Volume 24 No. 1 ISO 9001:2008 Organization ISSN 2394-3289 January-March 2018

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ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

New interventions from IIHR

Biological insecticide – *Beauveria bassiana*

Brinjal weevil *Myllocerus subfasciatus* has assumed serious dimension in the recent past. Farmers resort to indiscriminate use of chemicals with very little effect. A non chemical method for the management of this serious pest using microbial bio-pesticides was developed at ICAR-IIHR. A field study on efficacy of microbial pathogens viz., *Bacillus* sp and *Beauveria bassiana* has been carried out. Drenching of the root zone with the microbial suspensions @ 1×10^8 spores/ml was initiated on spotting of terminal leaf damage by the adult insects. It was found that there was a significant reduction in the terminal leaf damage in treated fields while in control the leaves were completely defoliated by the feeding of the adults. In the treated fields the damage varied from 0 to 10% only. The liquid formulation of *Bacillus* sp and Wettable Powder formulation of *Beauveria bassiana* with more than 12 months shelf life has been developed.

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Control of root-knot nematodes on tomato

Many farmers in India have found the infestation of the root knot nematode (*Meloidogyne incognita*) on tomato in serious form and are loosing their crops. The farmers resort to use of carbofuran with very little effect. Use of bio-pesticides was found very helpful for the management of tomato. In this direction, the research carried out at IIHR led to the development of bio-pesticide formulations with nematicidal properties. They are *Bacillus subtilis* 1% A.S and *B. amyloliquefaciens* 1% A.S. In tomato (cv. Shivam), substrate treatment with *Bacillus subtilis* or *B. amyloliquefaciens* 1% A.S. @ 5 ml/kg cocopeat in pro-trays and soil application of 5 tons of FYM enriched with either of them at 5 litre/ha recorded significantly higher yield (21.2 to 23.4 % increase over control) and lower nematode population in soil and roots of tomato (73.4 – 75.1 % decrease).

Crisper assisted cleavage polymorphism

A simple method for genotyping of SNP Polymorphisms in any organism was developed that is suitable for small to medium laboratories. A patent titled "Crisper Assisted Cleavage Polymorphism" for SNP genotyping was filed on 11.11.2017 (Application No. 201741040311).

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Underutilized and Underexploited Crops – A Perspective

'Arya' cucumber is a plant of family *Cucurbitaceae* that resembles another vegetable melon (*Cucumber melo var. flexuosus* commonly called snake cucumber). This melon is used in all the three forms, i.e. as salad at tender stage, followed by vegetable (curry) at mid maturity and as fruit on maturity (early maturity). 'Arya' is cultivated on a limited scale, mostly by those farmers cultivating vegetable crops in districts Alwar (Rajasthan) and Rewari (Haryana).

The crop is easy to grow with minimum inputs and farmers reported that it is drought tolerant. It fetches good return similar to other cucurbits during summer and rainy seasons. Its fruits generally do not have tendency of bursting on ripening like *phunt* (*C. melo var. momordica*). Arya fruits have high demand during rainy season due to short supply of other vegetables in that season. It is also grown as inter-crop with pigeon pea but inter-cropping is less preferred as yield declines.

It is cultivated during rainy season and in summer with assured irrigation. Sandy-loam soil is suitable for its cultivation owing to good percolation. Majority of farmers use seed of selected matured fruits of previous crop grown at their farm, while in some cases they also purchase from the local market for cultivation. Infestation of diseases and pests in the crop is negligible and therefore its cultivation requires minimum inputs. Plant starts fruiting after 50 days from the date of sowing, and fruit yield decreases by the end of September. Matured fruit length varies from 80-100 cm, while for salad purpose 15-25 cm long fruits and for vegetable purpose 30-75 cm long fruits are preferred. A mature fruit produces generally 30-40 g seeds. Market price of salad cucumber varies from ₹10-30/kg and total selling of farmer's produce is ₹35,000-40,000/acre. During short supply of cucumber, market price of its fruits goes up to ₹40/kg.

The cooking of vegetable is same as bottle gourd after peeling and removing the seeds. Salad is as good in taste as cucumber, and farmers say it is more nutritious than cucumber. Under cultivation majority of the output (80 %) is consumed for salad purpose and remaining (15-18 %) as vegetable purpose, while very less as fruit (only at initial maturity). Consumption of salad is mostly

Variability and different stages of fruit of Arya (*left*); Arya in farmers' field (*center)* and Fruits being sold in local market (*mandi*) in Rajasthan (*right*)

at local restaurants (*dhaba*) but vegetable consumption is mostly at local level/ self use by farmers in village or town. Morphological, biochemical analysis and organoleptic evaluation of the cultivars have revealed its variability in fruit, good taste at young stage and high nutritional status (especially vitamin C). Owing to its high demand in the area of cultivation, drought tolerance and declining area under cultivation there is an immense need to collect and conserve the germplasm before the germplasm is lost. ICAR-National Bureau of Plant Genetic Resources, New Delhi has identified this less-known underutilized vegetable melon and its areas for germplasm collection. Future works on extension of its cultivation and diversification through value addition have been identified.

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Buckwheat to contribute Rhizosphere Phosphorus in acidic soil

Indian soils are deficient in phosphorus (nearly 49%). In soil system P is very immobile and thus in acid soil fixation is a great problem. Soils of Sikkim are acidic in nature. Sustainable management of limiting/fixed soil P in acid soil can be enhanced by buckwheat cultivation. In extracting soil phosphorus of low availability from the acid soil, it is an efficient crop and this is possibly through the mechanisms such as enzyme and organic acid exudation, root-associated mycorrhizae, root acid, organic ligands, nutrient scavenging activity etc. These different mechanisms promote P release and/or compete for P adsorption sites.

Field experiment was conducted on clay loam soil during two consecutive years 2014 and 2015 (*rabi*) to evaluate effect of organic nutrition on phosphorus nutrient availability and yield attributes of buckwheat. The pooled analysis showed that FYM 5t/ha + neem cake 0.5 q/ha + seed treatment with biofertilizers 200 g/kg seed recorded highest seed yield (15.12 q/ha) along with B:C ratio 2.03 and harvest index 35.12. Results also showed an increase in soil pH ranged from 0.05 to 0.13 units in all treatments along with soil organic carbon from 0.07% to 0.25%. Soil available phosphorus (Bray P_1) decreased from initial 22.6 kg/ha to 16.80 kg/ha in the mentioned treatment indicating P uptake capacity of buckwheat from soil. In another pot study results revealed that lack of difference in buckwheat biomass between all the treatments may be a compensatory mechanism to uptake greater P uptake. Soil-P availability and concentration of rhizosphere tartrate was significantly higher in no-added FYM plot than added FYM plot suggesting organic-anion root exudation have a role in buckwheat-rhizosphere P-dynamics.

The buckwheat crop has ability to acidify its rhizosphere and absorb P, which is necessary for its different metabolic processes. For the next crop rotation buckwheat can significantly increases soil-P availability only after its biomass is incorporated into the soil from less labile inorganic pool (*i.e.* Ca-P) to more labile available pool. In acid soil with high aluminium (Al^{+3}) toxicity, P solubilization is accelerated by some of the organic anions like oxalate, tartrate which are exudated by buckwheat roots. These oxalate and tartrate anion interacts with different phosphate complexes to increase the P in soil solution. This statement suggests that direct rhizosphere chemical alteration play greater role to enhance P uptake. Thus, in soil having low-P sustainable management of limiting/fixed soil-P can be enhanced with such wonderful underutilized pseudocereal. Soils of Sikkim are acidic in nature and thus this pseudocereal can be an important god gifted natural tool for the researcher to combat and manage soil acidity. Thus, a hidden economic benefit with buckwheat cultivation is that it not only improves the soil quality but also boosts fertility which ultimately increases the crop yield of the next season.

Effect of buckwheat on soil P availability and organic acids

Variable	Added FYM	No-added FYM
Soil-P availability µg (g dry soil^{-1})	13.94b	15.3a
Buckwheat shoot biomass g dm plant^{-1}	0.36a	0.35a
Buckwheat root biomass g dm plant^{-1}	0.27a	0.28a
Rhizosphere tartaric acid conc µg g^{-1}	0.27b	0.51b

Mean (± SD) soil-P availability, dry buckwheat plant biomass, and rhizosphere tartaric acid concentration at the time of buckwheat harvest.

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Hybrid variety of safflower promises to make farmers richer

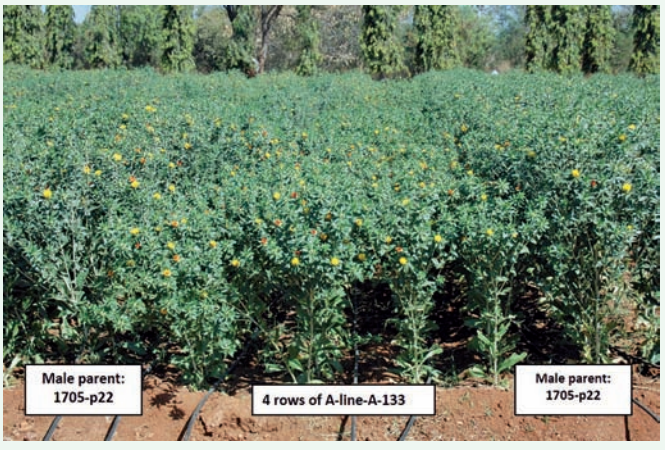
DSH-185 is the first public sector CGMS-based safflower hybrid developed at ICAR-Indian Institute of Oilseeds Research. It has been released and notified for all India cultivation. DSH-185 is a cross between A-133 (CGMS line) x 1705-p22 (a restorer line). Wild species, *Carthamus oxyacantha* is the source of cytoplasmic genetic male sterility in A-133.

On an average, DSH-185 gives the seed yield of 14.3 q/ha under rainfed, 21 q/ha under irrigated conditions and 17.4 q/ha at national level. It gives the oil yield of 4.12 q/ha under rainfed, 5.7 q/ha under irrigated conditions and 4.89 q/ha at national level. On an average, DSH-185 exhibits 25-30% superiority in seed yield over the best check varieties, A1 and PNBS-12 and 15.2% superiority over the GMS-based national hybrid check, NARI-H-15. It has 28-29% oil content and recorded 25-28% superiority in oil yield over A1, PNBS-12 across test locations.

The potential of DSH-185 vs. variety has been demonstrated in farmers' fields under dry and irrigated conditions in Maharashtra, Madhya Pradesh, Telangana and Chhattisgarh States. DSH-185 recorded on an average, 17 q/ha seed yield under dry conditions in Chhattisgarh as against 5 q/ha seed yield of check variety, A1. In Maharashtra, it gave 21 q/ha against 16 q/ha yield of variety, A1 under irrigated conditions while in Telangana, DSH-185 gave 10-14 q/ha against 4-5 q/ha of state variety, Manjira under dry conditions. It is resistant to *Fusarium* wilt which is the major disease of safflower.

Seed production technology of DSH-185 and A and B lines has been perfected. Training programmes for DSH-185 seed production have been taken up at ICAR-IIOR.

DSH-185 in farmer's field



DSH-185 seed production (4:1 row ratio of A-line and male parent) under isolation

Demonstration of DSH-185 vs. A1 in farmer's fields in Maharashtra

Training in seed production of DSH-185 hybrid seed

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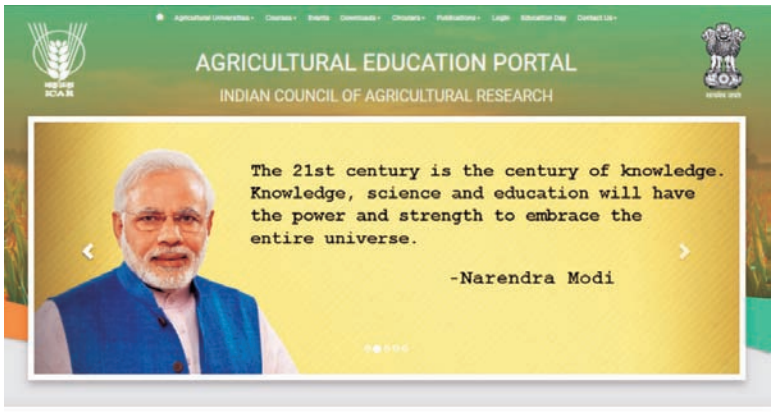
Release of Education Portal – ICAR

The Minister of Agriculture and Farmers Welfare Shri Radha Mohan Singh released the Education portal of ICAR in the Conference of Vice Chancellor's of Agricultural Universities and Directors of ICAR Institutes on 8 March 2018 at New Delhi. The portal has been developed on the lines of KVK portal released by the minister earlier.



Strengthening and Development of Higher Agricultural Education in India

Education Portal-ICAR (**https://education.icar.gov.in**) will act as a single window platform for providing vital education information/announcements/event schedules/ e-learning resources from Agricultural Universities across the country to the rural youth in an easy and fast way on their doorsteps. It will also help in management, monitoring and promoting activities/schemes of Agriculture Education Division, ICAR. Education Portal-ICAR has been designed and developed by the Division of Computer Application, Indian Agricultural Statistics Research Institute (IASRI) under the guidance of Agricultural Education Division, ICAR. The portal has been developed as an ICAR initiative under the Digital India programme of the Prime Minister of India and for the first time all the agricultural universities have come on a single platform to disseminate the information for the benefits of the students and farming community.

Features of the Portal

- Provides information about all programmes of Strengthening, Scholarships, Trainings, e-learning resources and Faculty Strengthening managed by Agricultural Education Division, ICAR under section "Strengthening and Development of Higher Agricultural Education in India".
- Provides link and covers vital information of agricultural universities for the benefit of students.
- Provides information about Courses (Bachelor, Master and Doctoral), Facilities, Student Strength, Faculty Strength and Scholarships.
- Provides Admission Announcements uploaded by universities under "Notifications" at the central place.
- Provides information and search facility about "Events" organized by universities under "Event" menu.
- Provides Advance Search Facility with multiple search options such as Stream, Subject, Course Category and University/College information on Courses along with seats, eligibility criteria and other information.
- Provision for generation of Unique Student ID (USID) by the universities/colleges and the information on the same is displayed university-wise under different categories on the home page under the link USID.
- USID will ensure the uniqueness corresponding to the student records in various academic processes and associated online systems.
- Provides access to Academic Management System developed by ICAR-IASRI and operational at Deemed and Central Universities of ICAR. Portal also provides links to other resources/sites important in the arena of agricultural education.
- Portal is being used by Agricultural Education Division, ICAR for data management of annual reports, financial sanction and release of funds on the basis of online demand and relevant data submitted by universities.
- Several checks, Standard and MIS reports have been developed in the Portal to aid in the monitoring of data.

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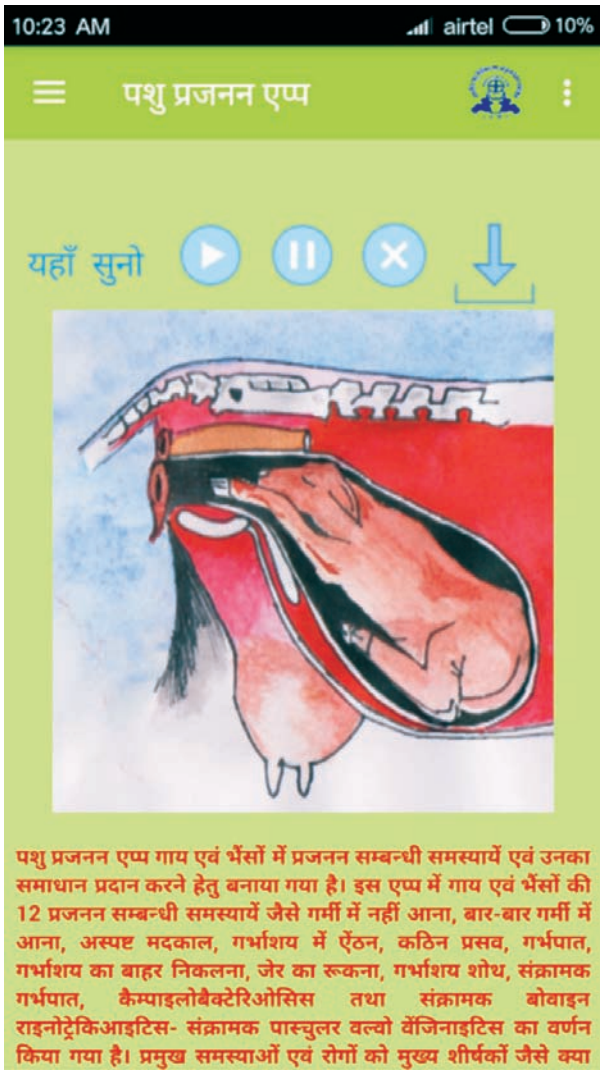
IVRI – *Pashu Prajanan* (Animal Reproduction) App

IVRI-*Pashu Prajanan* (Animal Reproduction) App, designed and developed by ICAR-Indian Veterinary Research Institute, Izatnagar, UP and ICAR-Indian Agricultural Statistics Research Institute, Pusa, New Delhi is targeted to impart knowledge and act as a ready reckoner for the Graduating Veterinarians, Field Veterinary Officers and Livestock Entrepreneurs about reproductive diseases / disorders in cattle and buffaloes and measures to treat and control them.



12 major reproductive diseases/disorders are covered in the App. All the information of reproductive problems/ disorders is provided under the major heads viz. What and How, Symptoms, Treatment and Prevention.

The major users of the App would be the Graduating Veterinarians, Field Veterinary Officers and Livestock Entrepreneurs.

The App additionally provides basic information on heat detection and artificial insemination in cattle and buffaloes.

Presently, the App provides information in 7 languages, viz. Hindi, English, Punjabi, Bengali, Assamese, Gujarati and Tamil. Translation work has been done for other languages viz. Kannada, Telugu, Malayalam, Marathi and Oriya and these will be uploaded soon. The App is available on Google Play Store for free.

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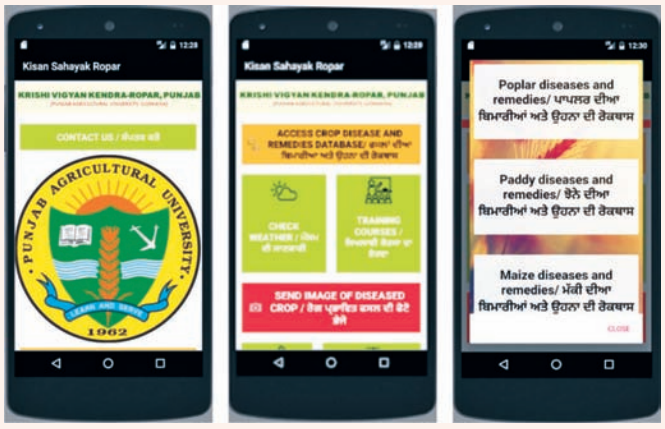
Farmer Friendly *Kisan Sahayak* App

There has been a paradigm shift in the extension methodologies used in disseminating agricultural information. With the increase in mobile subscriptions in the last decade it has emerged as a new technology and is playing a greater role in extension work besides convention television and radio. With 40% of the social media users, second in the world, its application in agricultural extension cannot be ignored as it has an immense scope in improving the reach of extension services to the large number of farmers. The usage of various social media platforms including mobile based applications, facebook, You Tube, Twitter is higher in India than even in the developed countries. Keeping in mind the immense scope of the Mobile based Application in agriculture extension *Kisan Sahayak* Application was launched by Krishi Vigyan Kendra, Fatehgarh Sahib. This *Kisan Sahayak* Application allows users to personally interact with scientists and exchange information in the form of text, video, audio, multimedia. It is becoming a popular platform among masses to share ideas and increase linkability and content sharing. This app is free to download and is available on Google Play



Store. Anybody can download and install the application on android mobile phones having android version 4.2 and above. This app has multiple features including the availability of crop disease database offline which provides offline information of crop disease, their possible remedies and pictures to help farmers to identify and defeat crop diseases. To provide farmers with the timely remedial measure for the crop diseases, a disease identification section is available on the App in which farmers can upload the image of the diseased plant along with his name and contact number. This image is sent to the concerned scientist of KVK who in turn will contact the farmer and advise him about the remedial measures. Weather information is another salient feature of the App, which has been availed from Indian Meterological Department. The farmers are updated about the training courses of various disciplines to be held at KVK along with a link to redirect the person to link of AgriMarket App. List of available seeds at KVK and other information about KVK such as location, contact details, navigation to KVK and details of all the scientists of KVK are other unique features of the App. The Farmer portal available on the App redirects the farmers to PAU's farmer portal, and farmers can also fill the form for queries, questions or even complaints in this App. The App is farmer friendly, free of cost and uses no paid promotions, sources or advertisement and hence has no operational cost.

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IVRI – *Shukar Palan* (Pig Farming) App

The IVRI- *Shukar Palan* (Pig Farming) App has been designed and developed by ICAR-Indian Veterinary Research Institute (Deemed University), Izatnagar in association with ICAR-Indian Agricultural Statistics Research Institute, New Delhi to impart scientific knowledge and skills to the Graduating Veterinarians, Filed Veterinary Officers, Developmental Organizations and Entrepreneurs for promoting commercial pig farming.

This is an educational App providing information about all the aspects of scientific pig farming from selection of the right breed of pig to its housing, scientific feeding, low cost feeding, breeding management, complete health care and general management. The App also provides information about various centers in the country from where the entrepreneurs can procure pigs / piglets of specific breeds.

The App additionally provides support for development of commercial pig farming projects of various sizes.

Further, it will also help the livestock entrepreneurs to market their pigs and piglets. The App also provides answers to FAQs on various aspects of pig farming.

It has a section where Do's and Don'ts for each segment of pig farming are elaborated. It is a complete guide for the establishment of a pig farm on scientific lines.

The IVRI *Shukar Palan* (Pig Farming) App is developed for Android platform. It is available on Google Play Store for free. The information in the App is presently in Hindi language and its English version will be launched soon.

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Pest management strategy against mirid bugs in *Bt* cotton

Cotton crop is ravaged by a group of insect pests accounting for profound crop loss. The main thrust of Indian cotton growers has so far been towards the repeated application of synthetic pesticides to combat pest problem and save the crop. Insect pest scenario with introduction of transgenic *Bt* cotton in Indian agriculture has seen a marked change. Mirid bug has become a serious pest in recent years. There is lack of information on strategies for management of mirid bugs, hence, there is dire need for environmentally sound management practices against it in *Bt* cotton. The present study aims at developing a suitable IPM strategy for this emerging insect-pest.

Parrot beak damage symptoms due to mirid bugs infestation and adult mirid bug

A field experiment was conducted at the Research farm of Hans Roever Krishi Vigyan Kendra, farmer's field in village Valikandapuram and Brammadesam, district Perambalur (Tamil Nadu) during *kharif* season of 2014-15 and 2015-16 with MRC 7918 BG II *Bt* cotton in Randomized Block Design with seven treatments replicated thrice to develop and validate pest management strategy on emerging pest, mirid bug of *Bt* cotton. The treatments included, T_1: sowing of lucerne as trap crop; T_2: application of azadirachtin 10,000 ppm @ 2ml/l (4 sprays at 15 days interval); T_3: application of acephate 75WP @ 1g/l (4 sprays at 15 days interval); T_4: $T_1 + T_2$; T_5: $T_1 + T_3$; T_6: T_1 + application of azadirachtin and acephate alternately; T_7: Farmers' practice (5-6 insecticidal sprays). Weekly observations were recorded for mirid bugs, jassids (*Amrasca biguttula biguttula*), whiteflies (*Bemisia tabaci*) and thrips (*Thrips tabaci*) and three beneficials, ladybird beetle (*Coccinella* spp.) and green lacewing (*Chrysoperla carnea*) and spiders were recorded. Two species of mirid bugs, viz. *Creontiades biseratence* (Distant) and *Campylomma livida* (Reuter) were recorded during the seasons. Seed cotton yield of each field was recorded over the three pickings. In 2016-17, validation of best pest management strategy was carried out in 10 ha of area in farmer-participatory mode in the village Annukur, district Perambalur, Tamil Nadu and was compared with farmers' practice.

The results of the experiment showed that the population of mirid bugs was found significantly lower in all treatments over farmers' practice. In respect to management studies, T_6 recorded lowest population of mirid bugs (average 0.34 bugs/plant) followed by T_5 (average 0.49 bugs/plant), T_3 (average 0.57 bugs/plant), T_4 (average 0.64 bugs/plant), as compared to T_7, farmers' practice (average 1.58 bugs/plant). The results of the experiment revealed that the population of sucking pests was significantly lower, and population of beneficials was significantly higher in treatment over farmers practice. It was also revealed from the data that there was significant increase of 63.43% seed cotton yield due to protection of crop with best suitable management technique (T_6) followed by 54.7% of T_5 and 47.81% of T_3 as compared to T_7, farmers' practice. Large scale validation in farmer-participatory mode results indicated low incidence of sucking pests in IPM as well as farmers' practices (FP) during the entire crop season. Population of mirid bugs was higher in farmers' practice as compared to the management fields and the differences between IPM and FP were statistically significant. Population of three beneficial insects, ladybird beetle (*Coccinella* spp.) and green lacewing (*Chrysoperla carnea*) and spiders was recorded significantly higher in IPM as compared to FP.

By incorporating these management practices, application of synthetic insecticides can be reduced to a minimum possible level. Mirid bugs either prevailing hitherto or newer ones have assumed key status warranting couple of sprays during reproductive phase. Key strategies and integrated approaches are essential for sustainable use of *Bt* technology. Such an approach poses a lower risk to people, wildlife and the

Field view of validation trial at Perambalur, Tamil Nadu

environment while simultaneously protecting economic interests among farmers.

The technology will be helpful in increasing the seed cotton yield and improving quality especially in terms of reduced pesticides contents, thereby improving the socio-economic status of cotton growers of the country.

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Groundnut increases cropping intensity in lateritic soils

In West Bengal water retention capacity of soil is poor and pH varies from 5 to 5.5. The area is dominated by cultivation of *boro* rice in *rabi*-summer and aman rice during *kharif*. Area under *boro* rice cultivation is decreasing day-by-day as groundwater level is going down every year due to erratic, uneven and scanty rainfall. The cropping pattern of the zone is paddy-paddy-fallow.

To find an alternate crop for this area which provided an assured return in terms of productivity and marketability, farmers from four villages namely Jamrasuli, Dhuliapur, Asthapara and Tura of West Medinipur approached the Krishi Vigyan Kendra (KVK). Realizing the magnitude of the problem, the KVK opted for agro-ecosystem analysis through PRA in the villages to characterize the present agricultural situation and identify the opportunity to introduce a new crop as per the need of the practising farmers. Finally, the KVK decided to introduce 'groundnut' in the selected villages as an alternate crop for that area.

Research and Development

In the initial years, the KVK assessed the performance of four varieties of groundnut namely, TPG-41, TG-26, TG-38 B and TAG-24 in a number of locations of those villages to find out the best suited variety or this identified agro-climatic condition. Finally the KVK came up with the recommendation of complete package for the cultivation of TAG-24 variety with seed treatment of *Rhizobium* @750/ha, soil application of gypsum @500 kg/ha after 30 days of sowing and boric acid @2.0 g/l of water after 15 and 30 days of sowing followed by foliar application of neem-based liquid 50,000 ppm @0.75 ml/l of water and management of aphid. The farmers harvested 20q/ha average yield with net return of ₹25,000/ha. The success prompted the KVK to conduct FLD during next *kharif* where 12q/ha and ₹16,000/ha net return could be realized.

Gradually horizontal spread of the technology started taking place and within next three years about 150 ha of area could be brought under groundnut cultivation. Requirement of 50-60 acre-inch water through 16-20 irrigation for *Boro* rice cultivation was a severe problem for the farmers. However, cultivation of groundnut was possible only with 10-12 acre-inch water (4-5 irrigations) which was affordable for the farmers. Moreover, cultivation of groundnut has positive impact on soil-health, created more man-days and ultimately led to less migration of labour from rural to urban areas. The analysis of soil indicates that pH has been changed to 5.6 from 4.8 followed by increase in available Nitrogen in soil to 210 kg/ha from 180kg/ha and available organic matter from 0.5% to 0.75%. During the period, additional man-days created was to the tune of 10,500 numbers which has resulted in 30% reduced migration of labour. Groundnut has a good market in West Medinipur as well as neighbouring districts also which enabled the farmers to get instant return and encouragement for groundnut cultivation.

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Collection of rice landraces grown in flood prone areas of eastern Uttar Pradesh

Flood prone tarai area of eastern Uttar Pradesh is well known for its humus rich fertile alluvial soils and habitats suitable for cultivated and wild rice. In India about 30% of rice growing area is prone to prolonged flooding, causing partialor complete submergence every year. In view of these facts, an area specific exploration was undertaken for collection of named rice landraces and its wild relatives from flood prone areas around the villages of Sharda, Ghaghra Koriyala, Sarayan, Chauka, Gomati, Kathana, Saryu, Rapti and Mohana rivers under Lakhimpur, Bahraich, Sravasti, Balrampur and Basti districts of Uttar Pradesh during 14-23 November, 2016. From these five districts, a total of 53 accessions of 45 diverse rice landraces having specific traits were collected from farmers' fields. Traits of landraces were recorded on the site through interaction with farmers. It has been observed that introduction of improved/hybrid varieties and rapid increase in sugarcane growing areas have significantly reduced the area of cultivation of traditional landraces. Now only 5-10 % poor and marginal farmers are growing some landraces namely *Bhainsalot, Zadan, Bailer, Brahma, Sainger, Mansada, Gajraj, Kala gainda* and*Karangi,* all having tall plant type, adapted to lowland areas along river side. Eastern Indo-Gangetic Plains (IGP) hold rich diversity in wild rice; hence *Oryza nivara* (*Tinni*), *O. rufipogon* (*Tinna*) and *O. sativa* var. *spontanea* (*Sumba*) were also collected. Some unique landraces collected include *Lalmati* with finest grain (8.12mm x 1.88 mm); *Chakava* with lowest 100 grain weight (1.17g) followed by *Shyamjeera* (1.18g) and *Kalanamak* (1.20g); *Dhania dhan* with shortest grain (5.35mm). Farmer informed that *Kalanamak* is one of the best scented landrace, covering largest area under cultivation followed by *Lalmati* and *Anjani.* Cooked rice of *Gadaria* landrace is supposed to be good for treatment of jaundice and diabetic problems; *Kala gainda* and *Mungphalia* are used for popping purposes and in religious ceremonies; *Mungphalia* matures before *Durga puja* hence fresh harvest is offered in various *pujas* and rituals (*Navratras,Pitri-paksh*). Important landraces namely *Bapu londva,Brahma*, *Bailer*, *Chakava*, *Dindhava*, *Farm gadari, Gadapuri*, *Ghar bharanva*, *Indrasan*, *Kala gainda*, *Manjhava,Mansada*, *Mehi, Motki masuri*, *Radha dhan,Ranikazara*, *Ram dhan, Sainger, Shankhar*, *Santokhia*, *Sathee* and *Zadan* were not represented in National Gene Bank and were collected from eastern Uttar Pradesh for the first time.

Rice landraces collected with specific traits

Specific traits	Landraces
Submerge/Deep water rice	*Chakava, Madhukar, Sainger, Mansada, Bhainsa lot, Zadan, Brahma, Bailer, Gadaria, Mehi, Karangi*and *Dindhava.*
Scented /Aromatic	*Anjani, Kalanamak, Lalmati, Dhania dhan, Bapu londva* and *Manjhava.*
Lodging resistant	*Indrasan, Shankhar, Chourasia, Karangi* (awned and awnless), *Sambha, Motki masuri, Bapu londva, Santokhia, Madhukar, Ramkazara,* and *Ghar bharanva.*
Softkernel	*Masuliha, Kalanamak, Shyam mansuri* and *Farm gadari.*
Sticky rice	*Gajraj, Radha dhan* and *Manjhava.*
Early and dwarf	*Sathee* and *Manjhava.*
Red rice	*Lalmati, Gadapuri, Zadan, Bhainsa lot, Dindhava, Brahma, Mehi, Kala gainda, Bailer, Santokhia, Gadaria, Ranikazara, Mungphalia* and *Manjhava.*
Popping type	*Kala gainda* and *Mungphalia.*
Medicinal rice	*Gadaria*: used in jaundice and diabetic troubles.

a, Grain and kernel variability in collected landraces, **b,** A show-piece from *Bapu-londwa* landrace for using as gift for married daughters, **c,** Habitat of *Karangi* landrace at submerged site, and **d,** *Bainsalot* landrace at submerged site having lodging resistant with high tillering.

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ICAR-Central Sheep and Wool Research Institute

Enhancing the productivity of sheep and rabbit through scientific methods by developing and applying new technologies

The ICAR-Central Sheep and Wool Research Institute is a premier Institution of Indian Council of Agricultural Research engaged in research, education and extension activities on sheep and wool. It was established in 1962 in the hot semi-arid region of Rajasthan at Malpura. At present, the campus is known by the name of Avikanagar. The campus is spread over an area of 1,591.20 ha. It has three Regional Research stations in different climatic zones of the country : North Temperate Regional Station (NTRS) in temperate region at Garsa, Kullu in Himachal Pradesh, Southern Regional Research Centre (SRRC) in sub-temperate region at Mannavanur in Tamil Nadu, and Arid Regional Campus (ARC) at Bikaner in the arid region of Rajasthan.

Northern Temperate Research Station, Garsa: The North Temperate Regional Station (NTRS) was established in 1963 at Garsa, Kullu (Himachal Pradesh). The station has elite flock of Fine Wool Synthetic sheep. The elite animals are made available to farmers of the region from station. The station has made sizable contribution in establishment of Angora rabbit farms and Angora shawl industries in the region.

Southern Regional Research Centre, Mannavanur: It was established in 1965 in sub-temperate region at Mannavanur (Tamil Nadu). Elite flocks of Bharat Merino and Avikalin sheep suitable to cold climate have been established at the station. The station has made sizable contribution in establishment and popularization of broiler rabbits in the southern regions.

Arid Regional Campus, Bikaner: It was established in 1974 as Division of Carpet Wool and Karakul Pelt Production. The centre has 636 ha of land. The campus is undertaking research on genetic improvement of Magra, Chokla and Marwari sheep breeds suitable for carpet wool production. The centre is contributing in increasing carpet wool production in the western Rajasthan through supply of elite rams of carpet sheep breeds.

VISION

To address the issues related to Sustainable sheep production and to inspire an exchange of ideas among experts, policy makers, stakeholders, industrial leaders and general public

MANDATE

- Basic and applied research on sheep husbandry
- Dissemination of technologies for sheep productivity enhancement and management

MISSION

- Enhancing mutton production through increasing prolificacy and genetic improvement through selection
- Improvement of sheep for wool production
- Development and improvement of technology for value addition in sheep products and by-products
- Disease surveillance, health care and disease diagnostic tools
- Validation, refinement and dissemination of developed technologies.

INFRASTRUCTURE

- Well-equipped laboratories for research in animal nutrition, physiology and reproduction, adaptation physiology, animal health, animal biotechnology, animal genetics, livestock product technology, wool fibre and textile chemistry.
- Sheep Farms: Presently institute is maintaining around 4,000 sheep and goats with basic required facilities.
- The germplasm maintained are Malpura, Patanwadi, Avishaan, Garole, Avikalin sheep and Sirohi goats at CSWRI, Avikanagar; Marwari, Magra and Chokla at ARC, Bikaner; Bharat Merino and Avikalin at SRRC, Mannavanur and Fine wool synthetic at NTRS, Garsa.
- Sheep washing and shearing facilities
- Institute has wool processing plant
- Feed technology unit
- Animal slaughter and product processing unit

- Guest house, PG hostel and Kisan Ghar facilities
- Auditorium, conference hall and committee room with AV aids.

MAJOR RESEARCH AREAS

- *FecB* gene introgression from Garole in non-prolific sheep for multiple births
- Avishaan sheep – a prolific sheep released for field testing
- Genetic improvement of sheep for enhancing mutton and wool production
- Breeding of sheep for resistance/resilience to gastrointestinal nematodes
- Intensive feeding of lambs for enhancing mutton production
- Use of prickly pears (cactus) in sheep feeding
- Memnaprash: Milk supplements powder for lamb feeding
- Avikaminmix a mineral mixture for sheep
- Ration balancing to reduce methane emission from sheep
- Avikasil-S An indigenous impregnated sponges for oestrus synchronization and AI with chilled semen
- Accelerated lambing system (3 lambs in 2 years) to increase life time production
- Modified worm management through single strategic anthelmintic intervention during mid to late monsoon
- Targeted selective treatment (TST) approach to reduce use of anthelmintics
- Neonatal mortality losses

Marwari

Malpura

Avikalin

- Identification of adulteration in Pashmina fibre with other fibres
- Fibre rich and low salt mutton products
- Mozzarella cheese and paneer from sheep milk
- Carcass evaluation and yield
- Avikhad organic sheep manure from wool waste
- Training and dissemination of technologies on different aspects of sheep production.

TECHNOLOGIES / PRODUCTS / PROCESSES DEVELOPED

- Avishaan: A prolific sheep
- Fat tail/rump sheep (Dumba): Extra ordinary growth and demand
- Malpura: A promising mutton sheep of semi-arid region of Rajasthan

Avishaan sheep

- Avikalin: A dual type crossbred sheep for carpet wool and mutton
- Chokla: Best carpet wool breed of Rajasthan
- Magra: A lustrous carpet quality wool sheep
- Marwari: A robust sheep breed of arid zone
- Gaddi Synthetic: Fine wool sheep for temperate region
- Bharat Merino: Fine wool producing sheep of India
- Sirohi: Dual purpose hardy goat breed of Rajasthan
- Molecular technique for identification of adulteration of meat of sheep and goats
- Application of FecB genotyping test in MAS programme in sheep
- DNA test for identification of the benzimidazole drug resistance in *Haemonchus contortus* parasite in sheep
- Finding of the Booroola fecundity (FecB) gene in Kendrapada sheep
- Artificial insemination in sheep with liquid chilled semen
- Embryo transfer technique in sheep
- Ram semen freezing technique
- Lamb feeding for mutton production
- Multi nutrient blocks
- Complete feed block technology for animal
- Prickly pear cactus: A promising feed resource during scarcity
- Herbal feed supplements: Nutritional and therapeutic intervention to ameliorate stress
- Conservation of monsoon herbage for scarcity period
- Pasture establishment
- Sheep flock health technology
- Worm management programme for sheep flocks of Rajasthan
- Targeted selective treatment (TST) approach for management of haemonchosis in sheep
- FROGIN: Software for forecasting gastrointestinal nematodiasis in sheep of Rajasthan
- Diagnosis of paratuberculosis (Johne 's disease)
- Diagnosis of caseous lymphadenitis
- Molecular technique for identification of wool and speciality hairs
- Aesthetic and durable carpet from indigenous wool and its blends
- Angora rabbit hair – Bharat Merino wool blended shawls
- Development of pure pashmina yarn using PVA as carrier
- Natural colour for wool and specialty hair fibre
- High quality blankets from indigenous wool
- Development of woolen handicrafts from coarse wool
- Anti-microbial and anti-moth properties of natural dyes for wool and specialty hairs
- Handmade felt and its products
- Development of fabric from fine wool of Dumba sheep
- Development of lustre wash process for carpet yarn

- Ornamental home furnishing from coarse wool braided yarn
- Value added sheep meat products
- Value added sheep milk products.

TRAINING AND CAPACITY BUILDING

The Institute organizes training programmes for:

- Field Veterinarians - Recent advances in sheep production and health
- Women empowerment and artisan capacity building – Woollen and handicraft products
- Sheep and goat farmers – Sheep and goat rearing practices.

The Institute provides training in the following areas for participants of foreign countries:

- Advances in sheep production and utilization
- Nutrition of range managed sheep
- Pre- and post- ruminant feeding for augmenting lamb production
- Artificial insemination in sheep
- Embryo transfer technology in sheep
- Marker assisted selection for prolificacy in sheep
- Detection of anthelmintic resistance and its management
- Processing and value addition of wool and specialty hairs.

CONSULTANCY AREAS

The Institute, through a team of scientists and technical officers, provides consultancy services to woolen industries, Central Wool Development Board, Commercial farms, Animal Husbandry Departments etc., on following areas:

- Sheep farming and economy
- Sheep diseases and prevention
- Reproduction and AI
- Feed and fodder development
- Meat products development
- Wool grading, processing and products.

EDUCATION

The Institute has linkages and collaboration and entered into MoU for post graduate and Ph.D. programmes with following Universities and Institutions:

RAJUVAS, Bikaner	Mewar University, Chittorgarh
MAFSU, Nagpur	IIS University, Jaipur
CGKV, Durg	SHIATS, Allahabad
NDRI, Karnal	UPTTI, Kanpur
IVRI, Izatnagar	ICT, Badhohi
Banasthali Vidhyapith, Tonk	

PATENTS FILED

1. Indigenous progesterone impregnated vaginal sponges for estrus synchronization in sheep
2. Method to deliver nematophagous fungus, *Duddingtonia flagrans* to sheep for biological control of *Haemonchus contortus*
3. Area specific mineral-mixture pellets for augmenting reproduction and production in sheep
4. Production of fermented probiotic feed, production protocol, fermentation conditions, drying, storage and uses thereof
5. Fermentation vessel for conducting gas production studies *(in vitro)*: fabrication, protocol and uses
6. Low cost, indigenous cradle for safe restraining of sheep for pregnancy diagnosis
7. Low cost, indigenous vaginal sponges for estrus control in buffaloes.

COPYRIGHTS

1. Computer software work – FROGIN (Forecasting for Rajasthan on ovine gastrointestinal nematodiasis) (SW-8118/2014)
2. Cinematograph film work – semen collection and artificial insemination (AI) in sheep (CF-3786/ 2014)
3. Cinematograph film work – estrus synchronization in sheep and goats (CF-3785/2014).

TRADE MARKS

1. AVIKAMINMIX (Label) No 3513442 dated 24.3.2017
2. AVIKESIL-S (Label) No 3513445 dated 24.3.2017
3. MEMNAPRASH (Label) No 3513446 dated 24.3.2017

SERVICES

- Supply breeding seed stocks on book value to farmers and development agencies
- Vaccination and drenching of farmers flocks
- Medicine and treatment of sick animals of farmers flock
- Wool procurement and processing
- Product manufacturing from procured wool
- Feed blocks/supplementary feed to farmer flocks.

FACILITIES

The Institute extends following facilities to farmers / stakeholders / industries / entrepreneurs

- Testing of wool and woollen products
- Testing of meat and meat products
- Disease diagnosis

- Analysis of feed and fodder
- Semen analysis and pregnancy diagnosis
- AI in sheep with chilled semen
- *Fec B* genotyping of sheep
- Detection of adulteration in Pashmina fibre products.

MAJOR ACCOLADES

1. ICAR award for the outstanding research contribution in small ruminant production for the biennium 1997-1998 to SMK Naqvi, Anil Joshi, Rajeev Gulyani, G K Das and JP Mittal
2. ICAR award for the outstanding research contribution in genetic improvement of sheep for the biennium 2003-04 to VK Singh AL Arora, AK Mishra, D Singh, SMK Naqvi, Anil Joshi, CP Swarankar and Satish Kumar
3. Dr. Rajendra Prasad Puruskar of ICAR for technical books in Hindi in the field of agriculture and allied sciences for the year 2005-06 to SC Dubey, AK Shinde and BN Singh for their book on Applied Animal Husbandry (Cattle, buffaloes, sheep, goats, pig, horse and camel)
4. Lal Bahadur Shastri young scientist award of ICAR for the biennium 2007-2008 to Suresh A for his research work on production and utilization of wool and woollens in India
5. Lal Bahadur Shastri young scientist award of ICAR for the biennium 2011-2012 to V Sejian for his research work on multiple stresses in sheep
6. Dr Rajendra Prasad Puraskar 2016 of ICAR for technical book in Hindi in the field of agriculture and allied sciences to Arun Kumar, Vineet Bhasin, SMK Naqvi, and Dr RS Gandhi for their book on *Unnat Bhed Palan*.

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Science, Technology and Innovation Policy: A New Paradigm

"Science technology and innovation for the people" is the new paradigm of the Indian STI enterprise. The national STI system must, therefore, recognize the Indian society as its major stake holder. Global innovation systems tend to bypass large sections of the community. Innovation for inclusive growth implies ensuring access, availability and affordability of solutions to as large a population as possible. Innovation, therefore, must be inclusive. The instruments of the STI policy will enable this to be realized. The policy will drive both investment in science and investment of science-led technology and innovation in select areas of socio-economic importance. Emphasis will be to bridge the gaps between the STI system and the socio-economic sectors by developing a symbiotic relationship with economic and other policies.

Capturing Aspirations

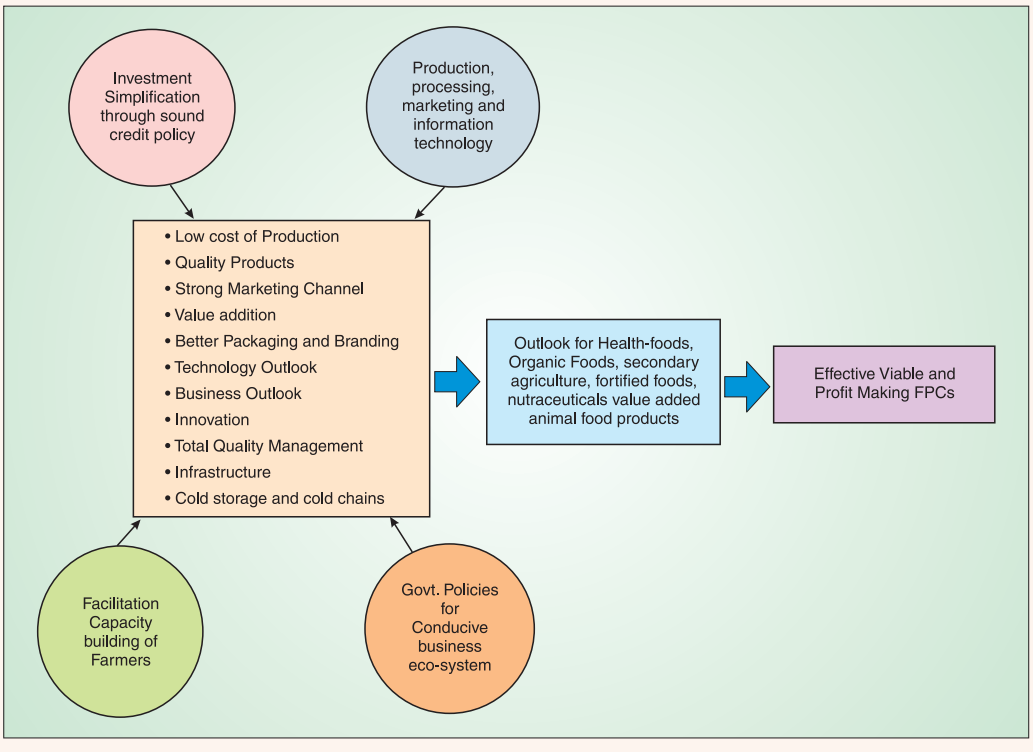
The key elements of the STI policy are:

- Promoting the spread of scientific temper amongst all sections of society.
- Enhancing skill for applications of science among the young from all social strata.
- Making careers in science, research and innovation attractive anough for talented and bright minds.
- Establishing world class infrastructure for R&D for gaining global leadership in some select frontier areas of science.
- Positioning India among the top five global scientific powers by 2020.
- Linking contributions of science, research and innovation system with the inclusive economic growth agenda and combining priorities of excellence and relevance.
- Creating an environment for enhanced Private Sector Participation in R&D.
- Enabling conversion of R&D outputs into societal and commercial applications by replicating hitherto successful models as well as establishing of new PPP structures.
- Seeding S&T-based high-risk innovations through new mechanisms.
- Fostering resource-optimized, cost-effective innovations across size and technology domains.
- Triggering changes in the mindset and value systems to recognize, respect and reward performances which create wealth from S&T derived knowledge.
- Creating a robust national innovation system.

Road map and strategies for effective viable profit making farmer producer companies

The Farmer Producer Company (FPC) concept has emerged as a new generation farmer's organization in India. It was introduced in 2002 by introducing a new part IX A into the Companies Act 1956 under the chairmanship of economist YK Alagh. The Producer Company is a special case of producer organization that is registered under Section IX A of the Companies Act, 1956. The FPCs are fundamentally farmer-owned and farmer-governed micro-enterprises which can be considered as hybrids between cooperative societies and private companies. The way of participation, membership and organization is similar to that of a cooperative, while the incorporation into corporate law allows greater flexibility and professionalism in their business actions.

FPCs have great potential in enhancing farmers income as also mentioned in the draft document of NABARD in 2017 for Doubling Farmers Income. There were 1048 FPCs reported registered till December 2017. But the questions arise about the performance of these FPCs, its effectiveness and sustainability. With due emphasis on Farmers Producer Companies in future, there is a need for a framework and strategies for high performing FPCs. Hence, this framework has been suggested based on the reserach insights. Effective and viable profit making FPCs have to be competent with other companies and rivals in the market. Apart from climatic pressure, in near future, the multinational companies and big corporates will challenge the FPC more in marketing domain. The unpredictable changes in political environment shall create an uncertainty. The FPCs need to be strong enough to resist the forces by their own. The most competent FPCs will be those who will focus the market first and produce quality products at lowest cost. Based on the theory of economies of scale, lowering cost of production shall only be possible through use of technology and scale. Value addition and marketing are the key area for capturing a major share in consumer's rupee. Strong marketing channel is highly required to have edge in market share followed by branding and advertising the product. Following the Good FPC Practices like total quality management, transparency, risk mitigation, financial assistance, management information system, unique business model, e platform for sale, exposure visits and capacity building shall guide the producer companies towards effective FPCs.



Strategies for Effective Viable and Profit Making Farmers Producer Companies

This is the era of e-commerce. Using e platform, companies are now reducing their huge marketing cost. They are investing the profit using e marketing technology to further innovations and make the company competent enough to produce high quality products at lowest cost. Ultimately quality products make a great brand value for a company and earn trust of consumers. There is a huge potential for FPCs to enter in post-harvest segment in India. This will not only help the company to earn good profit but

will reduce the post-harvest loss which is quite high in India, 30-40% in fruits and vegetables. The FPCs for better profit have to capture the niche market like Health and Nutri foods, organic foods, nutraceticals, fortified foods, functional foods, medicinal and aromatic plants, cash crops etc.

Four areas need to coalesce into a coherent vision if profit making FPCs are to be made. These are (i) facilitation, (ii) investment, (iii) technology, and (iv) policy backed by research.

Facilitation is required for organizing primary groups, skill development of farmers, changing their business outlook to form a competent company, initial market research and legal formalities to form a company. The organization of primary producers groups cannot be taken for granted, someone needs to facilitate the process. Leadership development and team building are the first step towards effective FPCs. the promoting organizations have a great role to play here. That is why this is the foremost important area followed by investment.

In FPC as investment is an issue as small and marginal farmers does not have huge capital to invest. Who will invest money in FPCs and at what cost, is important enough to make it successful. Is it a bank or any other financial institutions? Government has to take initiatives to help FPCs in getting loans and other financial assistance at lowest possible interest.

Technology includes production technology, processing technology, marketing technology and most important, information technology needs to be emphasized enough to make quality produce at competitive costs.

Lastly, policy support that creates an enabling environment which offers the most effective incentives to the FPCs are equally important as the earlier three. But the policy should be based on research. Several ground level studies suggested that there should be same facilities and provisions for small FPCs and cooperatives, tax exemptions for all FPCs for first five years. Promoting e-market and reducing commissions at *mandis* and regulated market and so on.

In order to enhance sustainable income of farming community, farmers have to be united not only to avail inputs at proper time, place and quantity but also to avail marketing facilities and link to domestic as well as export markets through the FPCs. Questions may arise about the performance, scope of replication and challenges of these FPCs. Till date some research has been conducted and much more in depth studies are required to answer the basic questions such as what is the impact of FPCs on empowerment and income security of farmers in India? What kinds of problem are they facing sector wise and in general? How can they be more effective in present context? What are the future prospects of FPCs? Emphasis have to be given in developing strategies for scaling up such enterprises particularly in developing value chains, strengthening social networking and enriching theories of cooperation and collective action.

Extension system has to play a great role in skill development and capacity building of farmers to make them good producers, leaders and businessmen. Awareness, entrepreneurial incubation, development of sector specific models and strategies through linkage and convergence are required.

In fact, social learning, collective action and interaction with a range of actors for facilitating innovation processes are some of the key roles that extension system needs to play. FPCs can play a crucial role for making innovation possible in rural and agricultural production and marketing systems. As innovation requires the existence of networks of people as a prerequisite, creating an FPC entails a process of networking, which is crucial for innovation to take place. As a result, an FPC can generate interaction by farmers with a range of actors, 'cross-wiring' them and their organizations with other actors, strengthening the social organization of innovation, both in terms of the parties involved and in terms of content, while more effectively identifying and using windows of opportunity.

The overall conclusion is that FPCs have a huge potential to capture the future food retails not only in India but in the world. Irrespective of the form of organization being floated as a producer company, especially of small and marginal producers, concentrated effort is to be made for developing and sustaining the institution. Such effort should be in the form of research, capacity building, policy and management support. It has tremendous possibility to become a model for enhancing sustainable livelihood

of small and marginal farmers in India and for income enhancement.

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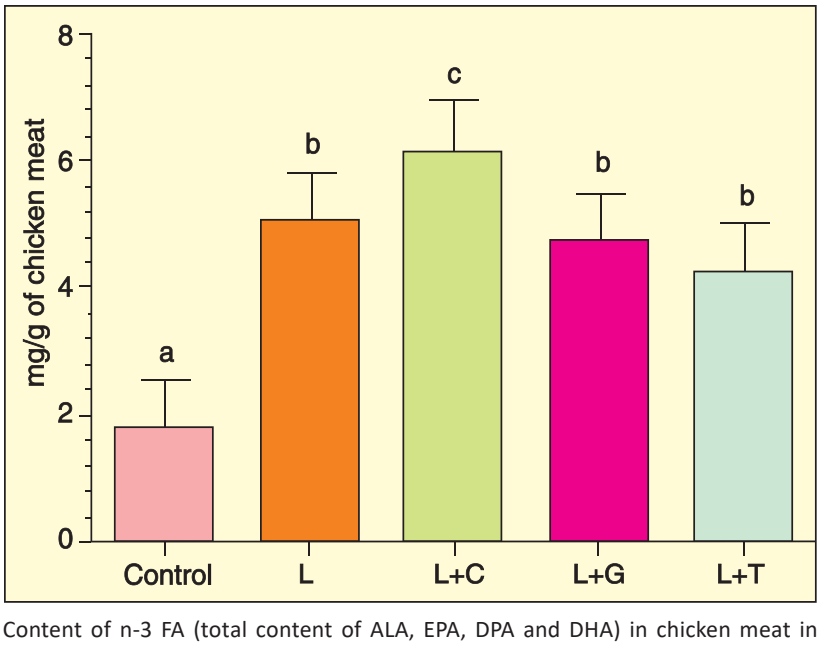
Raising omega-3 rich chicken

In India, chicken meat is preferred over other meat for its higher protein content (22-27g/100 g, meat) as well as low content of cholesterol (60-90mg/100 g, meat) and saturated fat (3.2-3.8 g/100 g, meat). The nutritional value of chicken meat can be enhanced with different health promoting bioactive compounds such as omega-3 fatty acids (n-3 FA), conjugated linoleic acid, vitamins, antioxidants etc. Consumer awareness regarding the health benefits of n-3 FA has led to growing interest in enhancing n-3 FA content in poultry meat through dietary supplementation of n-3 FA rich feed ingredients like fish meal, flax seed, linseed oil, marine algae etc. Linseed (*Linum usitatissimum*) oil is one of the richest dietary sources of α-linolenic acid (ALA), which is a long chain polyunsaturated n-3 FA and is vital for various physiological functions.

Chickens have the ability to convert ALA to eicosapentaenoic acid (EPA, 20:5n-3), docosapentaenoic acid (DPA, 22:5n-3) and docosahexaenoic acid (DHA, 22:6 n-3), which are functionally most important n-3 FA in human metabolism. Hence it is possible to feed ALA enriched feed to broiler chicks for obtaining meat enriched with ALA, EPA, DPA and DHA.

A comprehensive study was conducted at the ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru for enhancing n-3 FA content in chicken meat by dietary supplementation of 2% linseed oil in broiler birds. In addition, 2% linseed oil was combined with either 0.5% curry leaf powder or 0.5% ginger powder or 0.5% turmeric powder and was fed to broiler birds to investigate the additional benefits of these natural antioxidants in reducing peroxidation of meat lipid.

The results confirmed that n-3 FA content in poultry meat was enriched by 2.3 to 3.4 fold in the treatment groups. It was also recorded that the addition of natural antioxidants (ginger, curry leaf and turmeric powder) did not reduce meat lipid peroxidation rate either in fresh or in preserved (until 14 days at 4°C) meat significantly. Interestingly, supplementation of ginger powder alongwith linseed oil, enriched n-3 FA content in meat by 2.6 fold with only 19% of additional cost of production.



Content of n-3 FA (total content of ALA, EPA, DPA and DHA) in chicken meat in different dietary groups. L: 2% linseed oil; L+C: 2% linseed oil + 0.5% curry leaf powder; L+G: 2% linseed oil + 0.5% ginger powder; L+T: 2% linseed oil + 0.5% turmeric powder.

Currently, n-3 FA rich chicken meat is not available in the Indian market. However, it may be noted that the price of n-3 FA rich eggs that are sold in the Indian market is nearly 80% higher than the normal eggs. A higher price of n-3 FA rich chicken meat is also expected if they are available in the market. The study suggests that the production of n-3 FA rich chicken meat through dietary manipulation can help in doubling the poultry farmers' income.

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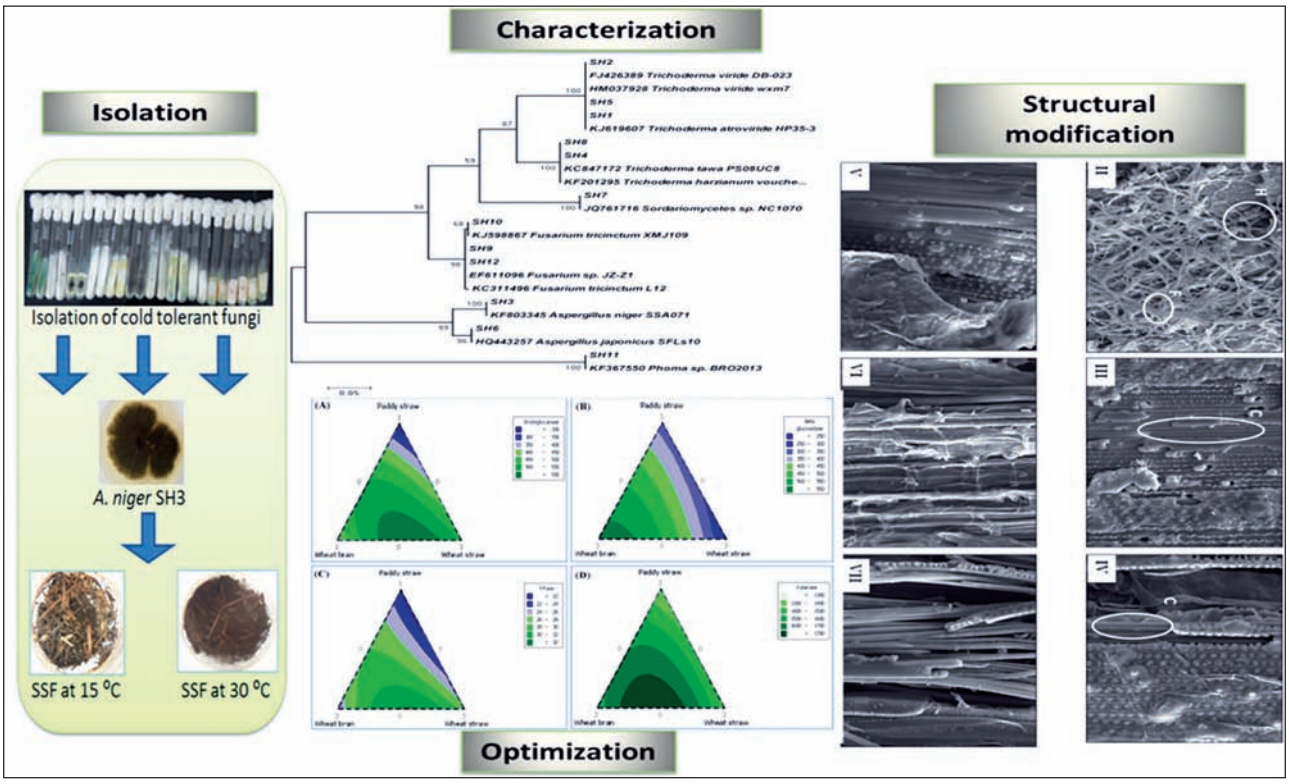
Using biomass for producing energy



Process optimization for cold active indigenous holocellulase cocktail production from *Aspergillus niger* SH3 and its application in biomass hydrolysis

The conversion of cellulosic biomass into monomeric sugars is the most costly and energy intensive process in bioethanol production as most commercial enzymes require temperature of 50 °C for optimal hydrolysis. Cold active cellulases produced by psychrophilic microorganisms can counter this limitation by hydrolyzing the biomass at low temperature. A fungal strain *Aspergillus niger* SH3 isolated from Himalayan region of India, was explored for cellulase and xylanase production deploying experimental mixture design to identify the best carbon source among wheat bran, wheat straw and paddy straw. *A. niger* SH3 exhibited the highest titer of endoglucanase (655.94 IU/g), β-glucosidase (540.57 IU/g), FPase (31.48 IU/g) and xylanase (1951.63 IU/g) under the optimized conditions after 7 days of solid state fermentation. The crude hydrolytic enzyme cocktail of *A. niger* SH3 was successfully used for saccharification of prê-treated paddy straw leading to high sugar yield (257.32 + 0.62-375.84 + 0.62 mg/gds) with very low enzyme loading (15 FPU/gds) and low incubation temperature (30-40 °C). This illustrates the three impressive traits of hydrolytic enzyme cocktail of *A. niger* SH3, which makes it a promising candidate for use at commercial scale for second generation Biofuel production.

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Published by Dr Satendra Kumar Singh, Project Director, Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi 110 012. *Phone:* 011-25842787; *Fax:* 011-25843285; *e-mail:* director.dkma@icar.gov.in. Lasertypeset by M/s Print-O-World, Shadipur, New Delhi 110 008, and printed in India at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase I, New Delhi 110 028.

Editing : **Seema Burman** ***Design & Production :*** **Dr V K Bharti and Punit Bhasin**

WAY FORWARD

INDIA has moved from an era of chronic food shortages during 1960s to food self-sufficiency and even food exports by 1990s. While the annual food grain production has increased from 50 mmt in 1950-51 to an estimated 283 mmt presently from near static cultivable area of 140mha ±2 mha, the horticultural production has increased from 25 mmt to 310 mmt over the same period. The agricultural exports during 2012-13 were US$ 41 billion against imports of US$ 20 billion and in the year 2017-18 exports are likely to cross US$ 45 billion. Undeniably, science and technology led developments remain key drivers of growth in Indian agriculture.

Rising national population, projected to be 1.5 billion by 2050, and per capita income are pushing up the food demand, which needs to be met through enhanced productivity per unit area, input and time. Moreover, dietary patterns are also shifting from low price calorie food towards high price calorie foods. The trend in demand at national level indicates that by the year 2026-27, it is likely to rise by 1.3% per year for cereals, 3.0% for pulses, 3.5% for edible oil, 3.3% for vegetables, and 4-6% for fruits and livestock products over base year 2011-12.

Indian agriculture is developing day by day. However, the overarching concerns, some of which are natural while others are manmade, include small and fragmented land holdings, climate change, nutritional and livelihood security, poverty alleviation, profitability, gender equity, ecology and environment, and competitiveness in terms of cost and quality. These will continue to be major issues before the NARS. Priority issues that call for attention include availability of water and its quality, soil health, genetic resource conservation, insulating farm production against increasing biotic and abiotic stresses, managing climate change, diversification, post-harvest management, enhancing input-use efficiency, energy management, increasing preparedness to match rapidly evolving trade regime, reducing knowledge lag, and congenial policy environment.

India's food security depends not only on producing cereal crops, but also diversifying the food basket to meet the demands of an ever growing population as well as changing consumer preference towards processed and value added products.In the changing context the need for Second Green Revolutionis being expressed for enabling a change in agricultural productionthat is necessary to meet and sustain the growing demands.

Challenge for public sector research is to increase the long-term productivity of agriculture and food industry, while maintaining and enhancing the natural resource base. The National Agricultural Research Systems (NARS), spearheaded by ICAR, is reorienting the priorities towards enhancing farm productivity, agricultural diversification and value addition to each commodity in direct synchrony with the market. To achieve this objective, deployment of new and latest research and technologies available globally has become imperative. In all, the role of agricultural

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research and education remains as the foundation for primary and secondary produce in agri-sector *per se*.

Consortia Research Platforms are proposed specifically in critical areas such as Water, Seed, Diagnostics and vaccines, Nanotechnology, Bio fortification, Agri-incubators, Natural Fibres, Health Foods, Hybrids, Secondary Agriculture, Farm Mechanization, Precision Farming and Energy, Genomics, Molecular breeding and Agrobiodiversity and networks in borers and phytochemicals. These platforms are intended to carry out multi-disciplinary, focused and time bound research in respective areas. The partnership of ICAR in terms of Inter-Departmental partnerships with core science institutions (public and private) are the major strengths of the consortia platforms.

The technological and knowledge empowerment of the farmers is imperative. Innovative initiative, *'Farmer FIRST'* to improve technology dissemination is contemplated. The programme will have enhanced farmers-scientists interface for technology development and application with the primary objective to take up technology development based on feedback with the participation of various stakeholders specially farmers**.** *Student READY* (Rural Entrepreneurship and Awareness Development *Yojana*) is another novel programme envisaged that aims at entrepreneurship development among youth. It combines both Rural Agricultural Work Experience (RAWE) and Experimental Learning courses to provide students with the grass-root level experience and entrepreneurship skills. The challenge that lies ahead is how to make agriculture and rural professions intellectually stimulating and economically rewarding to enable to attract and sustain rural youth in agriculture and allied sectors.

Technology can show impact only if enabling conditions, policies and economic environment are favourable. The seeds sown for science-led inclusive agricultural growth will lead to an all-round development of a resilient, globally competitive and profitable agriculture.

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