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PROMISING TECHNOLOGIES

Weed management in organically grown tomato

Organic agriculture when practised for a long-term basis can eliminate harmful effects of chemicals on the crop produce and also on the environment. Weeds are, however, the major bottleneck in practising organic agriculture. Among the non-chemical approaches of weed management, mulching is a good option.

Prepare the field thoroughly for tomato-crop by removing soil clods and crop residues. On the leveled field, small pits are dug at a spacing of 60 cm × 40 cm; and vermicompost is mixed in the field at 5 tonnes/ha. Spread black polythene-sheet on the field, and on it round holes of 15-cm diameter are made at the above-mentioned spacing. Transplant 20-day-old tomato-seedlings in the middle of the hole, and water them regularly as per the need. Due to polythene-sheet, weed seeds do not germinate.

In tomato-crop, weeds are a serious problem; reducing its fruit yield by 70%. A few weeds may even grow up in the vicinity of tomato-plants, while black polythene cover is on the field, these need to be removed manually. Care should be taken that

An organically grown tomato field with black polythene-sheet to control weeds

Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001, India
www.icar.org.in

- Black polythene sheet cost for one hectare field is approx ₹25,000-30,000; it can be reduced by using it 3 to 4 times.
- With this technology, there is complete control of weeds, better conservation of soil moisture; and pests and diseases infestations are comparatively lesser.
- Tomato-fruits yield would be 40-50 % higher than farmer's practice; and organic tomatoes may fetch 30-40% higher price in the market. The benefit: cost ratio obtained in the field study was 3.69 compared to 2.99 with farmer's practice.

polythene-sheet is not damaged by stray animals. After the last picking of tomatoes, carefully remove polythene-sheet, wash it thoroughly in running water, and store it properly for the next use. The polythene-sheet may be used on the same field for more than 3 years to have the maximum economical benefit.

Following are the precautionary measures to be adopted for using this technology: *(i)* The field should be clean, well-prepared and leveled before spreading black polythene; *(ii)* There should not be any source of pesticide contamination such as water sources from other fields; *(iii)* Polythene-sheet should be handled with care for future use for the succeeding crops. After use even small pieces of polythene-sheet should be removed from the field and disposed appropriately.

R.P. Dubey
ICAR-Directorate of Weed Research
Jabalpur (Madhya Pradesh) 482 004

Pulses production enhancement through summer mungbean

Mungbean, a fast growing and remunerative pulse crop, with low water requirement can have the requisite yield potential in meeting shortfalls of total pulses production. There are certainly avenues for higher production of summer mungbean (with existing low coverage or land-use) through amalgamation of improved technologies — varietal intervention (Samrat, IPM 02-3, IPM 99-125, SML 134), compatible pre- and post- emergence herbicides/ pesticides application, precision management in crop cultivation, complemented/supplemented with appropriate micro-irrigation- based irrigation scheduling and suitable land configuration (raised bed/ridge planting, especially during *kharif*), replenishing nutrients based on *Soil Health Cards* for optimum fertilization, including application of Zn, S and Mo (in presence of adequate P and K) ,and use of suitable machines from planting (IIPR No Till Drill) to harvesting operations/value-addition.

Field experiments in the North Plain Zone have revealed that when summer mungbean is planted during the last week of March after potato/garlic or winter vegetables, it requires only two irrigations (due to higher residual soil moisture) in comparison to normal 3-4 irrigations for later planted crop, after wheat/vegetables (with low residual soil moisture in April). Significant improvement in seed yield (31%) with water saving (11% less water use and 43.2 % enhanced WUE) was recorded with precision tillage carried out by laser leveler. Sprinkler irrigation enhanced irrigation efficiency of mungbean with 20% lesser water use and 24 % higher WUE over flood or normal irrigation at podding and seed- setting. A popular mungbean variety Samrat suffered in hot summer due to blanket irrigation owing to irregular *in-situ* depressions/ ponding zones developed in the fields, especially when it was not accompanied by laser leveler.

IIPR No Till drill (with labour requirement of around 40man-hr/ha; field capacity of 20hr/ha, low cost of <1000 INR/ha and low energy of operation of <80 MJ/ha)

Large plot demonstrations laid to study effects of overhead sprinkler irrigation + improved agro-techniques (paired row, narrow row spacing with sprinkler irrigation) showed beneficial role of sprinkler irrigation in late afternoon/ evening hours in summer mungbean. Although there were similar yield gains

Irrigation scheduling aided with overhead sprinklers and laser leveler (precision tillage)

Influence of tillage and irrigation on mungbean yield (kg/ha)

under sprinkler *vis-à-vis* flood irrigation at critical stages (two irrigations at branch and pod), yet there was significant water economy through micro-irrigation (35-50%). Planting at uniform 30- cm row spacing with farmer's practice reduced its seed yield to the extent of 16-20% over 22.5- cm row spacing. Variations in performance of different varieties also exists (10% additional yield was realized with Samrat at 1.23 tonnes/ha over IPM 205-7 at 1.12 tonnes/ha, when mungbean was sown during the last week of March).

In variety × row spacing evaluation trial under late planting (after wheat), significant higher grain yields were obtained at 15cm ×10 cm (1.56 tonnes/ha) when mungbean was planted during the 2nd week of April

Biomass and grain yield (tonnes/ha) of summer mungbean under different sowing dates

Row spacing	Sowing date			
	March last week		April 2nd week	
	Total biomass	Grain yield	Total biomass	Grain yield
15 cm x 10 cm	3.42	1.28	7.06	1.56
22.5 cm x10 cm	3.25	1.22	5.58	1.24
30 cm x 10 cm	2.78	1.05	4.45	1.04
C.D. (0.05)	0.19	1.13	1.23	0.45

over 22.5cm×10 cm and 30cm×10 cm. Although varieties differ in their yield performance; yet 22.5cm×10 cm spacing was found optimum and economically superior (as with low seed rate) irrespective of varieties and sowing dates.

Diversification and intensification of rice-wheat cropping system in the northern India through introduction of pulses has long been neglected by farmers as a profitable and viable enterprise. Development of infrastructure facilities like irrigation water availability renders this system feasible and economically viable. Over several trials conducted on on-farm situations, it has been amply demonstrated that such possibilities do exist, and low-input requiring pulses can be popularized as a soil- building crop also. In the studies at on-farm (Fatehpur and Kanpur Dehat of Uttar Pradesh), farmers cultivated mungbean Samrat just after harvest of winter wheat with low inputs and only 2-3 need- based irrigations. The crop was planted at 30- cm row spacing in line or broadcast in the entire field after plough, followed by a plank. Comparison of both revealed yield reduction in the latter due to inadequate plant stand and plant population and little/inadequate plant protection.

Seed yield of summer mungbean realized was up to 750 kg/ha in 60-65 days without any second picking (due to synchronous maturity). Higher gross returns to the extent of ₹ 33,000 within a short span of 2 months motivated farmers to take-up spring/summer mungbean cultivation, especially where supplementary irrigation can be managed. Farmers also realized higher rice yield due to improved soil fertility; as mungbean was buried in the field. As there are better returns, farmers have started growing summer mungbean after wheat/garlic or even after potato. As the water requirement of the crop is lesser in comparison to other cereals and oilseeds, mungbean can be profitably grown and adopted under water-scarcity areas and rainfed/dryland areas (through supplementary irrigation with water harvested from farm-pond, micro-water storage tanks).

Thus, within the technology framework, substantial productivity enhancement with existing short-duration varieties of pulses is possible, which fit- in well in different

(inter-) cropping systems to augment vertical expansion of pulses. Mungbean for example through the development of new plant types, photo-thermo-insensitive cultivars and matching agrotechniques can help expanding areas under pulses further in the non-traditional areas, thereby both up- and out-scaling productivity (over seasons and locations) and overall production scenario of the country.

N.P. Singh, C.S. Praharaj, S.S. Singh, Ummed Singh and **N.Kumar**
ICAR-Indian Institute of Pulses Research
Kanpur (Uttar Pradesh) 208 024
e-mail: cspraharaj@hotmail.com

High fibre *Tortilla Chips*

Snacks, particularly potato and corn chips, are preferred by all age groups throughout the world. Mostly, chips are deep-fried, thus resulting in products with high fat content. Health conscious consumers choose mostly functional foods with desirable health benefits. Lately, functional ingredients such as fibres are being added to different processed foods.

A technology for low-fat corn chips through baking has been standardized. Corn, the base material used for tortilla-chips making, was procured from the local market. It was nixtamalized by cooking it in calcium hydroxide solution (1%) for 30 min. Then it was steeped in the same solution for 4 h, followed by thorough washing in water. This was ground to get masa and dried to powder form. For preparing high- fibre tortilla chips, nixtamalized corn masa was replaced with 0, 10, 20 and 30% of ground wheat-bran or rice-bran or pulse seed-coat or dry soy-okara. Tortilla chips are prepared using the following— 100 g masa, 15 g shortening, 3 g sodium chloride, 1.5 g sodium bicarbonate and 50- 55 ml water. The blend is mixed at a low speed with a hook for 30 seconds and for 90 seconds at the medium speed. The masa is allowed to stagnate by covering with a stretchable film and is equilibrated for 30 min. After equilibration, masa is sheeted to 1-mm thickness and cut to form tortilla chips. The chips are baked at 200°C, cooled and are stored in polyethylene bags.

Tortilla chips enriched with 10% wheat-bran

Tortilla chips enriched with 20% soy-okara

Tortilla chips composition

Sample	Protein (%)	Crude fibre (%)	Fat (%)	Ash (%)	Total anti-oxidant capacity (µ mol Trolox/g)
Control	6.64	1.95	15.72	4.12	9.53
Soy-okara					
10%	7.20	4.24	18.27	4.20	14.66
20%	9.03	5.76	17.52	4.14	15.40
30%	9.10	8.01	14.05	3.93	15.93
Wheat-bran					
10%	7.43	5.91	19.47	4.20	10.82
20%	7.84	7.74	18.90	4.60	13.05
30%	8.16	9.10	16.92	6.50	16.16

Tortilla chips prepared by incorporation of soy-okara or wheat-bran at 20% were found the best, followed by those with addition of rice- bran and pulse seed -coat at 10%. Protein and fibre content of the chips increased with increased fortification (maximum protein is in soy-okara fortified chips). With increasing percentage of added fibres, chips antioxidant capacity also increased significantly.

- These chips are a good source of proteins and crude fibres; addition of soy-okara increases overall protein content by 3%; the chips can be used in fortification programmes to combat malnutrition in children.
- Chips are developed through baking.
- Chips from maize with addition of soy-okara or rice-bran or pulse seed-coat are gluten-free, and hence are good for celiac patients.

Shruti Sethi and **Sangeeta Gupta**
Division of Food Science and Post-harvest Technology
ICAR-Indian Agricultural Research Institute
New Delhi 110 012
e-mail: docsethi@gmail.com

Control *Parthenium* with *Zygogramma bicolorata*

Parthenium hysterophorus (Asteraceae), locally called Gajarghas or Congress grass, is an alien plant introduced into India in the early fifties along with wheat, imported from the USA. Since then it has spread and invaded 35 million hectares in the country.

Parthenium causes skin allergy, hay fever and breathing problems in man and animals; besides it reduces crop production and causes loss of biodiversity. Its occurrence from Port Blair Island (Andman and Nicobar), Minicoy Island (Lakshadweep) and cold region of Jammu and Kashmir can be considered as an indicator of its wide adaptability in India. It has immense power of seed production; up to 25,000 seeds can be produced by a single plant.

In non-cropped area, *Parthenium* can be effectively managed by using a host-specific exotic bioagent *Zygogramma bicolorata* of family Chrysomelidae, a native of Mexico, which is also the place of origin of *Parthenium*. Bioagent(500 to 1,000 in number) can be released in a *Parthenium*- infested area in different patches in 50 to 100 in number; covering entire infested area during rainy season (June to August), when plenty of fresh *Parthenium*- plants grow-out. After establishment, bioagent increases its population and infests *Parthenium*. Once established, bioagent works on a sustainable basis. due course infested site may have restoration of biodiversity also. Results have shown that in non-cropped area, bioagent suppresses *Parthenium* effectively during rainy season.

At Jabalpur, study based on the herbicide-cost incurred in the area controlled by beetle was calculated, and found net economic returns 135% per annum by the third year, which increased to 608 and 2700% per annum for a single herbicide application by 4th and 5th year, respectively. The returns would have increased multifold

Before release **After release** **Defoliation by bioagent** **Restoration of biodiversity**

Sequence of restoration of biodiversity due to continuous work of bioagent at the given site

On approaching winter season, its survived population undergoes diapause in the soil and emerges intermittently when conditions are congenial. Its maximum population emerges during the next rainy season but it may emerge throughout the year. Augmentative releases can be made by collection of adult-beetles from the area of abundance to the area of poor establishment. Biological control helps control existing *Parthenium* and reduces its seed bank; and in a if benefits derived in the form of environmental safety and sustainability were also taken into consideration; about 8 million hectares could be saved from *Parthenium* due to the bioagent.

Shushilkumar
ICAR-Directorate of Weed Research
Jabalpur (Madhya Pradesh) 482 004
e-mail: sknrcws@gmail.com

Colour shade-nets for crop protection under changing climate

Agricultural production is decreasing due to increased air temperature and intensity of solar radiations because of changes in the climate. Keeping this in view, an experiment was conducted during summer at New Delhi

to know micro-environment under differents colour shade-nets and their influence on the biophysical parameters of spinach.

Spinach (variety Pusa Bharti) was sown during summer. The crop was raised under white, black, red, green coloured shade-nets and in control (without shade-net). Different weather parameters (temperature, relative humidity and wind speed), light intensity, percentage reflectance, canopy temperature, photosynthetically active radiations, soil moisture, soil temperature, crop-growth parameters (leaf area, biomass, leaf length, chlorophyll content) and radiations interception were measured at different growth stages. Radiation-use efficiency, water-use efficiency and different heat indices were computed.

Experiment under different colour shade-nets

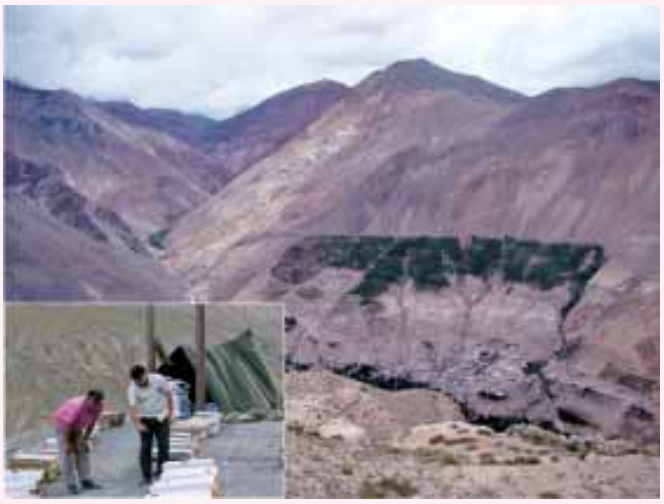
Air temperature, wind speed, soil temperature, canopy temperature, light intensity, radiations and different accumulated heat indices such as Growing Degree days (GDD),Photo Thermal Units (PTU), Helio Thermal Units (HTU), Photo Thermal Index (PTI) were found lower under different colour shade-nets as compared to control, and percentage reflectance and value of Normalized Difference Vegetation Index (NDVI) and Vegetation (VI) were more in green, followed by red, black, control and white. Heat-use efficiency was higher under green shade-nets, followed by red, white, black and control. Relative humidity and soil moisture showed higher value under colour shade-nets than in control. Biomass, leaf area, chlorophyll content, yield as well as radiation-use efficiency and water-use efficiency also were higher in coloured shade-nets. And the yield was highest under green as well as red shade-nets, followed by white, black and control. From the above studies, it can be concluded that coloured shade-nets can be a new, multi-benefit tool for crop protection. Among different shade-nets, green and red shade-nets have been found better, followed by black and white.

Ananta Vashisth, Rekha Kumari Meena, P. Krishnan and **Balaraj Singh**[1]
Division of Agricultural Physics
ICAR-IARI, New Delhi 110 012
[1]ICAR-NRCSS, Ajmer (Rajasthan) 305 206
e-mail: anata.iari@gmail.com

Herbal honey from tribal cold deserts of India

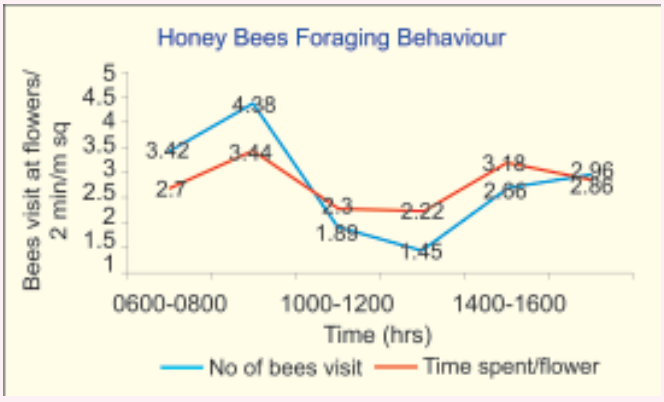
Cold desert region of Himachal Pradesh has been known for about 113 plants of medicinal value. Caper-plant, *Capparis spinosa* (syn. *Capparis rupestris*, *Capparis ovata*), is one such medicinal-herb found growing sparsely in Pooh valley of district Kinnaur and Spiti valley of district Lahaul-Spiti of Himachal Pradesh. Caper-plants are found growing up to 3,500 m above sea level in Leh and Ladakh, though usually grow wild at the lower altitudes in cold desert regions of the north-west Himalaya. Caper-bush possesses strong antiviral properties, which are beneficial in the preliminary treatment of acute viral hepatitis and liver cirrhosis. As an antioxidant, it helps delaying signs of aging, like wrinkle formation. The herb is also anti-inflammatory, useful in treating pain associated with joint aches and rheumatism. The plant extract also is useful in treating senile pruritus, itching and other ailments associated with old age and anxiety neurosis.

After pollinating apple-trees till the end of May, the honey-bee colonies did not find alternate nectar and pollen-yielding flora in and around the apple-orchards. Therefore, 42 bee-colonies were migrated to Poh locality (Spiti valley) of Himachal Pradesh at an altitude of 3,242 m amsl to extract honey-dew from willow plantation, densely grown in the area; for survival of honey-bee colonies during the dearth period. But it was noticed that honey-bees were frequently visiting bush-type vegetation, locally called Himsra, growing sparsely in the valley. The flowering period of Caper-bush was, therefore, exploited for honey- bee colonies survival and additional herbal honey harvesting during the lean period. The scientific literature had no information with respect to its honey-yielding potential. Thus, Caper-bushes in Samdho, Sumra, Giu, Hurling, Lari, Poh, Sichling areas



along the Indo-Tibetan border were harnessed for honey-yielding potential. Locally, the bushes are found growing spontaneously well in cracks and crevices of rocks and stone-walls.

The peak foraging activity and time spent/visit/flower of *Apis mellifera* were recorded on the bushes from 0800 to 1000 and 1600-1800 hrs; and the least activities were observed from 1200 to1400 hrs.



Total sugar was found much less from Caper-bush honey than other multiflora/uniflora honey. Based on the results obtained, it is concluded that 80% of the chemical

composition of honey samples collected from cold desert region confirmed to the requirement of Codex Alimentarius 2001. A total of 256 kg herbal honey extracted from 42 colonies in 80 days in two harvests resulted in revenue generation of ₹130,560. This honey was marketed as 'Telangi Honey' named after the Panchayat adopted under the NICRA project. This unifloral honey demonstrated a unique flavour and aroma which can be utilized as a herbal medicine for diabetic patients.

Physico-chemical properties of Caper-bush honey

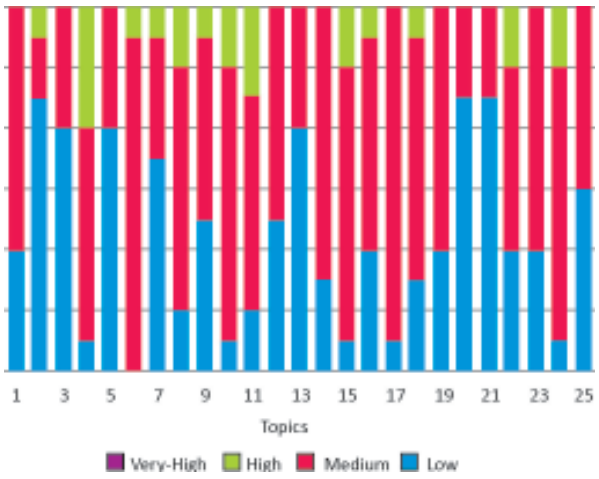
Parameter	Concentration
TSS (°Brix)	74.0
Titratable acidity (%)	0.25
Moisture (%)	17.14
Reducing Sugar (%)	41.66
Non-Reducing Sugar (%)	5.63
Total Sugar (%)	46.29
Total Phenols (mg/100g)	42.87
Ash contents (%)	0.32
pH value	3.4
Organoleptic quality	5.5

This region thus requires consideration as a potential area to support honey-bees feeding during dearth months. The production of herbal honey from a rich herbal medicinal source will provide additional remuneration from dry temperate and cold desert of tribal area after termination of pollination period of apples.

RS Chandel, Rakesh Kumar, Rajender Sharma and **Pramod Kumar**[1]
Dr YS Parmar UHF-RHRTS and KVK, Sharbo, Kinnaur (Himachal Pradesh)
[1]Dr YS Parmar UHF-RHRTS Dhaulakuan, Sirmour (Himachal Pradesh)
*e-mail:*rs_c@rediffmail.com

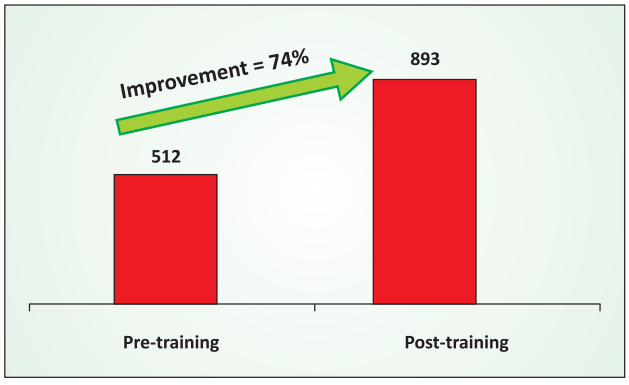
Training programme for the officers of the *Indian Economic Services*

Training programme for 5 days from 23 to 27 May 2016 was organized for the Indian Economic Services (Probationers-batch 2015) on the Core Issues Related to Agriculture Sector. Twenty- five topics on important issues related to agriculture were covered. Topic-wise pre-training assessment of the participants indicated that they had mostly medium to low level of knowledge-base in most of the topics. The overall assessment indicated that 55 % of them had medium level of knowledge while 37 % had low level of knowledge.



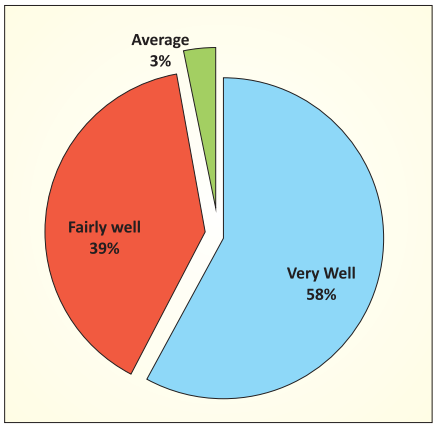
Participants' pre-training topic-wise knowledge-base

Contrary to pre-training assessment, post-training assessment indicated their high level of knowledge-base on most of the topics. Their overall post-training knowledge-base to maximum extent was 64% in high category, followed by very high (18 %), medium (17 %) and low (1 %). Pre-training composite knowledge-base score of participants at 512 increased to 893 in the post-training evaluation, showing a growth of 74.41 %.

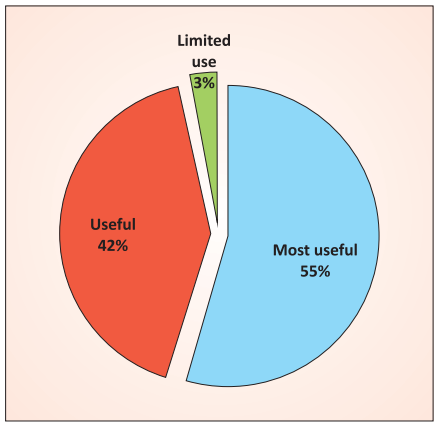


Pre- and post-training composite knowledge-base score and proportional improvement

Elicitations from trainees on the coverage of different topics suggested that 58% participants believed that topics were well covered, while 39% of them rated as covered fairly well. Similarly their opinion on usefulness of the topics was as follows: 55% found topics most useful, followed by 42% suggesting them as just useful, and 3% found some topics of limited use. Some of the participants opinionated that number of topics should have been lesser and coverage should have been more comprehensive and deep, while others emphasized that exposure to more number of topics with the discussion on key policy, as followed by the organizers, was more appropriate. All of them indicated their desire to visit more facilities and technologies in the Pusa complex.



Participants' elicitation on the extent of coverage of different topics



Participants' elicitation on the extent of usefulness of different topics

Approximately, 84 % participants were very satisfied with the training; 16% were either partially satisfied or partially dissatisfied. A number of them desired for open field experiments, which did not happen due to absence of crops in the fields.

Rajesh K. Rana, Usha Ahuja and **Renu Martolia**
ICAR-National Institute of Agricultural Economics and Policy Research
DPS Marg
New Delhi 110 012
e-mail: rkrana 2004@yahoo.com

Diversity of landraces and crop wild relatives from Uttarakhand

Landraces and traditional cultivars of crops are the most important plant genetic resource (PGR), and therefore hold an important position in the cultural heritage throughout the world. Crop wild relatives (CWR) can be better adapted and are a good source of new genes for improvement of varieties for acclamatization to changing climate. Keeping this in view, an exploration was undertaken in Nainital and Udham Singh Nagar (latitude 29° 18' - 29° 3'N and longitude 78° 50' - 80° 5'E) districts of Uttarakhand during October 2015. This area, being the transitional zone between foothills and lesser Himalayan zone, is the hot-spot of diversity of traditional landraces and crop wild relatives.

Field of wild rice (*Oryza nivara*), collected from Sitarganj, Udham Singh Nagar, Uttarakhand

A total of 42 accessions (23 taxa) of different agri-horticultural crops collected, comprising 15 of cultivated and 27 of wild relatives/ wild economic species, include **cereals**: *Oryza sativa* (silky dhan), *O. nivara* (jangli dhan), *Eleusine coracana* (manduwa); **vegetables:** *Abelmoschus manihot* var. *tetraphyllus, Amaranthus dubious, A. spinosus*, *Coccinia indica* (wild kundru), *Cucumis sativus* var. *hardwickii*, *C. sativus* (kakri/kheera), *Luffa acutangula* var. *amara, L. acutangula* var. *hermaphrodita, L. graveolens, Trichosanthes bracteata, T. cucumerina, Solanum indicum*, *S. nigrum* (makoi); **spices and condiments:** *Cleome viscosa* (jakhya); **legumes:** *Vigna unguiculata* (sonta), *Glycine max* (kala bhatt); **oilseeds:** *Sesamum mulayanum* (wild); **fibres:** *Corchorus tridens, Crotalaria striata.*

Among landraces/local types significant ones are: *Glycine max* (black-seeded soybean, kalabhatt), *Eleusine*

Landraces and crop wild relatives collected and identified from Uttarakhand

Crop group	Botanical name	Vernacular/local names	Source* and period of availability	Remarks
Cereals	*Eleusine coracana*	Manduwa, koda	CFS; Oct.- Nov.	Traditional staple food for making *chapatti*; rich in nutrition
	Oryza sativa	China dhan,Silky dhan	CFF; Oct.- Nov.	Landrace; now very rare in the area
	Oryza nivara	Jangli dhan	CW; October	Wild relative of paddy
Vegetables/spices	*Abelmoschus manihot* var. *tetraphyllus*	Wild bhendi, Sukhlai	CW, CFF; Oct.-Nov.	Wild relative of okra; roots/ stem used as organic clarificant for local jaggery production
	Cleome viscosa	Jakhya	CW; Oct.- Nov.	Potential condiment/spice in farmer's field
	Cucumis sativus	Hill cucumber (pahadi kheera)	CFF; Sept.- Nov.	Landrace; cultivation now occasional; fruit tasty, used as salad and for preparation with curd
	Luffa acutangula var. *amara*	Jangli tori	CW; Oct.-Nov.	Crop wild relative of sponge-gourd
	Trichosanthes bracteata	Indrayan	CW; Oct.- Nov.	Related to pointed- gourd; medicinal use
	Trichosanthes cucumerina	Jangli chichinda	CW; Oct.- Nov.	Related to pointed-gourd
Oilseeds	*Glycine max*	Kala bhatt	CFF,CFS; Oct.-Nov.	Landrace of soybean; growing out of cultivation; used as local *dal* (bhaat churkani)

* CW-Collected from wild; CFF-Farm field; CFS-Farm store

Hanging fruits of *Trichosanthes cucumerina* at Ramgarh, Nainital, Uttarakhand

coracana (open and closed types of head), *Cucumis sativus* (pahadi kakri/pahadi kheera), primitive cultivars of paddy (China and Silky dhan) and among wild species are: *Luffa* (*L. acutangula* var. *amara*, *L. graveolens*), *Abelmoschus manihot* var. *teraphyllus*, *Solanum nigrum*, *S. indicum*. Wild paddy (*Oryza nivara*) has been reported growing for the first time in shallow water-bodies at the foothills in Jaspur, Rajpur and Sitarganj areas of Udham Singh Nagar.

During exploration, information on diversity in landraces, uses, losses of genetic resources and their important traits was collected from 12 villages and 35 households of two districts. It was observed that spread of high-yielding varieties (HYVs), vast urbanization and fast changing land- use patterns were the prime reasons of genetic erosion and loss of primitive cultivars/local landraces. Damage of crops mostly vegetables by wild animals was the main causal factor for discontinuation of their farming, especially by small-land farmers in Nainital district and adjoining areas.

Anjula Pandey, D.P. Semwal, Rita Gupta and **S.P. Ahlawat**
Division of Plant Exploration and Germplasm Collection
ICAR-National Bureau of Plant Genetic Resources
New Delhi 110 012
e-mail: anjuravinder1960@gmail.com

Button-mushroom-spent-substrate used for compost preparation

The country produces around 1.20 lakh tonnes of fresh mushrooms per year, and button -mushrooms account for 85% of it. Spent-mushroom-substrate, the left-over crop- residue after mushroom harvest, is the secondary product from mushroom cultivation. For every one kg of fresh mushroom production, around 3-5 kg of spent-substrate is generated from different mushrooms. It is around 5 kg in the case of button- mushroom. So in consequence of 1.20 lakh tonnes of fresh mushroom production, country produces around 5-6 lakh tonnes of spent-mushroom-substrate (SMS), which may cause environmental problems. This substrate is still a nutritionally rich organic residue. Considering nutritional composition of the substrate, a series of experiments were conducted to use it as a basal ingredient for button-mushroom compost-making in partial replacement to wheat-straw, which otherwise has many other primary uses also.

Quality characteristics of button-mushroom compost prepared with wheat-straw replacement by button-mushroom-spent-substrate

SMS treatments	Button-mushroom compost properties								
	TOC (%)	OM (%)	TKN (%)	Phosphorus (%)	Potassium (%)	C:N	Total sugars (µg/ml)	Cellulose (%)	Lignin (%)
Standard formulation	34.7	59.9	1.9	0.9	1.8	18	24.2	24.8	37.2
20% w/w wheat-straw replacement with SMS and N balancing	34.7	59.9	1.9	0.7	1.6	18	30.0	24.6	44.4
20% w/w wheat-straw replacement with SMS without N balancing	35.8	61.7	2.0	0.8	1.9	18	34.4	26.4	46.2
30% w/w wheat-straw replacement with SMS without N balancing	35.4	61.0	2.1	0.7	1.8	17	34.4	25.6	46.4

TOC – Total organic carbon, OM – Organic matter, TKN – Total Kjeldahl nitrogen

Button-mushroom spent-substrate with around 55-60% moisture was used in three different proportions—20% w/w and balancing of nitrogen with poultry manure; 20% w/w without N balancing and 30% w/w without N balancing. Standard formulation with wheat-straw 1,000 kg, poultry manure 700 kg, wheat-bran 150 kg, urea 15 kg and gypsum 35 kg was kept as control. The improved formulation has wheat-straw 700 kg, poultry manure 490 kg, wheat-bran 105 kg, urea 10.5 kg, button-mushroom- spent-substrate 600 kg and gypsum 35 kg. Standard two- phase short method of compost-making was used for button- mushroom compost preparation. The process was repeated 5 times. Composts prepared from different SMS substituted treatments were found nutritionally richer than the compost prepared from standard formulation. Percentage of nitrogen, cellulose, lignin, total organic carbon, organic matter, total sugars and potassium content was higher in composts prepared with substitution of wheat-straw with different proportions of SMS as compared with the compost from the standard formulation.

Wheat-straw (*left*) and button-mushroom-spent-substrate (*right*)

Button-mushroom crop on the compost prepared with wheat-straw replacement by button-mushroom-spent-substrate

In all trials, compost output/unit wt of wheat-straw used was higher (3.18 to 3.31) in the case of wheat-straw replacements with SMS compared with the standard formulation, where it was 2.8. In two trials, fruit-body yield/q fresh compost was higher in all SMS substituted treatments, while in one trial it was higher in 20% w/w SMS substituted treatment only; and in the rest, it was at a par with the standard formulation.

The mushrooms harvested from wheat-straw replacement composts with button-mushroom-spent-substrate were richer in contents of ash, vitamin D and minerals, especially of potassium, potassium: sodium ratio, iron, manganese, zinc, selenium and copper. These were at a par with respect to protein content and slightly lesser in fibre content.

Compost production by substitution of wheat- straw with button-mushroom-spent-substrate led to saving of ₹ 600/ tonne of fresh compost production.

The saving for a small size mushroom unit with production capacity of 100 tonnes of fresh mushroom/ year can go around 3.0 lakh/year, and this can go up to 30.0 lakh for mushroom unit with production capacity of 1,000 tonnes of fresh mushroom production/year.

Button-mushroom fruit-body yield in composts prepared with different proportions of wheat-straw replacement by button-mushroom-spent-substrate

SMS treatments	Fruit-body yield in 2 weeks crop (kg/q compost)		Nos of fruit-bodies/ q compost		Mean fruit-body wt (g)	
	Trial - I	Trial - III	Trial - I	Trial - III	Trial - I	Trial - III
Standard formulation	16.82	11.36	1,431	738	11.75	15.40
20% w/w wheat-straw replacement with SMS and N balancing	16.93	13.05	1,338	791	12.65	16.50
20% w/w wheat-straw replacement with SMS without N balancing	16.10	13.24	1,368	812	11.77	16.30
30% w/w wheat-straw replacement with SMS without N balancing	16.27	12.77	1,364	803	11.93	15.90
$CD_{0.05}$	2.46	1.63	87.52	64.28	1.78	1.15

Quality characteristics of fruit-bodies harvested from composts with button-mushroom-spent-substrate

Parameters	Different compost formulations							
	Standard formulation		20% w/w wheat-straw replacement with SMS and N balancing		20% w/w wheat-straw replacement with SMS without N balancing		30% w/w wheat-straw replacement with SMS without N balancing	
	Flush-I	Flush-II	Flush-I	Flush-II	Flush-I	Flush-II	Flush-I	Flush-II
Protein (%)	40.71	36.57	33.80	39.52	39.15	44.19	31.68	41.68
Crude fibre (g/100 g)	2.07	1.81	0.80	1.41	1.69	1.18	1.01	1.69
Ash (g/100 g)	10.23	11.05	10.35	11.44	11.20	11.47	9.98	11.83
Vitamin D (µg/100 g)	231.9	678	612.6	737.8	241.8	632.7	340.6	1285.7
Potassium (%)	4.47	5.25	4.76	5.50	5.10	5.39	4.65	5.68
Potassium: Sodium	88.87	71.82	89.64	83.59	91.23	80.33	82.45	82.80
Iron (mg/kg)	98	89	104	98	107	179	132	173
Manganese (mg/kg)	8.45	7.44	7.60	9.07	8.72	9.81	9.73	10.28
Zinc (mg/kg)	61	52.6	53.8	60	79.2	64.6	60.2	66.2
Selenium (mg/kg)	2.45	3.60	2.17	4.22	2.24	5.51	2.04	5.39
Copper (mg/kg)	37.1	34.7	34.2	36.5	45.1	46.1	34.7	46.0

The savings have only been calculated with respect to the saving on the raw materials, considering mushroom productivity at the same level. This is an environment friendly process.

O.P. Ahlawat and **Bindvi Arora**
ICAR-Directorate of Mushroom Research, Chambaghat
Solan (Himachal Pradesh) 173 213 *e-mail:*
ahlawat22op@gmail.com

Colourful radishes for healthier salad

Radish is an important salad-vegetable grown and consumed throughout the world for its fleshy roots. Anthocyanins' (the most versatile polyphenols and a class of pigments) presence is responsible for pink, red, purple and violet coloured radishes. Among anthocyanins, pelargonidine and cyanidine, are responsible for pink/red and purple/violet colour, respectively. Coloured radishes in salad as colorants are gaining popularity because of their antioxidant properties and other potential health benefits. Anthocyanins, in general, are known to lower possibility of cardiovascular disease, prevent obesity, inhibit formation and progression of atherosclerosis, and reduce risk of diabetes, certain types of cancers, oxidative stresses and age-related diseases.

The six genotypes developed have better yield potential, superior root quality (uniform shape, smoother root and a fewer secondary roots), more phyto-nutrients, and are found to have potential in four categories of root pigmentation—red exterior (VRRAD 143 and VRRAD 131-2); red exterior and red xylem (VRRAD 130); purple exterior (VRRAD 131 and VRRAD 135); and purple exterior and purple xylem (VRRAD 151). They possess 80-250% higher ascorbic acid (18.5–26.5.0 mg/100g FW), total phenolics (32.5–65.0 mg/100 g FW), anthocyanin content (90–175 µg/g FW), antioxidant-FRAP value (3.15–5.90 µmol/g FW) and antioxidant-CUPRAC value (5.25–11.50 µmol/g FW as compared to white-coloured commercial cultivars. Therefore, dressing salads with these radishes would make salad more nutritious and healthy.

B.K. Singh, T.K. Koley, Bijendra Singh and **P.M. Singh**
ICAR-Indian Institute of Vegetable Research
Shahanshahpur, Varanasi (Uttar Pradesh) 221 305
e-mail: bksinghkushinagar@yahoo.co.in

Plant wealth in *Home Gardens* from Dhari Block of Uttarakhand

In recent years, Home Gardens have created interest as a sustainable agriculture system for on-farm crop-diversity conservation as well as for generation of income.

The present study was conducted in Naula gaad watershed management of Dhari block (situated between longitude 29°52'47'' N and latitude 78°38'15'' E ; total geographical area of Dhari block is 238 km^2) for selection of plant diversity, especially for Home Gardens, and understanding the role of these gardens in day- to -day life. With questionnaire and survey, information was collected from 6 villages—Chaukuta, Dhanachuli, Gajar, Kasiyalekh, Podiyal and Pokhrar (situated between 1,700 and 2,200 m asl)—and 30 households. Ninety-three plant species were documented, belonging to 79 genera and 51 families. Of fruit species, 20 varieties documented comprised apple, apricot, peach, pear and plum. Some well-acclimatized varieties in temperate condition are: *Bar/*

Plant genetic resource maintained in temperate *Home Garden*

Plant wealth conserved in *Home Gardens*

Crop groups- 11	
(A): Cereals (04)	*Hordeum vulgare* L.; *Secale cereal* L.*; Triticum aestivum* L.; *Zea mays* L.
(B): Pseudocereals (01)	*Eleusine coracana* (L.) Gaertner
(C): Pulses (07)	*Cicer arietinum* L.; *Glycine max* (L.)Merrill; *Lens culinaris* Medikus.; *Macrotyloma uniflorum* Lam.; *Phaseolus vulgaris* L.; *Vigna radiata* (L.) R.Wilczek; *Vigna unguiculata* (L.) Walpers
(D): Leafy vegetables (06)	*Amaranthus caudatus* L.; *Brassica rugosa* Prain; *Brassica nigra* (L.) Koch.; *Brassica juncea* (L.) Czernajew & Cosson; *Spinacea oleracea* L.; *Trigonella foenum-graecum* L.
(E): Vegetables (13)	*Brassica oleracea* var. *botrytis* L.; *Brassica oleracea* var. *capitata* L.; *Capsicum annuum* L.; *Colocasia esculenta* (L.) Schott; *Cucumis sativus* L.; *Cucurbita maxima* Duchesne; *Lageneria siceraria* (Molina) Standley; *Lycopersicon lycopersicum* (L.) Karsten; *Pisum sativum* L.; *Raphanus sativus* L.; *Raphanus sativus* var.*caudatus* (L.) Hook.f & Anderson; *Solanum melongena* C.B.Clarke; *Solanum tuberosum* L.
(F): Fruits (18)	*Actinidia chinensis* Planch.; *Citrus aurantifolia* (Christmann) Swingle; *Citrus jambhiri* Lush.; *Citrus pseudolimon* Tanaka; *Citrus reticulata* Blanco; *Citrus sinensis* (L.) Osbeck; *Mangifera indica* L.*; Morus alba* L.*; Musa balbisiana* Colla.; *Passiflora edulis* Sims; *Prunus armeniaca* L.; *Prunus domestica* L.; *Prunus persica* (L.) Batsch; *Punica granatum* L.; *Pyrus communis* L.; *Pyrus malus* L.; *Saccharum officinarum* L.; *Vitis vinifera* L.
(G): Spices (07)	*Allium cepa* L.; *Allium sativum* L.; *Capsicum annuum* var. *annuum* L.; *Coriandrum sativum* L.; *Curcuma domestica* Valeton; *Mentha arvensis* L.; *Zingiber officinale* Roscoe.
(H) Medicinal plants (11)	*Aloe vera* L.*; Artemisia nilagirica* var. *septentrionalis* (C.B Clarke) Pam. Panini*; Ajuga bracteosa* Wallich ex. Benth.*; Bidens pilosa* L.*; Pilea scripta* (Buch-Ham ex D.Don) Wedd.*; Prunus cerasoides* D.Don*; Hedychium spicatum* Buch-Ham.ex J.E Smith.*; Mimosa pudica* L.*; Rumex nepalensis* Sprengel*; Tegetus patula* L.*; Urtica dioica* L.
(I): Fodder (03)	*Avena sativa* x *sterilis* Bor; *Medicago sativa* L.; *Trifolium repens* L.
(J): Fire wood (03)	*Pinus roxburghii* Sargent; *Quercus leucotrichophora* A.Camus; *Salix babylonica* L.
(K): Ornamentals (20)	*Alcea rosea* L.; *Begonia cucullata* Willd.; *Calendula officinalis* L.*; Cestrum nocturnum* L.; *Chrysanthemum coronarium* L. and *Chrysanthemum morifolium* Ramat.; *Dahlia variabils* (Willd.) Desf.; *Echeveria secunda* var.*glauca* (Baker) Otto; *Echinocereus procumbens* (Engelm.) Lem.; *Gladiolus* x *gandavensis* Van Houtte; *Hibiscus rosa-sinensis* L.; *Jasminum arborescens* Roxb.; *Lemaireocereus pruinosus* Otto.; *Nerium oleander* L.; *Ocimum basilicum* L.; *Pelargonium* spp.; *Petunia* x *hybrid* Vilmorin; *Rosa* spp.; *Tagetus erecta* L.; *Trachycarpus takil* Becc.; *Thuja orientalis* L.

Early/ 112, Bhura Delicious/Delicious/D.K, Fenny, Hara Pichola/ Buckinghum, King David, Red Golden, Rhymer/ 12, 22, 103 of **apple**; *Babbugosa/Kakadiya/Tumadiya, Chusani/Early, Gadmehal, Jagnail* of **pear**; *Badami, Chapta, Gola, Morpankh* of **apricot**; *Early Zone, Nactarine, Red Zone* of **peach**; *Centaroza, Jethiya, Jitua, Sarsoma* of **plum.**

The livelihood and culture of the block closely depend on the natural resources and Home Gardens to fulfill basic needs of the locals. The Gardens conserve genetic diversity of useful plants, which provide food and nutritional security. By adopting different crop sequences, locals maintained soil fertility and environmental health.

VandanaTiwari, K.S. Negi, Rajni Rawat, S.N. Ojha, P.S. Mehta and **S. Chandra**[1]
ICAR-National Bureau of Plant Genetic Resources
Regional Station, Bhowali, Niglat
Nainital (Uttarakhand) 263 132
[1]Department of Botany, S S J Campus
Almora, Kumaun University
Nainital (Uttarakhand) 263 601
e-mail: ksnegi1960@gmail.com

Rediscovered endemic fish, *Labeo rajasthanicus,* from western Rajasthan

The fish *Labeo rajasthanicus* was first described from Jaismund Lake in western Rajasthan region, based on the single specimen; it was never reported since its first description in 1970. The taxonomic status of the fish was not stable due to conflicting opinions—is it a valid species or is a synonym of *L. boggut*.

The present report redescribes species *L. rajasthanicus,* based on the specimen collected from its type of environment and other adjoining localities with the confirmation of its taxonomic status as a valid species and designation of a neotype; as the holotype specimen is no longer available. Morphometric and molecular data distinguish this from its congeners under genus — *L. gonius*, *L. boggut* and *L. dussumieri.* Analysis of the morphometric and meristic data as well as truss network measurements of all the four species confirmed distinct identity of this species.

Labeo rajasthanicus NBFGR-LRT-36 (TL 361 mm) recorded from river Tidi, western Rajasthan

Among all morphometric and meristic characters, anal fin rays showed significant differences ($p<0.05$) among four species. Divergence in cytochrome oxidase c subunit I (COI) sequences also indicate species level distinction of *L. rajasthanicus* from others of gonius group of genus *Labeo*. Genetic and morphological evidences support *L. rajasthanicus* as a separate species from all related congeners, and a diagnostic key has been described. *L. rajasthanicus* closely resembles visually another species *L. gonius,* found in this region, and therefore, its distinct identity was a enigma for a long time. The new information has been incorporated in the database, Catalog of Fishes, California Academy of Sciences, USA.

The present explorations have confirmed that *L. rajasthanicus* has restricted distribution, possibly endemic to a few rivers of western Rajasthan, including some parts of river Chambal, and thus there is a need to develop management and conservation strategies for this species.

The species is an important food fish of the region. The captive broodstock was raised through wild collections at the MPUAT fish farm and used them to produce seeds for pilot-scale aquaculture and stock enhancement. The taxonomic recognition of the species could establish its identity and aid in preventing accidental hybridization with its congeneric species.

ICAR-National Bureau of Fish Genetic Resources
Canal Ring Road, Near Telibagh
P.O. Dilkusha, Lucknown (Uttar Pradesh) 226 002

ICAR-Central Plantation Crops Research Institute Kasaragod

A Century of Service to the Nation **– A premier agricultural research institute on the plantation crops, especially, coconut, arecanut and cocoa**

In 1916, The Central Coconut Research Station was established by the Presidency of Madras, and subsequently in 1948, it was taken over by the Indian Central Coconut Committee, from which it came under the tutelege of the Indian Council of Agricultural Research. The ICAR in 1970 formed CPCRI by merging Central Coconut Research Stations at Kasaragod and Kayamkulam as well as the Central Arecanut Research Station, Vittal, and its five substations at Palode (Kerala), Kannara (Kerala), Hirehalli (Karnataka), Mohitnagar (West Bengal) and Kahikuchi (Asom). The research centres under the CPCRI for spices, oilpalm, coastal agriculture and cashew have been upgraded to independent institutes – IISR, IIOPR, CCARI and DCR, respectively.

At present, CPCRI mainly focuses research on coconut, arecanut and cocoa. Its headquarters is situated at Kasaragod, Kerala, and its two regional stations are at Kayamkulam (Kerala) and Vittal (Karnataka). There are four research centres under the Institute at Mohitnagar (West Bengal), Kahikuchi (Asom), Kidu (Karnataka) and Minicoy (Lakshadweep). Besides, there are two KVKs (Kasaragod and Kayamkulam) under the Institute. An All-India Co-ordinated Coconut and Arecanut Improvement Project (AICCAIP), started functioning from 1972 at the CPCRI, Kasaragod, has also been renamed as the All- India Coordinated Research Project (AICRP) on Palms in 1986. This AICRP has 15 centres on coconut, four on arecanut, eight on oilpalm and two on palmyrah.

The Institute produces quality planting materials of coconut, arecanut and cocoa for distribution to farmers. Seed-gardens of improved varieties have been established at the Institute as well as at the farmer's garden to augment planting material production. **CPCRI nurseries at Kasaragod, Kidu, Kayamkulum and Vittal have been graded with 'four-stars' in five-star scale by the National Horticultural Board.**

Quality planting materials are produced to an extent of 1.2 lakh coconut seed-nuts, including 40,000 hybrids; 5 lakh arecanut seed-nuts, including one lakh seedlings; and 1.1 lakh cocoa-pods, including 70,0 grafts/seedlings, annually.

Four star accredited coconut nursery

MANDATE

- To develop appropriate production, protection and processing technologies for coconut, arecanut and

cocoa through basic and applied research.
- To act as a national repository for genetic resources of these crops.
- To produce parental lines and breeders' stocks of plantation crops.
- To develop improved palm-based farming systems through more effective use of natural resources to increase productivity and income per unit area.
- To collect, collate and disseminate information on the above crops to all concerned.
- To co-ordinate research on these crops within the country and execute research programmes under the All- India Co-ordinated Research Project on Palms.
- To transfer technologies developed at the CPCRI to farmers through co-operation of Developmental Departments/Boards by sponsoring training programmes, workshops, demonstrations, etc.

INFRASTRUCTURE

Agricultural Technology Information Centre (ATIC): The Centre at the CPCRI, Kasaragod, provides a 'single window' delivery system of service to farmers of the following – Quality planting material, various technological inputs and products and priced publications.

Institute Technology Management Unit (ITMU): This takes care of intellectual property management and commercialization of technologies, developed at the Institute, in partnership mode through licensing with entrepreneurs.

Cyber-extension through video-conferencing

Library

Business Planning and Development Unit (BPD): This is functioning at the headquarters, and has all basic facilities needed for business incubation.

Laboratory Facilities: Well-established laboratories are at the CPCRI with modern facilities/equipments/ instruments, required for high-quality research.

Library: The Institute has one of the oldest and richest collections of literature pertaining to plantation crops. To provide better information retrieval and resource-sharing, an online union catalogue of library publications, providing web online public access catalogue (OPAC), has been developed.

Cyber Extension: A group video conferencing system through ISDN is installed at the ATIC, CPCRI, Kasaragod.

Agricultural Knowledge Management Unit: It is functioning with blade servers and a National Knowledge Network (NKN) router for knowledge-sharing.

Agro-processing Centre: The Centre houses many technology gadgets, designed and a developed by the Institute. This includes machineries for the production of virgin coconut oil, coconut chips, tender coconut punch and cutter and portable snowball tender-nut machine.

SALIENT ACHIEVEMENTS

Genetic Resource Conservation

- The Institute maintains world's largest repository of coconut germplasm of 438 accessions (306 indigenous and 132 exotic) from 28 countries. Of arecanut, 164 germplasm collections are conserved (23 exotic and 141 indigenous) at the CPCRI, RS, Vittal. And of cocoa, 344 germplasm are conserved.
- An International Coconut Gene Bank for South Asia (ICG-SA) has been established under the tripartite agreement among the ICAR-FAO-ITPGRFA. The Institute hosts National Coconut Gene Bank (NCGB), and serves as the National Active Germplasm Site (NAGS) for coconut, arecanut and cocoa.
- Through intensive breeding experiments, 19 high-yielding coconut varieties, including six hybrids, involving tall and dwarf as parents, were released for commercial cultivation. These varieties yield annually 1.63 to 6.28 tonnes of copra/ ha.
- In arecanut, a protocol developed for somatic embryogenesis and plantlet regeneration is the major breakthrough for mass multiplication of dwarf hybrids and yellow-leaf disease-tolerant palms.
- In coconut, efforts are being made to refine protocol for regeneration of plantlets through somatic embryogenesis from plumule explants.
- Coconut embryo-culture protocol has been developed for long-term storage and for easy transport of germplasm during exchange.
- Techniques have been standardized for cryopreservation of mature coconut zygotic embryos and coconut pollen.
- Sequence characterized amplified regions (SCAR) markers have been developed for confirming hybridity at the seedling level in coconut and in arecanut.
- The CPCRI hosts Distributed Information Sub Centre

(Sub-DIC) under the Biotechnology Information System Network (BTISnet) and the Bioinformatics Centre and the Agri-Bioinformatics Promotion Centre (ABPC).

Varieties

Coconut

Dual-purpose varieties for copra and tender-nut

Kalpa Pratibha–Tall, green fruits, yield 16,107 nuts/ha/year

Kalpa Haritha–Tall, green fruits, tolerant to eriophyid mite, yield 20,886 nuts/ha/year

Kera Chandra–Tall, round-shaped green fruits, yield 19,470 nuts/ha/year

Kalpa Samrudhi–MYD × WCT hybrid, oval-shaped green fruits, yield 20,744 nuts/ha/year

Kalpa Sreshta– MYD × TPT hybrid, oval-shaped green fruits, yield 29,227 nuts/ha/year

Chandra Sankara– COD × WCT hybrid, oval-shaped brown fruits, yield 20,532 nuts/ha/year

Chandra Sankara

Dwarf varieties for tender-nut

Chowghat Orange Dwarf – Orange-coloured round fruits, yield 19,824 nuts/ha/year

Kalpa Surya – Orange-coloured oval fruits, yield 21,771 nuts/ha/year

Kalpa Jyothi – Yellow-coloured oval fruits, yield 20,718 nuts/ha/year

Kalpa Jyothi

Varieties for root (wilt) disease prevalent tracts

Kalparaksha – Semi-tall oval-shaped green fruits, yield 17,748 nuts/ha/year

Kalpasree – Dwarf, oval-shaped green fruits, yield 15,930 nuts/ha/year

Kalpa Sankara – CGD × WCT hybrid, oval-shaped green fruits, yield 14,868 nuts/ha/year

Kalpa Sankara

Varieties for copra and moisture-deficit tolerance

Chandra Kalpa – Tall, brown-coloured oblong fruits, yield 17,700 nuts/ha/year

Kalpatharu – Tall, brown-coloured oval fruits, yield 20,709 nuts/ha/year

Kera Keralam – Tall, green-coloured oval fruits, yield 26,019 nuts/ha/year

Kalpa Mitra – Tall, greenish oval fruits, yield 15,222 nuts/ha/year

Kalpa Dhenu – Tall, large, green fruits, yield 14,160 nuts/ha/year

Kera Sankara – WCT × COD hybrid, oval-shaped green fruits, yield 19,116 nuts/ha/year

Chandra Laksha – LCT × COD hybrid, oval-shaped fruits, yield 19,293 nuts/ha/year

Chandra Laksha

Arecanut

Mangala–Semi-tall, dry kernel yield 4.11 tonnes/ha

Sumangala – Tall, dry kernel yield 4.38 tonnes/ha

Sreemangala– Tall, dry kernel yield 4.36 tonnes/ha

Mohitnagar – Tall, dry kernel yield 5.03 tonnes/ha

Swarnamangala – Tall, dry kernel yield 5.18 tonnes/ha

Kahikuchi – Tall, dry kernel yield 5.07 tonnes/ha

Madhuramangala – Tall, dry kernel yield 4.85 tonnes/ha

Nalbari – Tall, dry kernel yield 5.69 tonnes/ha

VTLAH 1 – Hirehalli Dwarf ×Sumangala hybrid, dry kernel yield 3.48 tonnes/ha, early flowering

Mangala

VTLAH 2

VTLAH 2 – Hirehalli Dwarf × Mohitnagar hybrid, dry kernel yield 3.62 tonnes/ha, early flowering

Cocoa

VTLCC 1 – Green to yellow-coloured pods, yield 911 kg/ha/ year

VTLCS 1 – Green to yellow-coloured pods, yield 1,700 kg/ ha/ year

VTLCS 2 – Green to purple-coloured pods, yield 1,850 kg/ ha/ year

VTLCS 1

VTLCH 1 – Green to yellow-coloured pods, yield 1,014 kg/ ha/ year

VTLCH 2 – Green to yellow-coloured pods, yield 800 kg/ha/ year

VTLCH 3 – Green to yellow-coloured pods, yield 993 kg/ha/ year

VTLCH 4 – Green to purple-coloured pods, yield 856 kg/ha/ year.

VTLCC 1

Optimized Utilization of Resources

- Coconut- or arecanut-based inter/mixed, multi- storied multi-species cropping as well as mixed farming systems have been developed with integrated livestock to increase total productivity.
- Coconut-based cropping systems with pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot-yam generated a net income of ₹3.7 lakh per ha, which was 150% higher than coconut monocropping (₹1.4 lakh), while coconut-based mixed farming systems (CMFS) comprising coconut, pepper, banana, cross-bred cows, poultry birds, goat and pisciculture generated net returns of ₹5.5 lakh; 288% higher than coconut monocrop.

Coconut-based high-density multi-species cropping system

- Arecanut-based cropping system with cocoa, banana and black pepper generated net returns as high as ₹8.8 lakh per ha; 132% higher than arecanut monocrop (₹3.80 lakh). Cropping systems like arecanut + vanilla, arecanut + medicinal and aromatic plants, and arecanut + cocoa generated 68%, 53%, and 26% higher net returns over monocropped arecanut. Arecanut-based mixed farming systems (AMFS) with dairying, freshwater aquaculture and fodder grass (Hybrid Napier) components generated net returns up to ₹6.6 lakh per ha; 74% higher than arecanut.

Clean and Green Environment

Recycling of crop wastes of coconut and arecanut through vermicomposting helped disposing of wastes and improving soil fertility; thus in a way reduced chemical fertilizers use and brought sustenance in yield.

- Coconut-gardens of one hectare can generate up to eight tonnes of leaf-biomass residue every year. Technology has been developed to utilize this waste for production of mushroom and vermicompost using local isolate of *Eudrilus* sp., earthworm. The waste could produce 1,660 kg of fresh mushroom, which could give a net income of more than ₹50,000 per year.
- Vermicomposting technology can generate ₹50,000 to 60,000 per year. It can also meet 50% of nitrogen requirement of coconut-palms. Vermi-wash produced from coconut-waste vermicomposting unit is a good liquid fertilizer for organic farming.

Vermicompost of coconut waste

- On-farm coir pith composting technology has been developed to produce organic input for plantation as well as soil-less medium for crops. Vermicompost produced from arecanut leaf wastes (12 tonnes/ha) also has potential to meet nitrogen and phosphorus requirements of arecanut which can save cultivation cost to the extent of ₹5,200/ ha. The yield of arecanut can be sustained at 2.6 tonnes/ha by recycling waste as vermicompost.
- Similarly, arecanut- and cocoa-gardens generate biomass of 12 and 8.5 tonnes/ ha, respectively, and the waste can be effectively utilized for production of vermicompost, oyster mushroom and as livestock feed. A net income of about ₹30,000 could be generated from vermicompost production from one hectare waste of arecanut- garden. Waste from arecanut leaf-sheath and bunch can result in 643 kg fresh mushrooms with a net income of about ₹30,000.
- Plant growth promoting rhizobacteria (PGPR) based products, *Kera Probio* and *Cocoa Probio,* have been released for clean and green, sustainable cultivation of coconut.

Protection against Pests and Diseases

Root (wilt), bud-rot, basal stem-rot and stem-bleeding of coconut; fruit-rot and yellow- leaf disease of arecanut;

black-pod and stem-canker in cocoa are major diseases causing substantial losses.

- Integrated disease management strategies developed for root (wilt) and leaf-rot affecting coconut-gardens could increase yield by 25-83%, depending on the disease severity.
- Prophylactic treatment with 1% Bordeaux mixture or placement of perforated fungicidal sachets or *Trichoderma* coir pith cake just before monsoon in the inner most leaf-axil of coconut saved thousands of coconut- palms in bud-rot endemic areas.
- Soil application of *Trichoderma* enriched neem- cake could revive several coconut-gardens affected with basal stem-rot and stem-bleeding disease.
- Phytoplasmal etiology of yellow-leaf disease of arecanut was established, and management of affected gardens with appropriate nutrient management has been advocated.
- Timely spraying of 1% Bordeaux mixture on arecanut bunches or covering bunches with polythene bags just before the onset of monsoon reduced losses due to fruit-rot.
- Adoption of integrated disease management involving phyto-sanitation and 1% Bordeaux mixture application helped farmers harvest healthy cocoa-pods, free from black-pod disease.
- *Trichoderma* coir pith cake, a new eco-friendly bioformulation, has shown potential to protect cocoa-trees affected with stem-canker.

Trichoderma coir pith cake against *Phylophthora* disease of cocoa

- IPM module for management of rhinoceros beetle has been developed through integration of biocontrol agents, *Oryctes rhinoceros* nudivirus (OrNV), Green Muscardine fungus (GMF), *Metarrhizium anisopliae*; botanicals (leaf-axil filling with neem/ marotti cake @ 250g mixed with equal volume of sand); and pheromone trap at 1trap/ ha.

Pheromone trap for rhinoceros beetles of coconut

- A PVC pipe pheromone trap has been designed for keeping Orycta lure – the aggregation pheromone for trapping adult rhinoceros beetles in coconut-gardens.
- Nano-matrix loaded pheromone for red-palm weevil and rhinoceros beetle are found long lasting and reduce cost by four times than commercially available pheromone lures.
- For management of black-headed caterpillar *Opisina arenosella*, biocontrol technology has been developed that uses release of stage-specific parasitoids *Goniozus nephantidis* and *Bracon brevicornis*.
- Integrated pest-management strategy involving soil application of neem-cake (2kg/ palm), chlorpyriphos and entomopathogenic nematodes (EPN) reduced root- grub menace in arecanut-gardens.
- Placing thiamethoxam (2g) in perforated poly-sachets in the innermost two leaf axils of areca-palms during April-May helped protecting palms from spindle-bug.
- IPM strategies developed for phytophagous mites and pentatomid bugs by spraying neem-oil emulsion (0.5%) have been found effective in controlling sporadic pests on arecanut.

Mechanization

The safety attachment incorporated by the CPCRI to Chemberi Joseph model of climbing device has become an effective solution since it could be operated even by women with proper training. Apart from this, manual- and-power operated coconut-husking machines; coconut-shell splitting device; de-shelling machine; tender coconut punch and cutter; coconut dryers of varying capacities and using different fuel sources; testa remover; coconut-slicing machine, coconut-milk expeller; VCO cooker; VCO fermentation tank;

Climbing machine

Virgin coconut oil cooker

copra moisture meter and telescopic sprayers are other major contributions from the Institute.

Patents

Tender coconut punch and cutter; Coconut desheller; Telescopic sprayer; Shell-fired copra dryer; Palm-climbing device

Agri-business and Plantation Crops

- There exists a huge scope for coconut-based agri-business in India; increasing present level of 8% of value-addition to 25%. Value-added products can thereby become a deciding factor in cost of coconut and would ensure fair, reasonable and steady income to coconut-farmers.
- In an effort towards value-addition, the Institute has developed a complete package of practices for production of virgin coconut oil, coconut chips, coconut honey, jaggery and sugar.
- The CPCRI has developed 'Coco-sap Chiller' for collecting fresh, hygienic and unfermented coconut inflorescence sap, called Kalparasa. Bottling technology has also been developed for Kalparasa to extend its shelf-life up to 45 days under refrigeration without adding any preservatives and additives. It has been demonstrated that a farmer tapping 15 coconut-palms for Kalparasa could earn on an average a net profit of ₹45,000 a month, while a tapper could earn ₹20,000 a month.

- Several technologies are available for arecanut by-product utilization such as making eco-friendly disposable plates and bowls from areca leaf-sheath, leaf- sheath fodder, oyster mushroom production from leaf and bunch wastes and vermicomposting. It is also noteworthy that about 1.8 tonnes of dry leaf-sheath waste is available from one hectare and micro-enterprise venture for production of arecanut leaf-sheath plates and cups accrued income of ₹27,000/ha.

Nutraceutical Aspects

Coconut is an excellent source of good fats (MCTs medium chain triglycerides), which encompass heuristic health benefits. Coconut oil application helps protecting skin from harmful UV rays of sunlight and various infections in addition to combating skin infections like dermatitis, eczema and psoriasis.

- Coconut-kernel fibres are a good source of dietary fibres. Lauric acids, polyphenols and antioxidants present in the virgin coconut oil (VCO) are beneficial and are used in baby-care, hair-care, skin-care and overall health-care formulations.

Virgin coconut oil capsules

- VCO developed by the CPCRI method contains 15 to 30 µg tocopherol/g , 500 to 700 µg polyphenol/g and 80 to 90% antioxidant activity; nearly 3 times higher than conventional coconut oil. VCO has proven to have positive effect on Alzheimer's patients.
- Tender coconut-water is a rich source of essential electrolytes like sodium, potassium, magnesium, calcium and phosphorus. It is also rich in tocopherol, polyphenol and antioxidant activity.
- Coconut sugar consumption provides metabolic energy and also essential minerals and amino acids.
- Cocoa contains physiologically active substances like flavanoids, stearic acid, methylxanthines (caffeine and theobromine) and magnesium, and these substances in cocoa help reducing free radicals, LDL cholesterol, blood pressure and platelet aggression.

Climate Resilience Technologies

- Rapid methods for identification of vigour and moisture stress tolerance at the seedling stage have been developed using physiological parameters. Moisture deficit-tolerant coconut varieties are Chandra Laksha, Kera Sankara and Chandra Kalpa. Moisture stress management strategies using burial of husk or composted coir pith in the basin and mulching with coconut leaves or with farm bio-waste gave higher soil-moisture retention and increased nut yield by 20 to 75%.
- In cocoa, five cocoa accessions (NC23, NC29, NC 31, NC39, NC42) and two hybrids (II-67×NC 42/94, II-67×NC29/66) were identified as moisture-stress tolerant. Info Crop-Coconut model developed can be utilized for delineating potential yield, climate-change impact and adaptation strategies for coconut plantations. This model projects increase in productivity of coconut by 4.3% in 2030 and 1.9-6.8% in 2080.
- The C-sequestration potential of coconut is very high (20 to 35 tonnes/ ha/ year). It is highest compared to any other plantation crops. Areca-cocoa system has a

standing biomass of 23.5, 54.9 and 87.10 tonnes/ha in 5th, 8th and 15th years of growth, respectively. Annual increment in biomass or net primary productivity ranged from 1.38 to 2.66 tonnes/ha in cocoa and 3.34-7.11 tonnes/ha in arecanut.

Soil- and -Water Conservation Techniques

- *In-situ* soil- and -water conservation techniques such as half-moon bund reinforced with pineapple planting, trench filled with coconut husk and bund reinforced with pineapple planting and providing catch pits help augmenting soil moisture availability in coconut plantations having mild slope, and could enhance coconut yield up to 60%. This reduced soil erosion from 2.73 tonnes/ha to 0.02 tonnes/ha. Further, it could reduce nutrient loss due to soil erosion (N from 7.98 to 0.36 kg/ha, P from 12.52 to 0.9 kg/ha and K from 28.5 to 1.1 kg/ha).
- Drip irrigation in arecanut, coconut and cocoa reduced water use to the extent of 35-40 % with 30-40 % increase in yield. Drip fertigation in these crops reduced use of chemical fertilizers from 50 to 75 % with increase in yield by 35-40 %.

Quantifying Impact

Consistent research efforts of the Institute have greatly contributed towards overall growth of area, production and productivity of coconut, arecanut and cocoa. In terms of Gross Value Output, coconut contributed ₹95,000 million to national income and arecanut ₹45,000 million. And cocoa, contributed to ₹2,000 million. In terms of exports, coconut earned ₹21,385 million (including coir products) while arecanut contributed to ₹300 million. The analysis on the impact of yearly planting materials supplied from the Institute indicated an economic impact of ₹1,604 lakh/ year, considering economic life-span of coconut-palms. The practice of recommended IDM measures would generate additional benefit of ₹10,200/ ha/ year, and in the long run, 8% more Internal Rate of Return would be generated per year. The overall economic impact per annum due to adoption of technologies has been estimated at ₹19,000 million.

- Development of diagnostic kits for quick detection of root (wilt) disease of coconut and yellow-leaf disease of arecanut.
- Studies on vector-pathogen relationship and identification of collateral hosts of root (wilt) disease of coconut and yellow-leaf disease of arecanut.
- Development of diagnostic kit for quick detection of *Phytophthora* sp. causing diseases on coconut and cocoa.
- Population/ antagonistic effect of *Hirsutella* in the field *vis-à-vis* eriophyid mite population.
- Exploring potential of entomopathogens and nematodes to manage red-palm weevil of coconut and root- grub of arecanut.
- Evaluation of newer pesticides and bioagents to evolve an integrated management practice.
- Identifying synergistic pheromone lures to develop volatile blend having better efficacy.
- Developing adaptation strategies for coconut, cocoa and areca to climate change.

FUTURE THRUSTS

- Enriching gene pool of coconut, arecanut and cocoa and development of superior genetic stocks.
- Marker-assisted selection for exploitation of desirable traits in coconut, arecanut and cocoa.
- Application of *in-vitro* regeneration protocols for mass production of quality planting material.
- Coconut genome sequencing.
- Development of site-specific precision farming practices.
- Conservation agriculture/ organic farming technology for quality production, and farming system approach for resource-use efficiency.
- Estimation of carbon sequestration under different coconut-based farming systems.
- Consortia-based bioinoculants development for plantation crops.
- Value-addition and product diversification.
- Processing and preservation of coconut sap.
- Development, evaluation and modification of processing gadgets/ equipments.
- Studies on development and management of water-conservation measures to augment water resources in plantations.
- Developing soil-less media for production of planting materials.
- Developing model mechanisms for improving livelihood security of farmers.
- Capacity-building of farming communities on adaptation strategies for analysis of impact and vulnerability to climate change in plantations.
- Impact assessment of R & D products and policies, including IPR and cyber-extension programmes.

P. Chowdappa
ICAR-Central Plantation Crops Research Institute
Kudlu P.O., Kasaragod (Kerala) 671 124
e-mail: directorcpcri@gmail.com

Genetic diversity in ashgourd

Ashgourd (*Benincasa hispida*) is a monotypic genus with centre of origin in the Far East. Selected pockets in various regions of India hold its good variability. North-eastern states of India are with several unique types of ashgourd—with extended shelf-life, scented flesh and with varied sizes and shapes. The medicinal landrace *Neykumbalam* of Kerala is a unique germplasm; characterized by small fruits (500g), more number of fruits per plant, extended shelf-life and therapeutic properties, and is highly adapted to organic cultivation in *kharif*. It is extensively used in the preparation of 'Kushmandarasayanam' by ayurvedic medicinal industry. At Thrissur, 17 ashgourd accessions, representing an array of variability, are conserved *ex-situ* in genebank. Majority of the North-Eastern Hill region collections are of a different morphological appearance, with a characteristic round stem, highly lobed, small and dark-green leaves and unique fruit shapes (pear-shaped, ridged, fine seeded and sometimes with non-ashy, green skin). Average highest single fruit weight recorded was 7.80 kg (IC 613452) and 7.20 kg (IC 596989), while the lowest was 0.55 kg of *Neykumbalam* (IC 613455) and 0.85 kg of *Marunnukumbalam* (IC 613454), both are Kerala medicinal landraces. Fruit length range was from 16.0 cm (JN/98-02, IC 613455) to 44.0 cm (IC 596989, IC 613448, SKY/AC264). Pear-shaped fruits were observed in IC 313444, IC 613445, JB/11-52 and IC 596992, and cylindrical, elongated fruits were found in IC 613449, SKY/AC270 and IC 613445. IC 613444 showed unique non-waxy green fruit surface. Co-efficient of variation showed that variability was more for number of fruits per plant, fruit weight and number of seeds per plant; and moderate variability was seen for fruit width and peduncle length and low variability was observed for fruit length.

Ashgourd variability

Kattakada Local - *Neykumbalam* (IC 613455) – used extensively in ayurvedic medicine

Marunnukumbalam – a medicinal landrace (IC 255376) from Kerala

Character	Range	Mean	SD	CV (%)
Peduncle length (cm)	3.5-14.0	6.8	2.3	33.0
Fruit length (cm)	15.7-44.3	27.8	8.3	29.7
Fruit width (cm)	8.8-53.3	16.2	7.1	43.4
Fruit weight (g)	31.0-7980.0	3044.3	1965.8	64.6
No. of fruits/plant	1.0-39.0	7.0	5.9	84.9
No. of seeds/fruit	41.0-3037.0	995.5	600.6	60.3
100 seed weight (g)	1.8-9.6	5.9	1.9	32.2

Joseph John K.[1] M. Latha[1], M. Abdul Nizar[1], L. K. Bharathy[2] and S. K. Yadav[3]

[1] ICAR-National Bureau of Plant Genetic Resources Regional Station, Thrissur (Kerala) 680 656

[2] ICAR-Central Horticultural Experiment Station Aiginia, Bhubaneswar (Odisha) 751 019

[3] ICAR-National Bureau of Plant Genetic Resources Pusa Campus, New Delhi 110 012

Bhima Light Red onion

Onion variety DOGR 571 LR was recommended for release in the Annual Group Meeting of the All-India Network Research Project on Onion and Garlic, held at Kanpur, Uttar Pradesh, on 4-5 April, 2016. It has been christened as 'Bhima Light Red'. It is suitable for cultivation in *rabi* in Karnataka and Tamil Nadu.

Bhima Light Red

It is a medium-maturing (115 days after transplanting) variety with light-

red globe bulbs of about 70 g with thin neck and 13% total soluble solids.

It is almost free from doubles and bolters. Its average yield in multilocation trials in the recommended zone was 38.5 tonnes/ha. And its total weight loss after four months of storage was less than 25%.

Directorate of Onion and Garlic
Pune-Nashik Road, Rajgurunagar
Pune (Maharashtra) 410 505

Bagging guava-fruits to reduce fruit-fly incidence

Guava is a very good source of pectin, vitamin C, fibres and carotene and lycopene. Guava-trees flower twice in a year – rainy season (July-August) and winter season (November-January). Since rainy-season crop is severely infested by fruit-flies and even fruits are insipid and of poor quality, farmers were forced to take usually only one crop, winter crop.

During rainy season, guava-fruits were bagged at the marble stage with a single-layer nonwoven spun-bound polypropylene fabric bags or a single-layer net bags to contain fruit-flies. Bags were removed on the date of harvest or a day before. During bagging, there was no need of insecticides. All other cultural practices were as usual. The harvested produce was virtually free from fruit-flies.

Bagged *vs* non-bagged guavas

Attribute	Allahabad Safeda		Hisar Surkha	
	Bagged fruits	Non-bagged fruits	Bagged fruits	Non-bagged fruits
Fruit weight (g)	172	153	122	110
Fruit-fly incidence (%)	0.0	62.3	0.0	66.4
Fruit drop (%)	5.2	32.2	6.4	28.7
Total soluble solids (%)	12.3	7.6	13.2	8.6
Vitamin C (mg/100g)	203.2	185.2	192.5	172.2

Guava-plant showing bagging of fruits. (*inset*) Right stage of guava-fruits (marble stage) for bagging

Excessive guava-fruit drop due to fruit-fly infestation

Attractive size and colour of rainy-season crop of bagged guava-fruits

Fully ripened bagged Hisar Surkha guava-fruits

Extensive damage caused by birds to non-bagged guava fruits

R.R. Sharma and **A. Nagaraja**[1]
Food Science and Post-harvest Technology
[1]Division of Fruits and Horticultural Technology
IARI, New Delhi 110 012
e-mail: rrs_fht@rediffmail.com

Rapid action plan for South American tomato pinworm: an invasive pest

South American tomato pinworm, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), also known as tomato leaf miner, is one of the destructive invasive pests, observed for the first time on the tomato-crop in Maharashtra. The pest was later observed in Karnataka, Tamil Nadu, Andhra Pradesh, Telangana and Gujarat. It can cause losses up to 90% in fruit yield and quality.

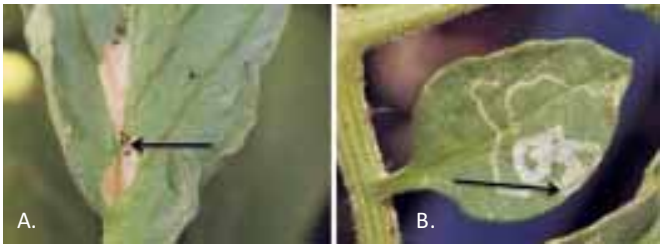
T. absoluta is native to South America. It was observed in Europe (Spain) in 2006. Since then, the pest has invaded other European countries and is present throughout the Mediterranean basin, including parts of North Africa and the Middle East. Presently, it has been recorded from Italy, France, Malta, United Kingdom, Greece, Switzerland, Portugal, Morocco, Algeria, Tunisia, Libya, Albania, Saudi Arabia, Yemen, Oman, Egypt, Sudan, South Sudan, Ethiopia and Senegal.

Adult moth is small with a body length of around 6 - 7 mm and with a wing span of 10-14 mm. The ground colour of the adult moth is greyish or silvery-grey, with darker patches on the fore-wings. The eggs are small, cylindrical, creamy-white to yellow, 0.35-0.40-mm long. Larva is cream-coloured with dark head in the early stage; later turns to slightly pinkish coloured with brown head. Pupa is brownish. The adult moth lays on an average 260 eggs on the underside of leaves, petiole, and on buds. Eggs hatching is over in 4-6 days. The larvae feed on leaves for a few hours before mining into plant tissues. Mined galleries can be seen on leaves, which are much wider in comparison to mined galleries of dipteran leaf miner (*Liriomyza trifolii*); often seen on tomato-crop. Dipteran leaf -miner excreta is like a black thread-like stain but in case of *T. absoluta,* it is like black pellets. Grown-up larvae of pinworm create large blotches on leaves. The excreta of larvae could also be seen inside mined galleries. Full-grown larvae are easily visible inside the galleries. Often more than one larva can be seen in a single leaf. Larva also affects terminal buds of tomato-plants and perforates fruits. The fruit infested by *T. absoluta* shows typical pin-holes compared to *Helicoverpa armigera;* wherein half body of larva is outside and half inside. To detect *T. absoluta,* fruits are cut open. There are four larval instars and the larvae completely feed on green material of the leaf by remaining within mined galleries. Grown-up larvae pupate inside mined galleries or drop down to ground for pupation. Life -cycle of the pest depends mainly on environment, and completes in 23.8 days at 27°C.

Tuta absoluta recorded from different states (Till June, 2016)

Sl No.	States	Hosts	References
1.	Maharashtra	Tomato	Shashank *et al.,* 2015
2.	Karnataka	Tomato, Potato	Sridhar *et al.,* 2014; ICAR, 2015; Ballal *et al.,* 2016
3.	Telanagana	Tomato	Anitha Kumari *et al.,* 2015
4.	Tamil Nadu	Tomato	Shanmugam *et al.,* 2016; Ballal *et al.,* 2016
5.	Gujarat	Tomato	Ballal *et al.,* 2016; Chavan *et al.,* 2016 (Per. Comm.)
6.	Andhra Pradesh	Tomato	Present study

A: *Tuta absoluta* infested fruits (Pin hole) B: *Helicoverpa armigera* feeding on tomato (Larval half body outside)



A. *Tuta absoluta* B: Dipteran leaf miner (*Liriomyza trifolii*) feeding on tomato. Excreta of dipteran leaf miner is like a black thread like strain but in case of *T. absoluta,* it is like black pellets (*see* arrows)

Tomato is the most ideal host for *T. absoluta,* however it is also known to attack several other solanaceous crops like brinjal (*Solanum melongena*), pepper (*Capsicum annuum*), potato (*Solanum tuberosum*), sweet-pepper (*S. muricatum*) and tobacco, *Nicotiana tabacum*. This moth has also been reported from several solanaceous weeds also, including *N. Glauca, Datura ferox* and *D. stramonium*

T. absoluta—Management Strategies

T. absoluta is very difficult to control using chemical pesticides since larvae remain inside the mined galleries. However, eggs are laid on the surface of leaves and other parts and thus are amenable for attack by several

predators and parasitoids. First instar larva after hatching remains on leaf before mining into leaf tissue. During this period, the insect can be managed effectively.

Population monitoring

Population of male moths can be monitored using pheromone traps available commercially (Ex. Pest Control (India) Pvt. Ltd ; Eprheromone Ipm Solutions etc.). Trapping of 20-50 moths/trap is considered a threshold level for initiating control measures.

Cultural methods

- Do not take seedlings from pest- infested areas.
- Two months gap between two crops is essential to avoid carry- over population in monocropping or in other solanaceous crops.
- After ploughing, cover soil with plastic mulch or solarize soil.
- Removal of alternate weed hosts, *Datura* sp. (Datura) and *Nicotiana glauca* (Tree tobacco).
- Use pest-free seedlings for transplanting.

Biological control

Conservation and augmentation of natural enemies — *Nesidiocoris tenuis* (Mirid bug), wasps, like *Neochrysocharis formosa, Goniozus* sp. and *Trichogramma* sp.

Insecticide application

- Once larvae are inside galleries only those chemical pesticides are effective which can penetrate leaf lamella.
- The Central Insecticide Board Registration committee made adhoc recommendation of chlorantraniliprole 10.26% OD @ 0.3 ml/L, cyantraniliprole 18.5% SC @ 0.3 ml/L, flubendiamide 20%WG @ 0.3 ml/L, indoxacarb 14.5% @ 0.5 ml/L and imidacloprid 17.8%SL @ 0.3 ml/L for a period of two years provisionally (up to March 2017).
- Please take care that same insecticide is not used all times ; it should have rotation with others.

Shashank, P. R.[1], Sachin S. Suroshe[1], Chandrashekar, K.[2], Meshram M. Naresh[1] and **C. M. Kalleshwaraswamy[3]**
[1]Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012
[2]Indian Agricultural Research Institute, Regional Station I T I Road, Aundh, Pune (Maharashtra) 411 007
[3]Department of Entomology, College of Agriculture University of Agricultural and Horticultural Sciences Shivamoga (Karnataka) 577 225
*e-mail:*spathour@gmail.com

Probiotic fruit-juices

Probiotic foods are a group of health-promoting functional foods with selected viable strains of lactic acid bacteria (LAB), which when taken in adequate amount confer health benefits to host.

A pilot plant (50-L capacity) has been established for production of probiotic fruit-juices from kinnow, mango and guava. It is a suitable option for small entrepreneurs/fruit-growers for value-addition of their fruits.

Pilot plant for probiotic fruit-juices

Probiotic guava, kinnow and mango juices were formulated with stable and viable beneficial lactic acid bacteria content in the recommended dose (10^6 cfu/ml) with a shelf-life of a month.

The various components of the plant are: Juicer for kinnow (automatic electric screw-type); Pulverizer for pulp extraction of mango and guava; Stainless steel-bin (Food grade) for juice/pulp collection; Batch pasteurizer; Autoclave (SS 304, vertical) for sterilization of glassware, culture medium for probiotic culture preparation; Cold centrifuge for harvesting probiotic cells; Horizontal laminar airflow (size 3'×2'×2') for providing aseptic chamber for housing bottling unit and for addition of probiotic culture; BOD Incubator for incubation of probiotic cultures; Pneumatic bottling unit and Refrigerator for storage of probiotic juice. A patent on 'Production of probiotic fruit-juices' was filed on 4 March 2013.

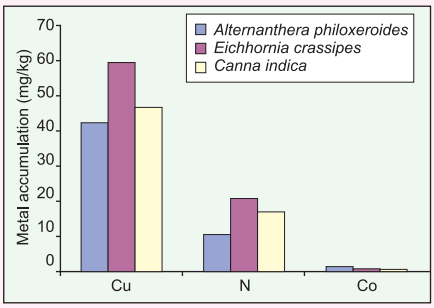
All-India Coordinated Research Project on Post-harvest Engineering and Technology
Punjab Agricultural University, Ludhiana Centre Ludhina (Punjab) 141 004

Phytoremediation through aquatic weeds

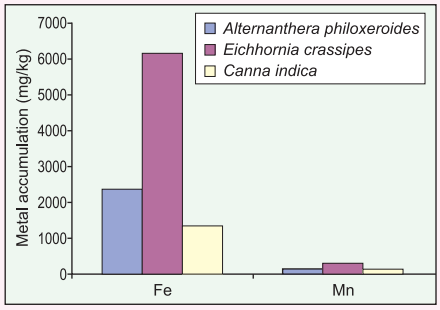
Large quantity of sewage water (about 38,000 million litres per day) from class I and class II cities is generated; out of which only 35% is treated. Control over the quality and composition of industrial waste, including removal of heavy metals, can be done by physico-chemical methods based on the coagulation (flocculation), followed by sedimentation, flotation, ionic exchange, reverse osmosis, extraction, adsorption on activated carbon, etc. However, high price and not being very effective has led to the search for more economical and simple procedures for primary and (or) final removal of heavy metals from waste-water. Among these promising techniques, phytoremediation of industrial waste-water(which involves removal of heavy metals by adsorption, accumulation, or precipitation using higher aquatic and terrestrial plants, and the subsequent processing, utilization or burial of the contaminated biomass in special areas) is one.

Aquatic macrophytes e.g. *Arundo donax*, *Typha latifolia, Eichhornia crassipes, Ipomea* sp. *Lemna minor, Polygonum* sp, *Alternanthera philoxeroides, Phragmites* sp. have paramount significance in bioremediation at constructed wetlands.

Arundo tested in wetland system showed removal of copper, nickel, manganese to the extent of 57.4, 62.0, 61.7 % from the industrial waste-water.



Accumulation of copper, nickel by aquatic weeds



Accumulation of iron and manganese by aquatic weeds

Extensive root growth in hydroponic tank at Jabalpur

Hyperaccumualtors are plants that can absorb high levels of contaminants of metals either in roots, shoots and/or leaves exceeding than soil/water. Higher concentration of lead was accumulated by *Vetivera zizinoides* (69 ppm), followed by *A. donax* (49 ppm), *C. procera* (21.0 ppm) and *S. indicus* (10.7 ppm) in shoots. Among macrophytes grown in ponds of Jabalpur, *Eichhornia crassipes* accumulated higher average concentration of nickel, cadmium, copper, iron and manganese 20.9, 1.14, 59.5, 6,171 and 352 mg/kg, respectively.

A pilot-scale macrophytes-based water-treatment system has been established at Urdua village of Panagar (Jabalpur). The treatment system comprises collection tank, settling tank, followed by treatment zone. The aquatic weeds, *Eichhornia crassipes* and *Pistia stratiotes,* are planted in separate treatment tanks. The waste-water from the river is pumped into collection tank, settling tank, and retained in the treatment zone in which aquatic plants are grown.

The water samples were collected from inlet and outlet zones of each tank after 7 days during first run and daily up to 5 days during 2nd run of the treatment system. The various water parameters were analyzed through multi-parameter water analyzer model Photolab RS12A (WTW make).

During 2nd run of pilot-scale system, except slight change in electrical conductivity, no change in *p*H, temperature and total hardness were recorded in water treated with *Pistia stratiotes* and *Eichhornia crassipes*. However, as compared with the turbidity of the drain water (64.2 Ntu), lower turbidty of 20.43 and 6.93 Ntu was recorded in water treated with *Pistia* and *Eichhornia,* respectively. Besides, turbidity other parameters — total dissolved salts (TDS), sodium, sulphate, chloride and chromium— in water were reduced to 24.1, 33.1, 68.7, 43.0 and 76.3 % respectively, after treatment with *Eichhornia* for 5 days.

Aquatic weed growth in treatment tank

Advantages of weed species for phytoremediation

The fast-growing weedy plants produce high biomass and have greater tolerance to metals, and require no care and no plant-protection measures. Weedy plant-assisted phytoremediation system has a potential to remove toxicants prior to irrigation use. This plant-based technique is also useful for irrigating fruit-crops in arid regions where water scarcity is the major problem. Perennial weeds like *Arundo* and *Eichhornia* as phytoremediation agents can be used for rhizo-filtration of heavy metals (Ni, Cd, Cu, Mn) from industrial waste-water mixed sewage water. As these weeds remove nutrients (nitrates, phosphates), they also have implications for checking flow of nutrients in surface water- bodies to control eutrophication.

P.J. Khankhane
ICAR-Directorate of Weed Research,
Jabalpur (Madhya Pradesh) 482004
e-mail: pjkhankhane@yahoo.com.ph

Technologies from the ICAR-NDRI, Karnal

Milk-based Smoothie

A ready-to-serve shelf -stable beverage, combining milk with minor cereals/legumes/pulses, fruit and vegetable solids, has been developed. Cereals and milk complement each other – lack of vital amino acids of the former and fibre and iron of the latter. The product is an on-the-run grab-and-go breakfast option for office-goers and children. As the product is shelf-stable for a reasonable duration, no additional refrigeration cost is incurred during the storage.

Milk-based smoothie

Cheese Dip

Technology for cheese dip has been developed using sodium caseinate, WPC-70, Cheddar cheese and milk fat with the addition of unique combinations of a stabilizer and emulsifiers. To enhance the palatability of the product, a spiced variant of the same has also been developed. The process for manufacturing cheese dip appears to have greater industrial potential.

Cheese Dip

Low Sodium Cheeses

Sodium has considerably been reduced in Cheddar and Mozzarella cheeses by using taste-taste interactions approach along with the conventional salt replacer as the substitute to sodium chloride. Taste-taste interactions were found significantly effective in eliciting saltiness of cheeses; prepared using a combination of sodium chloride and potassium chloride. This sodium reduction did not affect sensory qualities of the cheese. Sodium content in Cheddar and Mozzarella cheeses has been reduced up to 75 and 69%, respectively.

ICAR-National Dairy Research Institute
Karnal (Haryana) 132 001
e-mail: dir@ndri.res.in

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WAY FORWARD

Agriculture continues to remain an important sector of our national economy with over 18% share in the GDP and more than 50% share in the workforce. As per the Agriculture Census 2010-11 of the country, total number of operational holdings were 138.35 million with average operational area of 1.15 ha. Small and marginal holdings (below 2.00 ha) constituted 85% of the holdings with 44.58% of the operational area. Expressing concern about the farming community, the Union Finance Minister, while presenting General Budget 2016-17 said *'.... We need to think beyond 'food security' and give back to our farmers a sense of 'income security'. Government will, therefore, reorient its interventions in the farm and non-farm sectors to double income of the farmers by 2022.....'.* To achieve double digit GDP growth, agriculture needs to grow above 4%.

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

Problems and challenges facing agriculture sector require action on many fronts – technology, policy, infrastructure and market. Though all are important, basic solution and basic ground for other factors to play their requisite role is only provided by the technology. With limited scope for area expansion, role of agricultural research and development is critical in generating employment and additional income for rural-poor. Enhanced productivity, profitability and competitiveness surface as the main sources of agricultural growth in the near future. **The approach in short run could be to reduce cultivation cost through promotion of in-hand technologies, which would improve resource- use efficiency.**

Resource-conserving technologies enhance profitability in agricultural production—Zero tillage, bed planting and laser land-leveling save on water (15-20%), nutrients (20-30%), energy (30-60%) and planting time (50-65%) and increase yield (5%). Ridge sowing, as compared to flat-bed sowing, followed by earthing-up reduces energy requirement by 12-20%.

There is a proverb '**Give a Man a Fish, and You Feed Him for a Day. Teach a Man to Fish, and You Feed Him for a Lifetime'.** This proverb holds true for our present- day farmers, rural-youth and women. To improve further agricultural research and technology, the ICAR has successfully completed the National Agricultural Innovation Project (NAIP), giving agricultural research and technology development system an explicit development and business perspective through innovative models. In other words, agricultural research system supported agriculture as a business venture and also as a means of livelihood security for rural people while maintaining excellence in science. Some of the successful models include, Integrated Rice-Fish-Poultry Farming System using common carps, Rohu, Mrigal, Catla. In Asom, Integrated Rice-Fish-Vegetable System was demonstrated in 168 hectares. Mushroom cultivation also ensured enhancement of family income at lower investments. Mushroom production using agro-waste, generated employment and augmented farm income. In one of the value-chains, main focus was on waste utilization. Jasmine-flowers packaging technology was developed for enhancing shelf-life of flowers; it enabled export of Jasmine-flowers from villages in Tamil Nadu to Gulf, European and American markets. Natural dye from flowers reduced use of chemical dye in the textile industry. These new technologies have helped farmers in improving their income by more than 2-3 times.

Besides technology, rural infrastructure, specially markets and roads are the key factors for enhancing farmers' income. Along with insurance is needed for price stability in times of abundance— extreme price fluctuations in onions, tomatoes, sugarcane and potatoes have almost been an annual feature. Farmers going for high- value crops such as Basmati rice 1121 and Pusa 1509 did not have the expected value for the produce. Thus, we need to safeguard interest of farmers in times of abundance also.

It is often reported that even when consumer pays high price for the commodity, farmers have very lowly returns from the produce. Such distortions need to be addressed. In nutshell, growth in farmer's income requires high growth in productivity, quality, and favourable and stable economic returns from farm produce; in other words a harmonious synergy is the need of the hour between research, extension and policy to make agriculture a profitable and an attractive and income-generating profession.

(T. Mohapatra)
e-mail: dg.icar@nic.in