In addition, wrapped fruits also registered higher antioxidant content.

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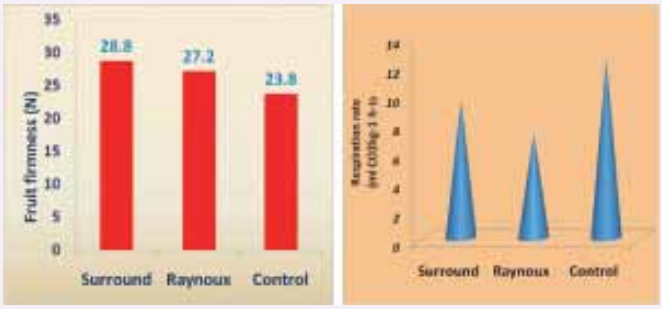
Particle-film technology ensures good colour development and improves quality of apples

With increasing awareness among consumers about harmful effects of residues of chemicals and pesticides, there has been a persistent search for developing some alternative approaches to reduce use of toxic chemicals. Development of a processed particle film technology (PFT) is one of them. It requires development of aqueous formulations from chemically inert mineral particles; specifically formulated for fruit coating as protective films. Many countries have commercialized films such as Surround, Raynoux, Eclipse, Cocoon, Parasol, Anti-stress-500, Purshade, Screen, but there was no report from India. Thus two films (Surround and Raynoux) were imported, and a systematic study was done on their effects on Royal Delicious apple.



Fruit firmness and respiration rate of PF-treated and non-treated apples

Three sprays each of Surround (3%) and Raynoux (1%) were given to apple-trees at fortnightly interval at Katrain (Himachal Pradesh), starting from 15 June 2015. All routine cultural practices were followed except use of fungicides and insecticides. Apples were harvested on 18 August 2015, and observations were regularly recorded. Results indicated that particle films (PFs) delayed maturity of apple-fruits, and Surround-treated apples developed very good red colour (Hunter 'a' value=52.4±0.2) than Raynoux treated or untreated (Control) fruits. Surround-treated apples were firmer and with better total soluble solids than untreated fruits, and they stayed longer under room condition. PF-treated apples' phenolics and antioxidant activity were higher. The incidence of Sanjose scale and apple scab was drastically reduced by Surround spray but no effect was observed on woolly apple aphid

Colour development in Surround-treated and untreated Royal Delicious

Advantages of Particle Films

- These films are developed from kaolin-based material, hence no risk of residue.
- The films are very easy to apply in the field.
- They are farmer-friendly and envoronment-friendly.
- Use of these films brings effective control on important insects and diseases of apple and also stops damage by birds.
- They improve fruit colour and thus attract consumers.
- Help maintaining firmness of fruits and thus increases shelf-life.
- There is a significant improvement in fruit size of apples.

Storage disorders of apple: Bitter pit and brown core

Effect of particle films on maturity, shelf-life, colour and quality of Royal Delicious apples

Particle film	Maturity date	Hunter 'a' value	Total phenolic content (mg/100 ml GAE)	Antioxidant activity (µM Trolox/ml)	Total soluble solids (%)	Shelf-life (days)
Surround	17th August	52.4±0.2	112.5±3.6	15.2±1.2	14.6±0.1	28
Raynoux	12th August	46.3±0.3	110.5±3.8	12.6±1.6	14.0±0.2	32
Control	8th August	33.2±0.2	99.5±4.2	10.4±1.5	13.2±0.2	21

Influence of particle films on insect-pests and diseases in apple

Particle film	Sanjose scale	Woolly apple aphid	Apple scab
Surround	2.8±0.4%	7.6±0.2%	2.2±0.4%
Raynoux	2.1 ±0.4%	2.6±0.3%	2.8±0.3%
Control	29.4 ±0.3%	7.8±0.2%	16.4±0.6%

over untreated fruits, although Raynoux reduced significantly its incidence. During storage, Raynoux as well as Surround-treated apples were with lower incidence of bitter pit,water core and brown core. It is presumed that this technology can become an integral part of organic apple production in India.

Storage disorders in PF-treated *vs* non-treated apples at the end of six months' cold storage

Particle film	Incidence of post-harvest disorders (%)		
	Bitter pit	Brown core	Water core
Surround	1.8±0.05%	2.3±0.3%	4.1±0.4%
Raynoux	1.2±0.05%	1.2±0.2%	2.2±0.2%
Control	16.2 ±0.4%	8.8±0.2%	11.2±0.3%

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Tribals' initiative in apple orchards for enhancing their livelihood security

Kinnaur district of Himachal Pradesh, stretching up to Tibetan border in the south-eastern Himachal, is a tribal district, representing dry temperate ecosystem. In this, apple farming has emerged as a major livelihood source for tribals. Almost 78% of the local people are involved in apple farming; accounting for over 27% of the total geographical area. The area under apple cultivation in 2015 in the district reached to 10, 828 ha with a production of 75,201.8 tonnes and it generated revenue of ₹280-300 crore in the GDP.

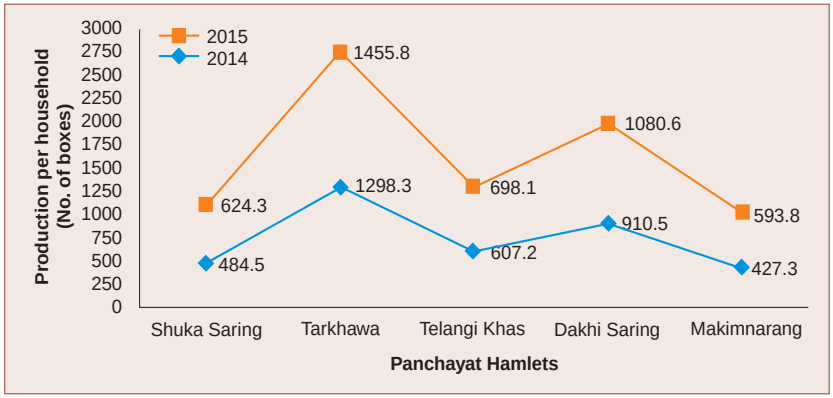
Normal apple production was between 2 and 2.2 million apple boxes (20- kg capacity), which was 6-7% of State's total yield, and productivity ranged from 6 to 11.5 tonnes/ ha. Consequences of the climate change are visible in this typical ecosystem; present variable production responses in apple are due to current status of pollinizer: variety ratio and available pollinator (Indian honeybee) density.

The study conducted in three development blocks of the district — Pooh, Kalpa and Nichar— revealed scarce availability of pollinizers to main variety (1:14 to 1:17) in the orchards. Habitat loss, land-use changes, apple dominated farming and excessive and indiscriminate use of pesticides resulted in huge losses of native pollinators. Due to fluctuating temperature during the critical period, particularly rains accompanied by low temperature, pollen transfer was inhibited because of restricted activity of bees. Apple flowers are killed below –2.2°C and bee activity completely stops below 4.4°C.

Pollination by honey-bees *Apis mellifera*

A scientific intervention on managing pollination in apple orchards was carried out in Gram Panchayat 'Telangi' District Kinnaur, Himachal Pradesh, to demonstrate its effect on crop productivity at the community level.

Thirty farmers of the 'Telangi' Panchayat were initially imparted a 5 days hands- on- training on 'Honey bees handling and hive management'. A Village committee named as Village Climate Risk Management Committee (VCRMC) was constituted for coordination with the KVK. A total of 60 colonies of honeybees (*Apis mellifera)* were provided to the Committee; and a total of 184 households inhabited in 923 ha having land holding of 0.44 ha were



Apple production in different hamlets of Panchayat after managed pollination

Post managed pollination fruit-setting and yield

motivated through various skill development programmes. This motivation encouraged them to contribute to 50% of the total intervention cost.

The 'VCRMC' comprising 13 members was involved in managing bee-colonies and for issuing instructions particularly on pesticide application on the apple orchards from time to time.

A total of 110 hectares falling under apple cultivation mapped through GPS for placement of bee-hives established a requirement of 120 colonies for pollination at the onset of flowering.

The experiment was carried out by placing *Apis mellifera* colonies in apple orchards in such a way that each colony covered a hectare of orchard at the time of 10 % flower-opening and observations were recorded on various qualitative and quantitative parameters pertaining to effect of honey-bee pollination on the apple- crop. Ten branches of one metre length on different sides of the plant were selected randomly within 25 metres of honey-bee colonies for observations. In natural pollinated orchards, selected at a distance of around 2km, observations were recorded.

The impact of managed bee pollination was assessed in terms of fruit-set, fruit drop and qualitative characters with natural pollination, with honey-bees and honeybees plus pollen dispenser. In bee-pollinated plants, fruit-set was more (21.2%) than natural pollinated trees (11.7%). Similarly, a significant ($p > 0.01$) reduction in fruit drop in honey-bee pollinated (26.5%) over the naturally pollinated (17.9%) orchards was recorded. The mean fruit weight was more (158.8 g) in natural pollinated compared to honey-bee pollinated, and mean length of fruits was 6.15 and 6.66; and breadth was 6.77 and 7.01 cm, respectively.

The scientific intervention in the apple-orchards over 110 hectares resulted in i) an average enhancement of 19.44% in apple-fruit yield and of ₹17,496/ family income; ii) Panchayat has at present its own apiary for pollination of the orchards and honey production; iii) A bulk of around 3.0 quintals of honey was extracted till the end of January 2016.

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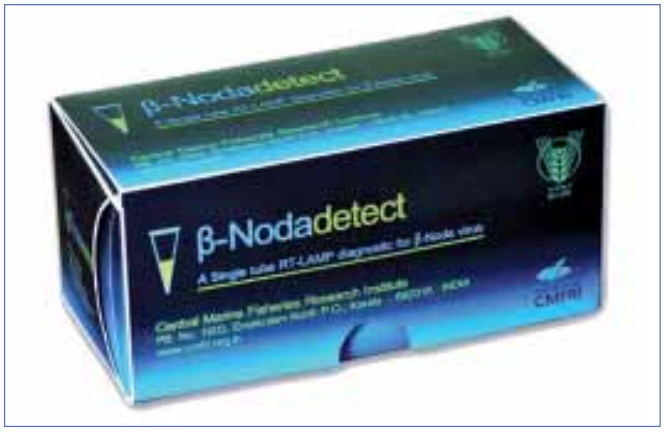
β-Nodadetect — A single tube RT-LAMP diagnostic for β-Noda virus in fish

Beta-Noda virus causes Viral Nervous Necrosis (VNN), also known as Viral Encephalopathy and Retinopathy (VER), in larvae and juveniles of marine fin-fishes; resulting in mass mortalities. No effective treatments were available, and those fishes surviving the infection became the carriers of the virus, facilitating vertical and horizontal transmission. Hence only preventive measures, like vaccination, regular screening of broodstock, eggs, larvae and fingerlings, besides effective disposal of positively diagnosed specimens, were the options available to prevent disease outbreaks. A single tube reverse transcription-Loop – mediated Isothermal Amplification (single tube RT-LAMP) kit named β-Nodadetect for the detection of β-Noda virus in the infected fish has lately been developed. The kit is highly specific, sensitive and rapid

β-Nodadetect kit in comparison to other fish disease diagnostic kits

β-Nodadetect (RT-LAMP)		RT-nested PCR	
Steps involved	**Approx. cost**	**Steps involved**	**Approx. cost**
RNA isolation, RT-LAMP	₹ 390/reaction	RNA isolation, RT-PCR, 1st Step PCR, Nested PCR, Agarose gel electrophoresis	₹ 644/reaction
Equipments required	**Approx. cost**	**Equipments required**	**Approx. cost**
Refrigerated centrifuge, Water bath	₹ 4.5 Lakh	Refrigerated centrifuge, Thermal cycler, Trans UV illuminator, Power pack, Horizontal electrophoresis unit	₹ 12 Lakh
Steps involved	**Time requirement**	**Steps involved**	**Time requirement**
RNA isolation, Reaction preparation, RT-LAMP	2 hours 15 minutes	RNA isolation, Reaction preparation, RT-PCR, 1st Step PCR, Nested PCR, Agarose gel electrophoresis, Trans UV visualization	6 hours 20 minutes



β-Noda virus kit

and can detect a single copy of virus in less than one hour. Positive reaction is diagnosed by a green fluorescence that can be visualized by naked eye under visible or UV light (using protective goggles), and there is no need for sophisticated equipment like a thermal cycler or trans-UV illuminator, as for other molecular diagnostic approaches.

The kit is mainly intended to screen marine broodstock fish to ensure certified specific pathogen-free eggs and larvae in a sensitive and rapid way. It would help timely identification of β–Noda viral infections in fish hatcheries and aquaculture systems during routine screening of eggs, larvae, fingerlings before shipping and/or stocking in aquaculture systems. It would also be useful for screening trash fish used as feed for cultured fishes to prevent horizontal disease transmission. The hatchery production of marine fish seeds is economically important in the context of enhanced marine fish seed requirements, arising out of increasing popularity of cage culture for marine and brackishwater fishes along the Indian coast. The kit would be of considerable application in timely diagnosis and controlling spread of disease in marine culture systems.

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WAY FORWARD

At present, livestock sector contributes to about 25% of the agricultural GDP in the country. Nonetheless, frequent livestock-human associations have also paved the way for spread of zoonotic diseases; and today zoonoses have become a major threat to humankind. For instance, 60% of 1,415 microbial diseases reportedly affecting humans are zoonotic. Among the emerging infectious diseases, 75% are zoonotic with wild animal vectors—for example Ebola virus, severe acute respiratory syndrome (SARS) coronavirus, Middle East respiratory syndrome (MERS) virus, Nipah and Hendra virus are through bats. In India, recent emergence of Crimean Congo haemorrhagic fever (CCHF) has also posed a great risk of epidemics. Rabies, brucellosis, leptospirosis, anthrax and tuberculosis in livestock are zoonotic, and incur huge losses to economy of the country, besides affecting human and animal health. Repeated occurrence of highly pathogenic avian influenza, caused by H5N1 strain of type 'A' influenza, and swine flu, caused by H1N1 strain, spread of Japanese encephalitis to newer area, Kyassanur forest disease (KFD) in Karnataka and Kerala, and rickettsial infections like scrub typhus from different parts of India, raise concerns.

Dr T. Mohapatra, Secretary (DARE) and Director General (ICAR)

A substantial susceptibility to food-borne zoonoses is due to increased demand for food. Cultural and farming practices such as stocking rates, mixing of species, methods of confinement, feeding, lack of proper implementation of disease control methods, weak veterinary infrastructure and insufficient public-private partnerships for desired support serve to spread zoonotic diseases in livestock. Further, slaughtering practices and contaminated environment along with unhygienic conditions during processing, packing, transportation and storage of food products accelerate occurrence of food-borne disease outbreaks. Realizing the issue, the Food Safety and Standards Authority of India has been established under the Food Safety and Standards Act, 2006, as a statutory body for laying down science-based standards for articles of food and regulating manufacturing, processing, distribution, sale and import of food.

While the National Standing Committee on Zoonoses (SCZ), formed by Government of India, recommends policies, operational research and inter-sectorial collaboration; R&D Institutions like National Centre for Communicable Diseases, Indian Council of Medical Research, Wildlife Institute of India (WII), International Development Research Centre, World Health Organization, International Livestock Research Institute and Indian Council of Agricultural Research are all involved in research, education and extension activities on zoonoses. The Public Health Foundation of India (PHFI) gave a Road Map to Combat Zoonoses in India. In the last 2 years, the ICAR has intensified discussions with the ICMR for control of zoonoses, and has enabled a platform for 'One Health' partnership with a proposal to establish a National Institute on Zoonoses.

The ICAR has developed many diagnostic kits for prevention and control strategies — ELISA kits for diagnosis of brucellosis in small ruminants and bovines; lateral flow assay and one flourescent polarization based differentiation between infected and vaccinated animals assay for diagnosis of brucellosis. The Council has also an outreach programme on zoonoses coordinated by the Indian Veterinary Research Institute in collaboration with 17 other institutions. Reliable diagnostics have been developed and improvized for serodiagnosis of Japanese encephalitis in swine and of leptospirosis, besides molecular diagnostic assays for species-specific detection of *Cryptosporidium parvum* in bovines and partial DNA chip/ microarray for para TB. The ICAR-NIVEDI (National Institute of Veterinary Epidemiology & Disease Informatics), Bengaluru, is providing policy advocacies on surveillance, vaccination, human-resource development and sero-monitoring under its National Brucellosis Control Programme. A National Animal Disease Referral Expert System (NADRES) has been developed by the NIVEDI to have location-specific understanding and forecasting of epidemiology.

The ICAR institutes also organize public awareness camps and human-resource development through periodic capacity-building training programmes for laboratory diagnosticians and researchers working at various central/ state diagnostic laboratories.

Timely diagnosis of pathogens in suspected samples would assist concerned health agencies in effectively combating emerging infectious diseases. In this regard, geographical information systems (GIS) and global positioning systems (GPS) gain relevance to facilitate monitoring, surveillance and prediction/forewarning of diseases. It is envisaged that climate change has aggravated spread of zoonotic diseases. The Council is all set to enhance communication across disciplines and organizations to converge its efforts towards 'One Health' and to provide a vigilant and robust system to address challenges associated with zoonotic diseases to enhance production and productivity of livestock sector vis-à-vis public health.

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