



A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

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PROMISING TECHNOLOGIES

Plant bioregulators for raising crop and water productivity

Productivity of sorghum and wheat, important staple food crops, continues to be low, especially when cultivated in drylands or with limited water supplies. Plant bioregulators (PBRs), like thiourea, salicylic acid and sodium benzoate, seem to play a vital role in enhancing yield and water productivity of these crops.

Field experiments were conducted (2012–16) to evaluate interactive effects of exogenous application of plant bioregulators (PBRs) and supplemental irrigations on yield and water productivity (WP) of winter wheat (HD 2189) and sorghum (Phule Suchitra) using line-source sprinkler system (LSS); a unique sprinkler system designed to produce continuously variable water levels, depending upon the distance from the main of the LSS. Among various PBRs, thiourea (10 mM) and salicylic acid (10 μ M), applied at crown-root initiation, flag leaf and milking stages of wheat, alleviated water stress at water deficits. PBRs were applied at the seedling elongation,



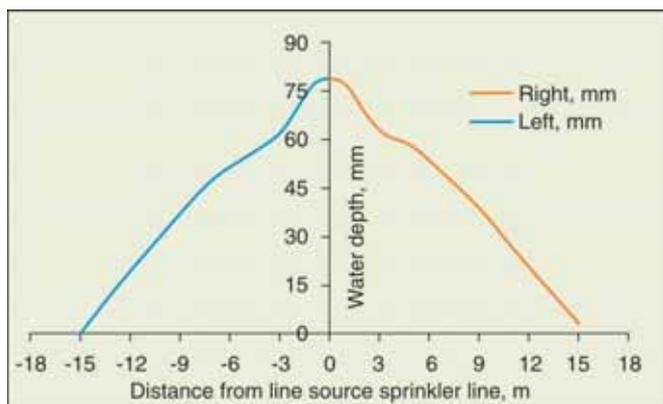
Response of wheat to PBRs at different irrigation levels

Indian Council of Agricultural Research

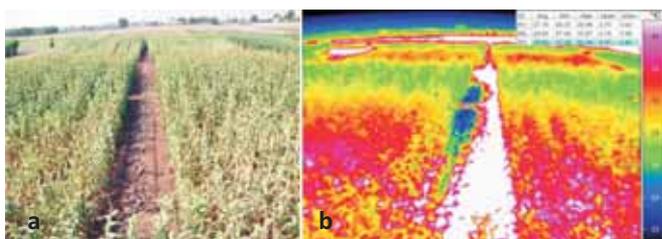
Krishi Bhavan, New Delhi 110 001, India

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PROMISING TECHNOLOGIES



Symmetrical water distribution pattern showing different irrigation levels, maintained during each irrigation using LSS



(a) Intensity of water stress and (b) canopy temperature of sorghum as affected by PBRs at various quantities of applied water at 75 DAS

reproductive and panicle emergence stages in sorghum. In sorghum, salicylic acid (10 μM) was effective under moderate deficit while sodium benzoate (100 mg/L) and thiourea (500 mg/L) were better under severe water deficits.

In both the crops, application enhanced grain yield, total biomass and water productivity as compared to the

Improvement in grain yield, biomass and water productivity with PBRs

| Crop | Improvement in grain yield (%) | Improvement in biomass yield (%) | Water productivity (kg/m^3) |
|--------------------------|--------------------------------|----------------------------------|-----------------------------------------------|
| Wheat (HD 2189) | 5.9-20.6 | 4.8-15.3 | 1.20-1.35 |
| Sorghum (Phule Suchitra) | 6.8-18.5 | 5.7-14.7 | 1.16-1.41 |

control. PBRs also reduced yield declination rate with the deficit irrigation as well as the irrigation water requirement i.e. 19–56% and 25–49% to achieve water productivity (WP) equivalent to the maximum without PBRs for wheat (1.18 kg/m) and sorghum (1.03 kg/m), respectively. Higher WP was recorded with PBRs under water deficits. PBRs maintained higher leaf-water content, lower canopy temperature, modulated stomatal opening and ultimately source-sink relations; thereby improving yields and water productivity under deficit irrigation. Integrating use of bioregulators with deficit irrigation can enhance substantially productivity vis-à-vis profitability from these crops under water-scarce conditions. However, before their recommendation as a useful tool, there is a need for large-scale field testing for defining their economic spray schedules.

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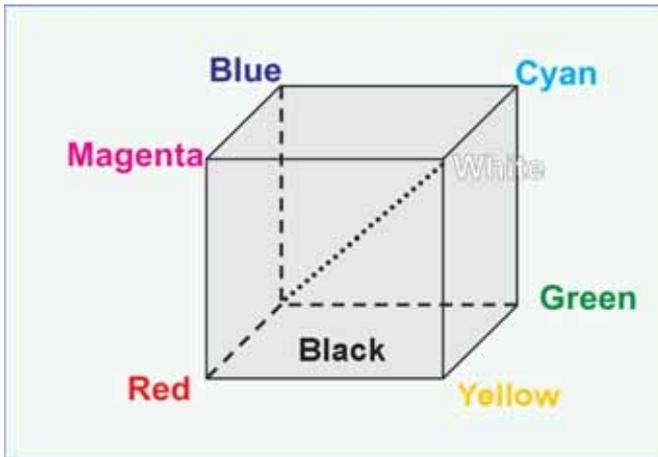
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Colour quantification of the food through RGB colour-cube concept

Colour is one of the most important quality factors which can attract consumers to food commodities. And this has gained more value in case of food commodities consumed fresh (fruits etc). A number of instrumentation techniques such as spectrophotometer, Hunter lab colour, tintometer etc. have been used for colour quantification. These techniques give an idea of the colour of the commodity, but for them, sophisticated and costly instruments, precise sample preparation and regular calibrations are needed. Keeping all these limitations into account, a non-destructive methodology has been standardized for colour determination of

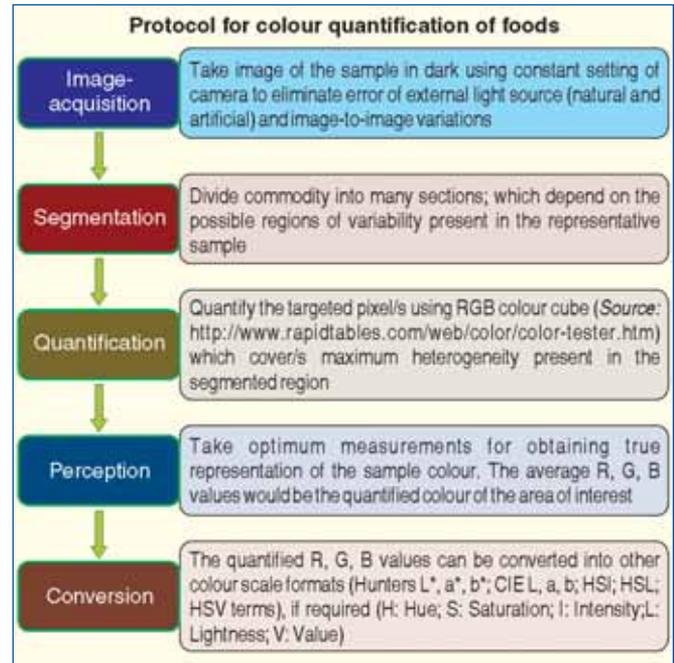
Advantages of the protocol

- This is a non-destructive method for colour evaluation of food.
- Single picture element (pixel) of desirability can be quantified.
- Immediate validation can be done at researchers' end to ensure whether the quantified colour is a true representative of the whole lot or not; unlike other established protocols.
- RGB values can be further converted into Hunters L^* , a^* , b^* ; CIE L , a , b ; HSI; HSL; HSV terms, which are universally accepted colour quantification formats.
- Requirement of specific sophisticated apparatus is totally eliminated, which reduces cost involved in colour quantification.
- The methodology can be adopted for solid as well as liquid food samples.



RGB colour cube

foods; using RGB colour-cube concept. The developed methodology is basically a transformation and a refinement of the already existing RGB colour-cube concept into a practical and feasible way. The basis of the concept lies in the fact that all existing colours in nature are secondary, made up of three primary colours — Red (R), Green (G) and Blue (B) in different ratio of intensities, ranging from 0 to 255. For example, when all the three primary colours are mixed in equal proportion in their minimum intensities, then black (R=0, G=0, B=0) is created while their maximum intensities (R=255, G=255, B=255) result in white colour. It is quite evident that R, G, B colours form three different dimensions of the cube and the remaining colours are formulated by their varying ratios. For example, yellow colour formulation involves contribution of only green and red in equal proportion at their maximum intensities without involvement of blue. The intensity of the blue colour would be zero (0) and quantified RGB value of yellow colour would be R=255, G=255, B=0. Similarly, using this methodology,



quantification of any particular unknown colour pixel can be done by applying RGB scale. Thus, by this protocol, all colour quantified values would be on R, G, B scale, and would range from 0 to 255.

Colour quantification of selected apple cultivars

| Cultivar | Area surrounding pedicle (1/3rd of the fruit) | Remaining 2/3rd portion of the fruit | Area surrounding pedicle (1/3rd of the fruit) | Remaining 2/3rd portion of the fruit | Cultivar | Area surrounding pedicle (1/3rd of the fruit) | Remaining 2/3rd portion of the fruit | Area surrounding pedicle (1/3rd of the fruit) | Remaining 2/3rd portion of the fruit |
|-----------------|-----------------------------------------------|--------------------------------------|-----------------------------------------------|--------------------------------------|----------------|-----------------------------------------------|--------------------------------------|-----------------------------------------------|--------------------------------------|
| Royal Gala | | | R=195 G=211 B=57 | R=226 G=158 B=52 | Scarlet Spur-I | | | R=194 G=166 B=81 | R=188 G=83 B=43 |
| Vance Delicious | | | R=188 G=191 B=39 | R=169 G=86 B=31 | Super Chief | | | R=208 G=184 B=47 | R=224 G=70 B=79 |
| Oregon Spur-II | | | R=180 G=191 B=53 | R=162 G=73 B=26 | Starkrimson | | | R=211 G=169 B=92 | R=169 G=86 B=31 |
| Royal Delicious | | | R=222 G=165 B=111 | R=205 G=103 B=53 | Top Red | | | R=173 G=157 B=33 | R=211 G=120 B=47 |
| Well Spur | | | R=214 G=208 B=146 | R=204 G=63 B=45 | Scarlet Gala | | | R=208 G=161 B=6 | R=232 G=100 B=54 |
| Silver Spur | | | R=176 G=192 B=49 | R=202 G=98 B=58 | Red Chief | | | R=194 G=201 B=34 | R=176 G=39 B=33 |
| Gale Gala | Top | Peel | R=228 G=203 B=76 | R=234 G=79 B=52 | | | | | |

PROMISING TECHNOLOGIES

Colour quantification: For standardization of protocol, 13 cultivars of apple (*Malus ×domestica* L.) with vast variability in fruit-peel colour — Royal Gala, Vance Delicious, Oregon Spur-II, Royal Delicious, Well Spur, Silver Spur, Gale Gala, Scarlet Spur-I, Super Chief, Starkrimson, Top Red, Scarlet Gala and Red Chief — were procured from the Regional Research Station. Each fruit of the selected cultivars was segmented into two broad portions — (i) Area surrounding pedicel (1/3rd of the fruit), and (ii) Remaining 2/3rd portion of the fruit. Images of the two regions were taken in dark under the constant setting of the camera. Since large variations in colour are observed in an apple-fruit, for precise colour representation, observations from nine different pixels of both the segmented portions of each cultivar were recorded in three different apples. The obtained values for different pixels were quantified using RGB colour-cube (<http://www.rapidtables.com/web/color/color-tester.htm>) and validated with actual visual perception of the colour of the peel of that particular portion.

This methodology can be utilized to carry-out routine colour quantification, development of score card for

determination of maturity indices of different fruits and vegetables, screening of germplasm of different commodities, acceptability of processed products and endpoint recognition of biochemical reactions for which colour is an important and deciding quality factor.

The advantage of this newly developed protocol over the established ones is that with this one can immediately validate if the estimated average value of the colour obtained is a true representative of the sample or not by comparing interpreted colour with the originally perceived sample colour.

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Dose-response curve for deciding optimum doses of herbicides in a mixture

Many of the farmers used tank-mix combinations of two herbicides for controlling broad spectrum weeds. Sometimes it worked well and good results were observed in the fields but many a time, combinations did not give optimum control of weeds compared to a single application. This can be owing to lack of compatibility among herbicides. Considering this, a study was undertaken to decide optimum doses of herbicides using dose-response curve for maximum control of weeds with a mixture.

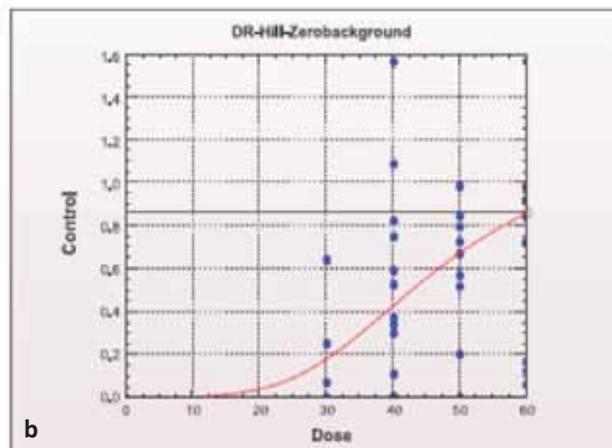
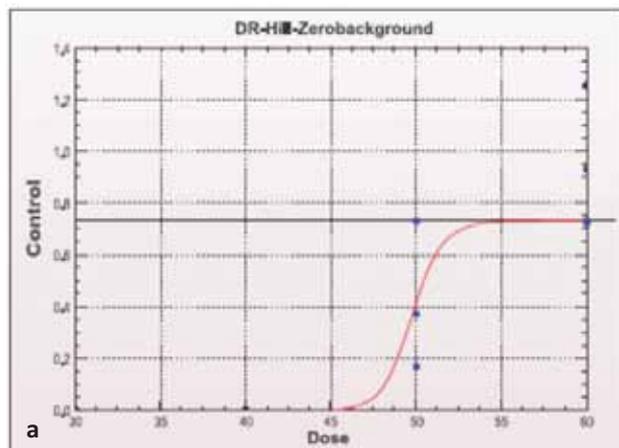
A field experiment was conducted in *kharif* 2013 in rice- crop at the farm level. Combinations of fenoxaprop and metsulfuron at different doses 30, 40, 50, 60g/ha and 2.5, 3, 3.5, 4g/ha, respectively, were used to control grassy and broad -leaved weeds. The experiment was laid out in 5² factorial Randomized Block design with 3 replications. There were diverse weed flora; dominant ones were: *Echinochloa colona*, *Alternanthera sessilis*, *Euclipta alba*, *Ludwigia adscendens*, *Dinebra retroflexa*, *Cyperus iria*, *Ammania bacifera* and *Commelina benghalensis*. Fenoxaprop controlled grassy weeds at the recommended doses, and at lower doses failed to control the same weeds; but it reduced *Echinochloa colona* very significantly. And metsulfuron controlled all broad- leaved weeds even at lower doses than the recommended. Growth parameters of rice-crop (plant

height and panicle length) were not affected by herbicides. At 12 days after application, data on percentage (%) weed control by different doses of these herbicides were taken, and dose response models were fitted to data. Among many models, Dose-Response Hill model was found the best.

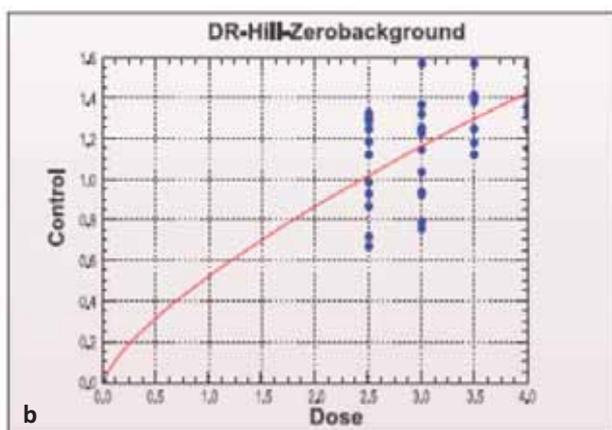
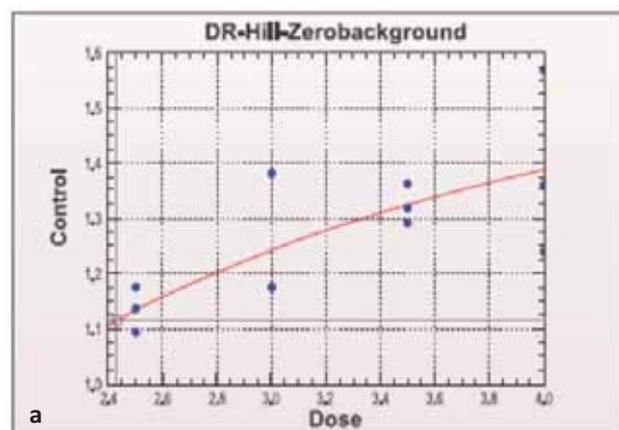
Dose-Response Hill model is given as follows:

$$y = \delta + \frac{\alpha x^\theta}{\phi^\theta + x^\theta}$$

Where, y is percentage weed control, δ is intercept, $\alpha = y_{\max}$, x denotes dose, θ is hill coefficient of sigmoidicity and ϕ denotes ED₅₀ value or the dose at which 50% control is noticed. Before fitting the model, error assumptions (normality, randomness



(a) Dose response curve of %weed control (arc sine value) of grassy weeds in rice-crop with fenoxaprop alone with Hill equation $y=(0.726*dose^{57.06})/(49.71^{57.06}+ dose^{57.06})$. (b) Dose response curve of %weed control (arc sine value) of grassy weeds in rice-crop with fenoxaprop in a mixture with Hill equation: $y=(0.801*dose^{4.05})/(44.9^{4.05}+ dose^{4.05})$



(a) Dose response curve of % weed control (arc sine value) of broad-leaved weeds in rice-crop with metsulfuron alone with Hill equation: $y= (1.38*dose^{1.58})/(1.68^{1.58}+ dose^{1.58})$. (b) Dose response curve of % weed control (arc sine value) of broad-leaved weeds in rice-crop with metsulfuron in a mixture with Hill equation $y= (1.44*dose^{5.28})/(2.94^{5.28}+ dose^{5.28})$

and homogeneity of the error variance) were confirmed with studentized residuals and Shapiro-Wilk normality test. Data were non-normal, therefore arc sine transformation was applied to make data normal. Hill model described relationship between the dose and the percentage weed control of the present data. From the investigation of fenoxaprop doses 30, 40, 50 and 60g/ha, a hill model was fitted to fenoxaprop alone as well as to the mixture data. Only 68% control of grassy weeds was observed even with full dose of fenoxaprop when it was applied alone. Its ED_{50} value was estimated as 49.71g/ha from the fitted model. When fenoxaprop was applied in a mixture with metsulfuron, its control increased from 68 to 73%. Its ED_{50} value was observed at lower dose i.e. 44.9g/ha as compared to fenoxaprop alone.

For fitting the data of metsulfuron at different doses, hill model was used for metsulfuron alone data as well as for the mixture data. When metsulfuron was applied alone, it controlled all broad-leaved weeds even at lower doses than the recommended ones. Its ED_{50} value was obtained as 1.68g/ha when applied alone but increased to 2.94 when applied with fenoxaprop in a mixture. Hence, it can be inferred that fenoxaprop has some antagonistic effect on metsulfuron when applied in a mixture. Fenoxaprop 52.81g/ha and metsulfuron 2.73g/ha should be used to maximize control of broad and grassy weeds, when applied in a mixture.

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NEW INITIATIVES

Row direction role on growth and biotic stress on *Brassica*

India is self-sufficient in foodgrains production, but is a net importer of edible oils. *Brassica* or mustard is the second most important oilseed-crop in India. It is sown in the field through broadcasting and line-sowing. Even in the line-sown crop, rows are maintained with no scientific basis. Research related to direction of rows to harvest more of solar radiations for higher yields was planned. By selection of appropriate row direction, micro-environment can be changed within mustard-crop.



Sowing mustard in different directions

In the study, three cultivars of *Brassica* — Pusa Vijay, Pusa Mustard 21 and Pusa Bold — were sown in two- row directions, viz. north-south and east-west during *rabi* of 2013-14. Split-plot design was followed with three replications in 4m × 4m plot. Regular observations on weather parameters, micro-meteorological parameters (solar radiations interception, crop profile temperature and relative humidity within the canopy), soil moisture, crop biophysical parameters (phenology, leaf area index, above ground biomass, yield and oil content), insect-pest (aphid) and disease (white rust) were recorded. The crop grown in north-south direction was observed to be more efficient in intercepting photosynthetically active radiations and in uptaking soil-moisture, and resulted in more leaf area index, biomass, seed yield and oil content than the crop grown in the east-west direction. Radiation-use efficiency was higher in north-south rows but water-use efficiency was higher in the east-west rows. Aphid population and

percentage disease index of white rust were substantially high in east-west rows. Probably, more radiation penetration and interception in north-south rows, increased crop profile temperature and decreased humidity within canopy, thus made crop micro-environment unfavourable for pest (aphid) and disease (white rust). Finally, it can be concluded that the crop sown in north-south direction can be most efficient in terms of producing more yield and suppressing major pests and diseases in the semi-arid environment of the north-south India.

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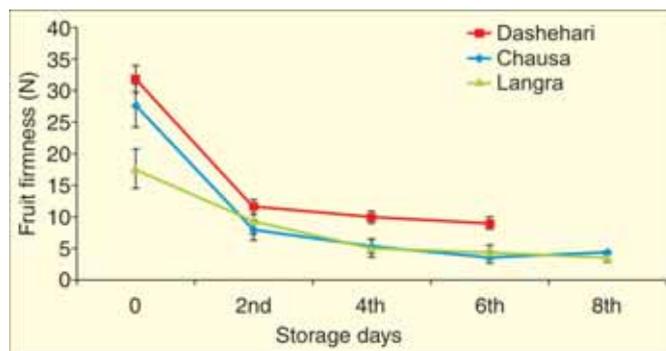
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Responses of mango varieties to exogenous ethylene for fruit-ripening

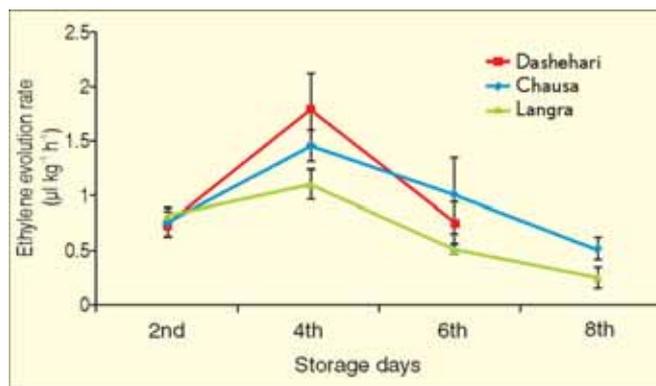
Artificial ripening of mango is an ancient practice and many traditional methods — use of smoke, paddy- straw and newspaper—for this, to some extent, are still prevalent. All of them are cumbersome, unhygienic and do not provide uniform fruit- ripening. Therefore, traders/ growers shifted towards use of calcium carbide (CaC_2) for ripening of fruits despite legal imposition. Lately, ethylene is commercially used for safe ripening of mango-fruits worldwide, but its gainful potential can be achieved only with proper understanding of the varietal responses

to ethylene concentration and exposure time. Thus, arose a need to standardize ethylene doses for different mango varieties.

In a two-season study, fruits from three different varieties (Dashehari, Chausa and Langra) were harvested at commercial maturity stage. Prior to ethylene treatment, healthy and uniform fruits from all the three were selected, de-sapped and cleaned. A total of 400 fruits were selected and were randomly divided into 4 lots of



Effect of exogenous ethylene on fruit firmness of Dashehari, Chausa and Langra mango during storage



Effect of exogenous ethylene on ethylene evolution rate of Dashehari, Chausa and Langra mango during storage

100 each. Thereafter, fruits were placed in plastic crates and kept for ripening in the ethylene chamber. The ripening chamber was maintained at $24 \pm 2^\circ\text{C}$ temperature, 95% RH and 100 ppm ethylene dose for 24 hours. After 48 hours of holding in the chamber, fruits were taken out and stored at ambient conditions ($25 \pm 2^\circ\text{C}$, $85 \pm 5\%$ RH) for 8 days. At two days interval, fruits of each variety were sampled randomly, and were



Unlawful and unhealthy method of mango-fruit ripening

Effect of exogenous ethylene on quality attributes of mango-fruits during storage

| Character | Variety | Storage period (days) | | | | | C.D. |
|---------------------------------|-----------|-----------------------|-----------------|-----------------|-----------------|-----------------|-------|
| | | Control (0) | 2 nd | 4 th | 6 th | 8 th | |
| TSS (°Brix) | Dashehari | 9.57 | 16.43 | 22.93 | 25.87 | - | 1.064 |
| | Langra | 8.20 | 12.17 | 15.20 | 21.23 | 24.77 | 0.921 |
| | Chausa | 8.13 | 13.43 | 16.23 | 20.37 | 26.90 | 1.549 |
| Acidity (%) | Dashehari | 0.92 | 0.31 | 0.24 | 0.23 | - | 0.366 |
| | Langra | 1.13 | 0.49 | 0.38 | 0.29 | 0.21 | 0.292 |
| | Chausa | 0.98 | 0.42 | 0.31 | 0.17 | 0.12 | 0.193 |
| Total carotenoids (mg 100/g FW) | Dashehari | 2.30 | 6.50 | 6.47 | 12.97 | - | 2.84 |
| | Langra | 1.53 | 2.77 | 6.70 | 7.07 | 10.50 | 5.45 |
| | Chausa | 2.20 | 3.27 | 7.17 | 9.03 | 11.27 | 2.84 |
| Total sugars (%) | Dashehari | 2.94 | 10.59 | 18.36 | 25.82 | - | 3.45 |
| | Langra | 3.01 | 8.17 | 14.66 | 18.47 | 20.78 | 2.44 |
| | Chausa | 4.68 | 12.12 | 15.35 | 19.43 | 21.67 | 2.06 |

Undesirable effects of excessive ethylene exposure on quality of mango-fruits

| Parameter | Optimum ethylene exposure | Excessive ethylene exposure |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Fruit firmness | Fruits retain higher firmness for longer time | Faster loss of fruit firmness |
| Shelf-life | Longer | Shorter |
| Chilling injury at optimum storage temperature (13°C) | None | Susceptible |
| Retaining period from the time of ideally ripened stage | Vendors could sale out fruits at ambient condition even up to 5 days without substantial loss | There is rapid loss in fruits's firmness, and fruits cannot be retained for more than 2 days in summer months (May-June) in north India |
| Mesocarp discolouration | None | Susceptible |

NEW INITIATIVES

subjected to analysis of physico-chemical attributes.

Dashehari reached to optimum soft- eating stage on the 4th day after ethylene treatment. Chausa and Langra reached at optimum ripening stage on the 6th day, while Dashehari was spoiled by that time. Chausa and Langra lasted up to 8 days in storage. Ethylene evolution peak was maximum ($1.81 \mu\text{l C}_2\text{H}_4/\text{kg/h}$) in Dashehari, and it was lowest ($0.40 \mu\text{l C}_2\text{H}_4/\text{kg/h}$) in Langra on the 4th day of storage. On 8th day, lowest peak ($0.31 \mu\text{l C}_2\text{H}_4/\text{kg/h}$) was noticed in Langra, closely followed by Chausa. High ethylene evolution peak possibly resulted in shorter shelf-life and more chilling injury and mesocarpic discoloration, particularly in Dashehari. Earlier studies on inter-varietal differences in surface morphology and anatomical features of mango-fruits highlighted varied cell configuration and compartmentalization, which may be the reason for easy entry and uniform distribution of exogenously applied ethylene in Dashehari-fruits compared to Langra and Chausa. Further, sharp and more prominent decline in fruit firmness of Dashehari, within initial 2-days, also indicated for more responsive nature of Dashehari to exogenous ethylene treatment. Ethylene sensitivity of these three varieties was as follow: Dashehari > Chausa > Langra.

Dashehari gave optimal ripening with <100 ppm ethylene dose while Chausa and Langra required around 100 ppm ethylene dosing for 24 hours at $24 \pm 2^\circ\text{C}$ temperature and 95% RH. Over exposure of ethylene, shortened shelf-life and thus resulted in more of post-harvest losses.

There is a need to work out an optimum ethylene dose and its exposure period to attain optimum ripening in each of the mango varieties. The best-fit approach for



each of the mango variety would benefit all stakeholders involved in mango-supply chain.

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*A Very
Happy New Year*

2017

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Weedy rice – different projections

Weedy rice infestation has now become a serious threat in the traditional rice belts of the country. Because of the morphological and biochemical similarities with the cultivated rice, control of weedy rice by hand-weeding or with the use of herbicides is not possible. Introgression between wild rice and cultivated rice has given rise to highly variable population of weedy/wild -rice forms, including annuals and perennials. Indian weedy rice has been reported to be *Oryza sativa* f. *spontanea*, belonging to *indica* group. Weedy rice is adapted to a wide range of environments. Its spread is likely to be accomplished through water, cattle, farm machinery, and as contaminants of new varieties.



More than 67 morphotypes of weedy rice were collected from different agroclimatic zones and geographical regions of the country. These have been characterized for their functional traits, and are being maintained as pure-lines since the last four years. Statistical analysis of the parameters recorded and diversity analysis at the molecular level using SSR markers have revealed that weedy rice does not differ based on the agroclimatic zones. It has also been observed that Indian weedy rice types are not necessarily taller than cultivated rice; its

shorter morphotypes are also available. Its morphotypes are phenotypically and genotypically diverse, vigorous and competitive, and have early panicle initiation, early and asynchronous maturity, high seed shattering and seed dormancy. This is an ideal example of **mimicry weed**.

This variability among weedy rice morphotypes can be a problem while devising management strategies to control them, but, on the other hand, varied morphotypes can be looked upon as potential germplasm; to be explored for beneficial traits. Weedy rice can germinate under anaerobic conditions. Thus, weedy rice is a naturally available germplasm resource which is to be managed in farmer's field, and can be used as a potential gene-pool source.

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Wild and cultivated leafy vegetables maintained by local tribes in Nagaland

Leafy vegetables including wild vegetables play an important role in meeting nutritional requirements of the tribal people of the North-Eastern Hills Region of India. Local people collect leafy vegetables from wild as well as grow them in their kitchen-garden and *jhum*-lands. Realizing significance of local diversity in plant species of this group, a crop-specific exploration was conducted for collection of cultivated and wild leafy vegetables from Dimapur, Peren, Kohima, Wokha, Tuensang and Mokokchung districts of Nagaland. Significant diversity comprising **cultivated leafy vegetable species** (*Amaranthus caudatus*, *A. hypochondriacus*, *Allium hookeri*, *A. chinense*, *Blumea balsamifera*, *Brassica juncea*, *Basella rubra*, *Eryngium foetidum*, *Hibiscus sabdariffa*, *Hibiscus cannabinus*,

Hyptis suaveolens, *Ocimum tenuiflorum*, *Ocimum basilicum*, *Rumex vesicarius*) and **wild leafy vegetable species** (*Amaranthus cruentus*, *A. viridis*, *Clerodendrum colebrookianum*, *C. wallichii*, *Elsholtzia blanda*, *Gynura cusimbua*, *Houttuynia cordata*, *Plukenetia corniculata* and *Zanthoxylum alatum*) were collected from cultivated (kitchen-garden, *jhum*-fields) and wild habitats (forests and community lands). This diversity is being maintained in *jhum*-fields as well as in kitchen-gardens by local tribes (*Sumi*, *Ao*, *Angami*, *Lotha*, *Rengma*, *Kuki*, *Zeliang*) in the surveyed area. Besides their uses as vegetables, other uses have also been recorded during the survey from the native farmers/ inhabitants, particularly those residing in remote localities. It has been observed that factors like introduction of improved cultivars, change in food

NATURAL RESOURCE MANAGEMENT

habits and modernization are weaning among young generation from the traditional systems; owing to these, a significant loss of valuable diversity from the region has been noticed. A total 23 germplasm samples (wild-9, semi wild/cultivated-14) were collected and conserved in the National Genebank/Field Genbank. Realizing the depletion of these locally important species of food and for other uses, a sincere effort was made to establish a Biodiversity Centre on 6.5 acres farmland in 2015 to conserve valuable plant genetic resource for the sustained availability on the one hand and to minimize their over-exploitation from the wild. Presently, more than 100 economically important species, including leafy vegetables, medicinal and aromatic



Wild leafy vegetables for sale in local market (a), leafy vegetable *Clerodendrum colebrookianum* (b), *Elsholtzia blanda* (c), Biodiversity Centre at Khensa Village, Mokokchung, Nagaland (d)

Major species of leafy vegetables, their vernacular name, habitat and uses

| Botanical name | Vernacular name | Habitat | Uses |
|---------------------------------------------|-----------------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------|
| <i>Allium chinense</i> | Nraa | Homestead | Young leaves added to vegetables and <i>chutney</i> prepared from fresh leaves and bulbs |
| <i>Allium hookeri</i> | Rupjalasung | Homestead | Young leaves added to vegetables and <i>chutney</i> prepared from fresh leaves |
| <i>Amaranthus caudatus</i> | Tatwa, Chulaie | Homestead/Jhum | Boiled leaves and young shoots consumed |
| <i>Amaranthus cruentus</i> | Tatwa, Chulaie | Homestead/Jhum | Boiled leaves and young shoots consumed |
| <i>Amaranthus hypochondriacus</i> | Tatwa, Chulaie | Homestead/Jhum | Boiled leaves and young shoots consumed |
| <i>Amaranthus viridis</i> | Tatawa | Wild | Boiled leaves and young shoots consumed |
| <i>Basella rubra</i> | Pattasak, Latsungen | Homestead | Boiled young leaves consumed |
| <i>Blumea balsamifera</i> | Takamtsu | Homestead | Boiled leaves are consumed |
| <i>Brassica juncea</i> subsp. <i>rugosa</i> | Kashanyu | Homestead/Jhum | Boiled leaves are consumed |
| <i>Clerodendrum colebrookianum</i> | Orum, Oruhma, Oremwa, Zuringbun | Both Wild and Homestead | Boiled young leaves consumed; supposedly good for high blood pressure |
| <i>Clerodendrum wallichii</i> | Tusuye | Both Wild and Homestead | Boiled young leaves consumed |
| <i>Elsholtzia blanda</i> | Mahakpatta, Nipio, Napha, Changjang | Homestead | Boiled leaves and young shoots consumed |
| <i>Eryngium foetidum</i> | Kikum, Kumbai, Duniatong, Naga dhaniya, Aong thonia | Both Wild and Homestead | Young leaves used as condiment; as substitute of coriander leaves |
| <i>Gynura cusimbua</i> | AnInglimon | Wild | Boiled young leaves consumed |
| <i>Hibiscus cannabinus</i> | Wakro | Homestead/Jhum | Young leaves and fruits cooked with vegetables and <i>chutney</i> prepared from fresh leaves |
| <i>Hibiscus sabdariffa</i> | Wakro/Hentsurhu | Homestead/Jhum | Young leaves and fruits cooked with vegetables and <i>chutney</i> prepared from fresh leaves |
| <i>Houttuynia cordata</i> | Knoknah, Nokna Azipongmydi, Senma (Zeliang) | Both Wild and Homestead | Boiled leaves consumed |

Continued

(Concluded)

| Botanical name | Vernacular name | Habitat | Uses |
|-------------------------------|--------------------------|-------------------------|----------------------------------------------------|
| <i>Hyptis suaveolens</i> | Tukuma, Ram tulsi | Homestead | Boiled leaves consumed |
| <i>Ocimum tenuiflorum</i> | Tulsi, Nangpera | Homestead | Young leaves used in preparation of <i>chutney</i> |
| <i>Ocimum basilicum</i> | Nangpera, Pig perilla, | Homestead | Young leaves used in preparation of <i>chutney</i> |
| <i>Plukenetia corniculata</i> | Aochisang, Watichang tau | Both Wild and Homestead | Boiled leaves and young shoots consumed |
| <i>Rumex vesicarius</i> | Palang, Khatta sag | Homestead | Young leaves consumed |
| <i>Zanthoxylum armatum</i> | Mong –Mong, Nechi | Both wild and Homestead | Young leaves consumed and seeds used as spices |

plants, are being maintained. The important species of wild leafy vegetables and other economic plants maintained in this Biodiversity Centre are :*Clerodendron colebrookianum, Eryngium foetidum, Lasia spinosa, Plantago asiatica, Plukenetia corniculata, Zanthoxylum rhetsa, Houttuynia cordata*); among medicinal and aromatic plants are: *Phyllanthus fraternus, Spilanthes acmella, Solanum indicum, Curculigo crassifolia, Centella asiatica, Aquilaria agallocha, Costus speciosus, Elsholtzia blanda Entada scandens, Stephania rotunda, Cymbopogon citratus, Litsaea citrata, Mesua ferrea, Terminalia chebula*; other economic species are:

Thysanolaena maxima, Rhus semialata, Calamus erectus, Dendrocalamus hamiltonii, Parkia roxburghii, Sterculia villosa, Caryota urens, Michelia champaca, Baccaurea ramiflora, Garcinia pedunculata, Artocarpus heterophyllus, Passiflora edulis, Myrica esculenta, Euphoria longan and Stixis suaveolens.

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High-yielding local oyster-mushroom (*Kannae cheaoe*)

Mushroom, a unique non-traditional cash-crop, is an excellent source of proteins, vitamins, minerals, folic acid and also of iron for anaemics. It is popularly called as “*Cheaoe*” in Nepali. Sikkim, being the distinctive hotspot of rich mushroom biodiversity, also serves as the habitat for a wide variety of mushrooms. A good number of potential mushroom species have been exploited from Nature, and have been used for food and medicinal purposes since ages by indigenous communities of Sikkim. Many mushroom species are found wild in Sikkim, especially with the onset of monsoon. Mushrooms are an integral constituent of dietary intake of populace of Sikkim. The wild edible mushrooms in Sikkim are sold at ₹200-400 per kg.

An edible oyster-mushroom was collected from the forest area of Sikkim. This mushroom has good adaptability for local climatic conditions, and can be cultivated in temperature range of 20-30°C with high relative humidity (more than 85%), prevailing in Sikkim, except during winter. The mushroom produces greyish-white sporophores. It gives good yield on paddy-straw, and can be grown on saw-dust, maize-husk (outer covering of cob) and other cellulosic waste materials.

Polythene- bag method is the most convenient method for cultivation of this mushroom. Good quality paddy-straw should be first chopped to a length of about 5 cm and soaked overnight (4-6 h) in cold and clean water. Soaked straw should be boiled at 70-80°C for 30 min. Then water is drained and straw is spread on to a clean floor and/or silpaulin sheet after disinfection with chlorinated water, and it is shade-dried.

Excess water should be squeezed out from straw.

Cultivation of oyster-mushroom is usually carried out in transparent polythene bags of 60 cm × 40-45 cm with a thickness of 80 gsm. The shade-dried straw bits are mixed with spawn following layer method of spawning in



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polythene bags. The bags are incubated in cool and dark place with 22-25°C temperature and 85-90 % relative humidity. Mushroom yield ranges from 900 to 1,500 g per kg dry weight of paddy-straw depending upon the climate, and is ready for harvest in 33-34 days after seeding. It is very fleshy, soft and tasty, and has been found good for pickle preparation. Its pileus is fan-shaped with 5-7 cm diameter. Stipe is lateral, and its size is 4-4.2 cm × 1-1.5 cm. It has a distinct flavour during cooking. The colour of the spores is white. As the mushroom is locally isolated and resembles local mushroom in appearance; and its taste is retained even after its domestication, it will be readily accepted by the people and would also fetch good price in the local market.

Mushroom spawn (seed material) of this local mushroom is produced, and is supplied to farmers. Farmers are very much satisfied with the performance and taste of the mushroom. Sikkim being an organic farming state, conservation and multiplication of local genetic resource, like different mushroom species, is very much important. In recent times, mushroom cultivation is becoming popular among the people because it adds to the income of especially those growers who are without land or have insufficient land, besides its role in nutritional security. Mushroom production has tremendous potential in Sikkim because of its congenial climate (tropical to alpine) and



availability of low-cost waste materials. The locally isolated oyster-mushroom (*Kannae cheae*) has good appeal, flavour and taste; it has tremendous potential to improve nutritional and livelihood security of people of Sikkim.

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Biocontrols for pulse-crops for managing insect-pests, diseases and nematodes

Biocontrol options have been explored for insect-pests and diseases since long for strategic management of structured pulse-based cropping systems. Insect-pests regulating biotic factors have also been determined through life-table studies on pigeonpea and chickpea. Egg-parasitoid, *Trichogramma* spp., has registered somewhat diminutive potential in pigeonpea and chickpea ecosystems. Larval parasitization by hymenopterans and dipterans have had overriding impact. A general predator, *Chrysoperla carnea*, prevails in the pigeonpea ecosystem, and was more pronounced in natural habitats of Phanda (Bhopal) on medium-duration pigeonpea all through vegetative to reproductive stages. In pigeonpea ecosystem, irrespective of the long- or medium-maturing varieties, predatory birds — black drongo, parakeet (*Psittacula krameri*), common mynah (*Acridotheres tristis*), house sparrow (*Passer domesticus*) — play a vital role. Accompanying bird species, rosy pastor, green bee-eater, blue jays and range of small omnivorous birds also are



Chrysoperla carnea



Trichogramma parasitoid of *Helicoverpa armigera*

found more at Kanpur. Among microbial agents, *Bacillus thuringiensis* manifested jumbled results. Undoubtedly, Nuclear Polyhedrosis Virus (NPV) resulted mortality as high as 75% under natural fields. Sorghum intercrop showed promising impact on pigeonpea for *Trichogramma* pervasiveness. Research investigations indicated conservation of natural enemies, irrespective of the locations; might be potential hub for providing consistent crop territory in the ecosystem.

HaNPV 250 LE (ARS, Gulbarga), Bt 0.1 % (BARC), Rimon (a new insect growth regulator) (Novaluron: Indofil

Chemical Company) and Jadoo 0.1% (Diflubenzuron + Alphamethrin) along with recommended dosages of endosulfan 0.07% (now phased-out chemical insecticide) were evaluated in 2003-04 against 2nd and 3rd instar reared healthy *Helicoverpa armigera* larvae in the laboratory as well as in the field. In laboratory, Rimon (0.2%) was most effective, causing 100% mortality of 2nd instar larvae of *H. armigera* after 144hr i.e., 6 days, which is in parity with *HaNPV*, *Bt* and endosulfan. In field, Jadoo and Rimon (0.1%, 0.2%) registered 9.8% pod damage, followed by *Bt* (11.5%) and *HaNPV* (11.8%) as against the control (15.5%). Highest yield was recorded in endosulfan (2,900 kg/ha), which was not considerably different from Rimon at both the levels with yield of 2,865 and 2,850 kg/ha, respectively, while Jadoo exhibited



Goniophthalmus sp (Diptera: Tachinidae) a potential parasite of *Helicoverpa armigera* in early pigeonpea ecosystem at Kanpur

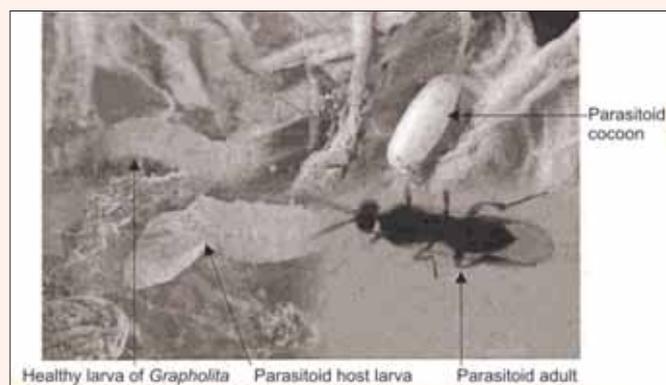
2,750 kg/ha, which was in parity with *HaNPV* (2,730kg/ha). Two generations of *H. armigera* were noticed on the early-maturing variety of pigeonpea; initiated from September until crop harvest (November end). *Goniophthalmus halli*, a larval-pupal parasitoid, caused 20% mortality of host pupae in November 2nd week (av.5.5%). In late-maturing pigeonpea, key mortality factors, bacterial and NPV infections in larval (av.13.40%) and pupal stages (av.14%), dominated. Two unidentified dipteran parasitoids caused larval mortality up to 9.0% of *H. armigera*. In early pigeonpea, natural regulatory factors were able to reduce *H. armigera* population by 27% at the end of the generation, and in late pigeonpea, it was up to 68%.

For podfly *Melanagromyza obtusa*, a dreaded pest of pigeonpea, hymenopteran was the only pupal parasitoid, highly active from January to March, causing maximum mortality of 12% during January (4th week). Mortality of *H. armigera* was observed due to biotic factors — sterility, NPV, fungi, bacteria and pupal parasitoids. In late pigeonpea, by and large, two

generations of podfly were observed. Key mortality factor was sterility, which caused hatching failure of eggs. *Euderus lividus*, a prominent larval-pupal parasitoid of *M. obtusa*, caused mortality to the extent of 3.62, 10.91 and 7.14 % of younger, older and pupal stages, respectively, in the first generation. Small, black, gregarious larval parasitoids emerged in the laboratory after 23 months and 8 days from hypothetically diapause larvae of *H. armigera*; collected from chickpea and pigeonpea fields. Larvae were hard, stiff, and white in colour, without any sign of purification. The parasitoid identified was *Copidosoma floridanum* (Ashmead) (Hymenoptera: Chalcidoidea: Encyrtidae). *Aspergillus flavus*, an entomogenous fungus, was evaluated against *H. armigera* in the laboratory. Spraying on the food was best method in comparison to administering dusting or other means. Egg parasitoid *Gryon clavigrallae* — a potential parasitoid — parasitized up to 66.67% of pod-sucking bug *Clavigralla gibbosa*, a serious pest of pigeonpea ecosystem. Spotted pod-borer *Maruca vitrata* Fab has a complex of predators — *Chelomenes sexmaculata* Fab, *Coccinella septumpunctata*, spiders and reduvid bugs.

A number of natural enemies were recorded on thrips in mungbean and among its predators, predominant in summer mungbean ecosystem, were *Brumoides suturalis*, *C. transversalis*, *C. septumpunctata*, *Chelomenes sexmaculata*. Dipterans appear to outnumber over hymenopterans in pigeonpea ecosystem. Of the 4 fungal pathogens recorded to cause disease on to lepidopteran borer in pigeonpea, little attention was given to exploit *Noumerea rileyi* (Farlow) Samson on the pest; environmental humidity plays a key role in epizootics of *N. rileyi*.

Bracon (*Habrobracon*) *hebetor* Say, found as one of the potential larval parasitoids of *H. armigera*, is being multiplied in the laboratory on the larvae of *H. armigera*, *Corcyra cephalonica* and *Galleria* sp., and 55 lab-multiplication generations have been completed. For laboratory multiplication of the parasite, different lepidopteran larvae were tried. The parasite covered totally larvae of *C. cephalonica* and *Galleria* sp. and *Maruca* sp. In case of *Maruca* sp, all larvae were paralyzed and died. Only 2 cocoons of the parasite were formed per larva in 25 cases. It may be due to small size, insufficient food availability for development of the parasite or may be due to some biochemical reactions. Maximal cocoons were formed in *Galleria* sp. (16-38), followed by *Corcyra* sp. (10-26). The findings indicate suitability of *C. cephalonica* for laboratory rearing of *Bracon* (*Habrobracon*) *hebetor*.



Apantalis sp. (Hymenoptera: Braconidae) – a potential and solitary larval parasitoid of leaf webber, *Grapholita critica* in early pigeonpea at Kanpur

A field experiment was conducted during *rabi* (post-rainy season) to study potential of bioagents against *H. armigera* in chickpea ecosystem. Larvae of *H. armigera* were collected from chickpea fields at weekly intervals and reared individually on semi-synthetic diet, and emergence of parasitoids was observed. The incidence of *H. armigera* and parasitization of *Campoletis chlorideae* started in 2nd smw and continued up to 11th smw. Its parasitization ranged between 0.3 and 22.9% with peak parasitization in 4th smw. The ectoparasitoid *Bracon hebetor* parasitization was initiated in 11th smw and continued up to the maturity of the crop *i.e.*, 15th smw. Lower temperature and higher relative humidity during January–March favoured parasitization of *C. chlorideae*. After 10th smw, higher temperature and reduced relative humidity favoured multiplication and parasitization of *B.hebator*.

White muscardine fungus, *Beauveria bassiana* (Balsamo) Vuillemin, was noticed pathogenic to *H. armigera*. Field investigation indicated that fungus controlled *H. armigera* effectively and lowered pod damage. Pod damage of 8.7% and grain yield 2.38 and 2.19 q/ha was recorded in chickpea plots treated with spore concentration of 2.82×10^7 and 2.82×10^6 spores/ml, respectively, in contrast to untreated control, which registered 16.3% pod damage and 1.84 q grain yield /ha.

Considerable efforts were made to manage important diseases of legumes by incorporating bioagents colonized natural substrates into the soil. *Trichoderma* is extensively investigated bioagent, operating in the pulse-based ecosystem; and is effective against wilts, rot (root, collar and stem) diseases, caused by different *Fusarium* spp., *Rhizoctonia solani*, *R. bataticola*, *Sclerotium rolfsii*, *Sclerotinia sclerotiorum*, *Ascochyta*, *Cercospora*, *Alternaria* spp. *Phytophthora* spp. and *Pythium* spp. Several isolates of *Trichoderma* spp. were characterized and evaluated against different fungal pathogens of

pulse-crops. Several native potential strains of *Trichoderma* sp. (IIPRTr) and PGPRs from pulses rhizosphere in different agro-eco-systems in India have been identified and well characterized for antagonistic potential against pests.

From pulse-growing fields, predaceous, endozoic and egg-parasitic fungi of root-knot nematode larvae were isolated. The fungi grew inside nematode larvae and disintegrated nematode body. Similarly, one endoparasitic fungus of cyst-nematode larvae was isolated. The predaceous fungus was isolated from soil collected from chickpea field, and was observed trapping nematodes on the water agar medium. Some egg masses of root-knot nematode collected from infected field were found black and infected. The fungus was isolated from these masses and the mycelium of the fungus was observed growing inside the eggs. This indicated possibility of biocontrol of cyst and root-knot nematodes in pulse-based cropping system. Field efficacy of two entomopathogenic nematodes (EPNs) species, *Steinernema masoodi* and *S. seemae*, was studied. Dust (powder) formulation worked better than liquid formulation and a dosage 30×10^5 IJs/ha was best. *S. seemae* was more effective than *S. masoodi*. Dose of 6×10^9 IJs of *S. masoodi*/pot was sufficient to kill physiologically mature *H. armigera* larvae; which dropped down to soil for pupation. A new heat-tolerant species *i.e.*, *Oscheius amsactae* (Nematoda: Rhabditida), has been identified and described. Its scanning electron microscopy (SEM), molecular and morphological characterization confined it to be a distinctly new species. *O. amsactae* was tested for bioefficacy against larvae of *H. armigera*, *G. mellonella*, *C. cephalonica*, and was found pathogenic; killed larvae within 48 hours. This EPN species infected also grey weevil (*Myloccerus* sp.), blister beetle (*Mylabris pustulata*) and some pests of vegetables like red-pumpkin beetle, *Aulacophora foveicollis* and *Epilachna* sp. EPN multiplication was best on *Epilachna*, which can be used for *in-vitro* mass multiplication of the species. *Oscheius* spp. were found very infective to *H. armigera*, *C. cephalonica* and *G. mellonella*. They have immense potential for use as entomopathogenic nematodes and can be easily multiplied on the artificial IIPR-media. Another new EPN species, *Steinernema* sp., N. (IIPR03), was identified on the basis of morphometric analysis. This species, isolated from chickpea rhizosphere, was virulent and multiplied well on *H. armigera*, *G. mellonella* and *C. cephalonica* larvae. Mortality of 2nd, 3rd, 4th and 5th instars larvae of *H. armigera* was 79, 75, 66 and 45%, respectively.

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PROFILE

ICAR–National Institute of Animal Nutrition and Physiology, Bengaluru

The basic and fundamental research in the area of Animal Nutrition and Physiology, carried out and contemplated by the Institute, hold the key for providing solutions to the existing and emerging problems in livestock production in the country



Genesis of the ICAR-National Institute of Animal Nutrition and Physiology (ICAR-NIANP) dates back to 1976, when the National Commission on Agriculture recommended its creation to work on the fundamental and the basic principles involved in optimum nutrient utilization. Realizing the national need for improvement of feed resources and their utilization by unraveling basic physiological and nutritional principles to improve animal productivity, the proposal for establishment of the institute was approved by the Planning Commission in the VIII five-year plan. In October 1992, ICAR constituted a committee of experts under

the chairmanship of Dr B.K. Soni to suggest location, structure, function and other related issues for the establishment of the ICAR-NIANP. On 24 November 1995, as per the recommendations of the stripe review

committee, the institute was established. Approximately 50 acres of farm land of the SRS ICAR-NDRI was transferred to ICAR-NIANP. The new campus of the institute was later developed

at Adugodu, Bengaluru, and it started functioning from that in 2003. The Institute has ISO 9000:2008 certification. **In 2012, the Institute was conferred Sardar Patel Outstanding ICAR Institution Award.**

MANDATE

- Basic and strategic research on physiology and nutrition for efficient livestock production.
- Capacity development in Animal Nutrition and Physiology.

OBJECTIVES

- To carry out quantitative and qualitative assessment of feed resources and to develop district-wise information system.
- To enhance availability of nutrients through various approaches viz., strategic supplementation, biotechnological interventions and feed-processing technologies.
- To enhance reproductive efficiency of livestock through physiological and nutritional interventions.
- To address issues of feed quality and safety.
- To develop strategies for validation of evolved technologies at user's level for production enhancement.

INFRASTRUCTURE

The Institute has eighteen state-of-the-art laboratories, equipped with advanced analytical facilities for research in the areas of macro- and micro-nutrients, feed quality and safety, feed additives and nutraceuticals, toxicology, energy metabolism, fermentation technology, rumen microbiology, reproductive physiology and biotechnology, molecular biology and proteomics, radioisotope and endocrinology, and climate change and stress physiology.

ARIS Cell and ASRB-ICAR Online Examination Centre: Agricultural Research Information Systems (ARIS) Cell looks after the maintenance of computers, network infrastructure and website. An Online Examination Centre for Karnataka has been established at the Institute for ICAR NET/ARS Prelim exams. The Centre is equipped with



100 test terminals, servers, UPS back-ups and dedicated high-speed internet connectivity.

Experimental Livestock Unit (ELU): It has facilities for housing large and small ruminants, poultry birds and mouse/rat. The unit is also equipped with a small-scale feed processing and storage facility. Recently, a laboratory animal-house facility has been inaugurated; it would develop with 15 crore outlay to carry-out basic and fundamental studies in Animal Nutrition and Physiology.



Guesthouse: A well-furnished guesthouse is maintained at the Institute campus.

MAJOR ACHIEVEMENTS

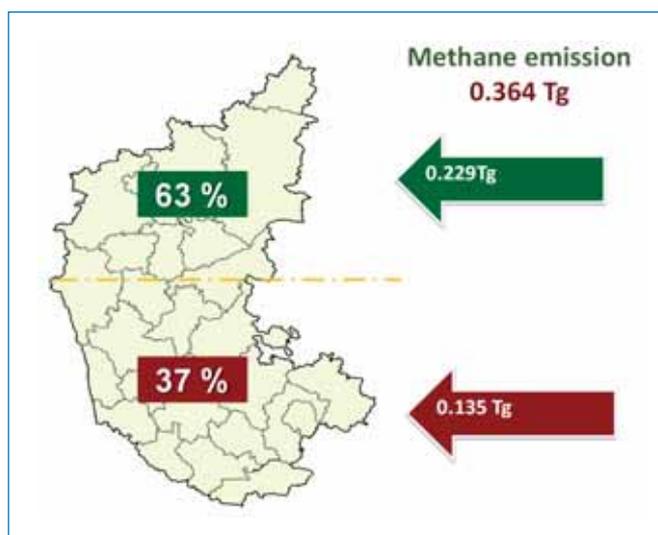
National Database on livestock population and feed resources

District and state level databases on animal and feed and fodder resources availability have been developed. The databases are updated regularly and refined for predicting requirements of the feeds and fodders in different parts of the country. Prediction equations are being developed to project future production and demand for feeds. Remote -sensing technology is being used for assessment, which would help in devising necessary strategies to address shortages of feed resources.



Enteric-methane emission database from livestock

District-wise database on enteric-methane emission has been developed; based on the methane-production potential of feeds and latest livestock census. Unlike others, NIANP database is principally derived from the methane-production potential of different feed resources/feeding practices. More than thousand feed resources were evaluated in the laboratory by *in-vitro* gas-production technique for generating primary data on methane-production potential to develop database.



The estimate revealed Uttar Pradesh as most enteric-methane emitting state (1.52 Tg/y); while Rajasthan, Madhya Pradesh, Maharashtra, Gujarat and Bihar stood next in the list of major methane-emitting states. The hilly states like Jammu and Kashmir, Uttarakhand and Himachal Pradesh contributed negligibly (<0.10 Tg) to country's annual enteric-methane emission.

Area-specific mineral mixtures

Micronutrients are required in small quantities, and can be supplemented more easily without affecting feeding practices. The area-specific mineral mixture is developed based on the micronutrient content in water, soil, feed and fodder, and biological material of animals. This is a more practical and cost-effective method of supplementation and for avoiding antagonistic effects of excess level of other minerals, thereby improving bioavailability of micronutrients. Mineral mapping for different agroclimatic zones was carried out. This technology has been commercialized and has a great potential in improving reproductive efficiency and immunity in dairy animals.



Approximately 300 animals with reproductive problems were given ASMM over two years. About 80-90 % of the animals recouped within 70 days of ASMM supplementation and about 50-60 % of animals became pregnant. All the animals with supplementation showed improvement in general health and marginal improvement in milk yield. This technology has been commercialized and adopted by the Karnataka Milk Federation (KMF) and Nandi Agro Vet, Bengaluru. The KMF is producing on an average 350 metric tons of ASMM per month.

Areca-sheath and pineapple waste as livestock feed

Over years, availability of paddy-straw has reduced in some coastal regions, and cultivation of areca as a commercial crop has increased. The areca-sheath, a by-product of areca-tree, has less lignin and silica, and is nutritionally superior to paddy-straw. Its use, however, has been limited due to physical structure. The technology developed processes areca-sheath in total mixed rations which reduces cost of feeding dry fodder by 50% with increased milk yield



besides mitigating shortage of dry fodder. Cows have a higher preference for areca-sheath based TMR as compared to paddy-straw. The study indicated a net saving of ₹14.4 per cow per day due to feeding of TMR with areca-sheath over paddy-straw.

Specific mineral mixture for small ruminants

The requirement of minerals varies considerably for small ruminants as compared to large due to their physiological needs. Specific mineral mixtures for small ruminants have been found useful in improving productive efficiency and immunity in small ruminants. In Rambouillet and Banner lambs, an additional body weight gain of 17 and 7 g/day/sheep was observed due to mineral mixture supplementation. Similarly, in Sirohi goat kids, an additional body weight gain of 8 g/day was recorded due to mineral mixture supplementation. The immune status in lambs in terms of antibody titre against PPR vaccine and lymphocyte proliferation assay was higher in supplemented lambs.



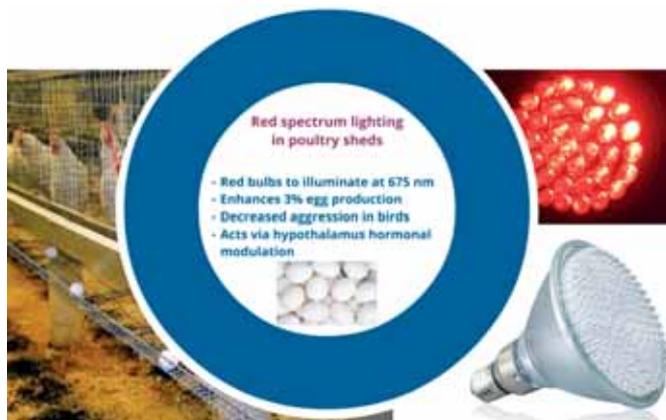
Low-cost azolla production

Azolla can be used as a valuable green-feed supplement, particularly under low-input livestock production system. Fresh azolla can be mixed with commercial feed in 1:1 ratio and fed to livestock; it saves 20-25% of cost towards purchase of commercial feeds. For small holders, a minimum pond size of 6 ft x 4 ft with durable plastic sheet like UV stabilized silpaulin, and side walls of bricks or excavated soil for Azolla cultivation was sufficient to produce about 800 grams of supplemental feed per day. Low-cost production method of azolla cultivation has been developed and popularized in rainfed regions and found to improve milk yield.



Poultry-layer house illumination to improve egg production

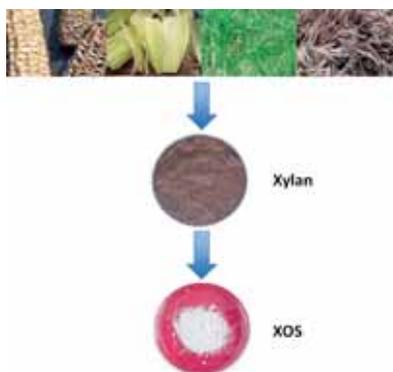
Egg production is dependent on the relative activation of two pathways. The inhibitory pathway is activated by stimulating retinal photoreceptors by incandescent band of spectrum, and stimulatory pathway is activated by direct action of red band on photoreceptors in the brain. Use of near red (675 nm) of the spectrum (using red



bulbs) increased egg production during 72 week period from 77.89 to 85.21%. This technology would augment existing management procedures in commercial poultry farms for enhancing egg production without any additional cost.

Pre-biotics from agricultural crop residues/ agricultural waste

Nutraceuticals are isolated from food ingredients, which have beneficial effect on the digestive process through manipulation of health-promoting bacteria, and thus improve general health and immunity.



Protocols for prebiotic formulations have been developed from agricultural wastes like finger millet straw, corn byproducts and natural grass by production of xylo-oligosaccharides (XOS), which would be cost-effective source for improving production and health of livestock.

Enteric-methane emission reduction from ruminants

Methane accounts for 2-12 % loss of dietary gross energy in ruminants, and is a potent greenhouse gas with global warming potential 25 times higher than carbon dioxide. Therefore, reducing ruminal methane would improve efficiency of nutrient utilization, and would also help protect environment from warming.

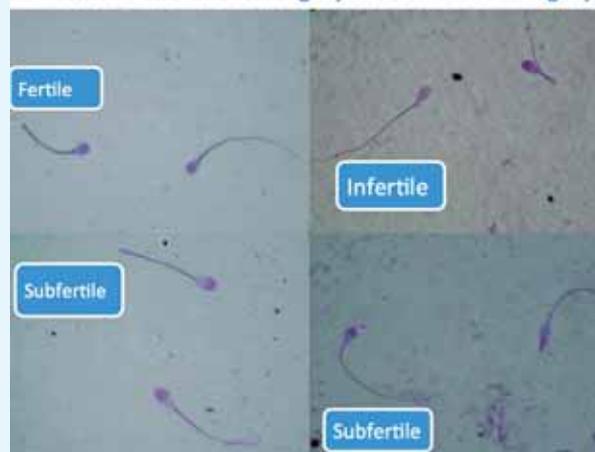


Plant secondary metabolites such as tannins as rumen modifiers are potential compounds since they are natural

HOST-Giemsa to eliminate subfertile bulls from AI chain

Conception rates following artificial insemination are poor, especially in buffaloes (~30%). One of the reasons is inability to identify subfertile bulls. To address this problem, a highly reliable advanced combination test that can detect semen of subfertile bulls has been developed, which involves assessing acrosomal and functional membrane integrities of sperm. Semen with sperms having both of these attributes has been shown to be positively correlated with fertilization ability in *in-vitro*. The technology helps to predict fertility of a semen sample and eliminates infertile semen being processed

Combination of tests- HOS-G Functional membrane integrity and acrosomal integrity



products which are environment-friendly and therefore have a better acceptance with regard to food-safety issues. Tropical-tree leaves containing-tannins such as *Autocarpus integrifolis*, *Jatropha curcus* and *Sesbania grandiflora* suppress methanogenesis by 25-30%. Therefore, tannins contained in these plants could be of interest in development of new additives for ruminants' nutrition.

Feed assist

Imbalanced feeding and undernutrition are major bottlenecks affecting production and reproduction of animals. There is a great need for an intuitive knowledg-based system which can suggest balanced ration for dairy animals. The Feed Assist software offers correct least cost ration under field conditions.

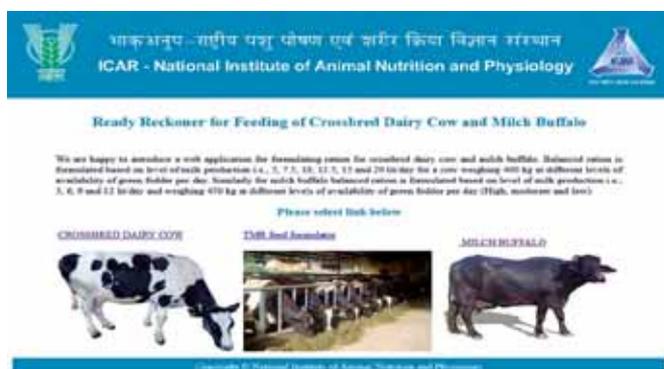
Feed chart

A farmer-friendly hardware tool has been developed for calculating amount of feed required for dairy cattle based on the body weight and lactation yield. This ready reckoner is available on the NIANP website.



Feed portal

A dedicated portal with all information pertaining to feed resources, feed exports and imports, nutrient requirements has been developed to help researchers, feed industry, planners, academicians and developmental



agencies in accessing correct information. This portal would help in better management of feed resources and also help developmental agencies and policy-makers in formulating better livestock developmental schemes.

FUTURE THRUST AREAS

- Precision feeding and phase feeding to resolve problem of feed shortage
- Residual feed intake as a tool for selecting animal for better performance
- Augmenting production intensity through genomic and

Fodder sprouts production

To overcome the problems of hydroponic fodder production like high cost, handling of very high moisture feed and risk of mould growth, a cost-effective method of producing mould-free sprouted fodder has been developed.



Pre-soaked seeds are treated with vinegar and sprouting seeds are grown on the low-cost bedding material like straw of paddy/wheat/finger millet/sorghum placed on the gunny mat with minimum use of water (2 to 3 sprays of water per day). They are grown for about 7 days and the entire straw-mat with fodder sprouts is rolled, taken out from racks and used for feeding livestock. It is an easy and low-cost contingency measure to tide over green fodder deficit without usage of power. About 8 litres of water is required for obtaining four kg of nutritive mould-free fodder sprouts from one kg of maize-seed in places with moderate climate.

- molecular tools
- Deconstruction of ligno-cellulosic biomass through manipulation of gut microbiota
- Modulating gut microbiota for better nutrient utilization
- Mining plant derived feed additives and nutraceuticals
- Nanotechnology for nutrient delivery
- Reducing greenhouse gases and environmental pollutants from animal farming
- Developing physiological and nutritional strategies for combating stress
- Understanding nutrient-gene interaction for various physiological functions
- Identifying biomarkers for selecting superior males and gametes for better reproductive efficiency
- Identifying water efficient crop-livestock production system to promote environmentally sustainable animal farming.

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Carryover of triasulfuron from wheat to soybean

Use of herbicides is replacing manual methods of weed management in crops like rice, wheat, soybean etc. For these crops, many choices of herbicides are available in the market. Low dose herbicides are becoming popular over old molecules like 2,4-D, isoproturon, butachlor, etc. Sulfonyl ureas—pyrazosulfuron, sulfosulfuron, chlorimuron, metsulfuron, mesosulfuron imidazolinones imazethapyr and andazamox— are capturing largest market share in rice, wheat and soybean because of their efficiency in managing weeds. But in the backdrop of their success, some cause phytotoxicity to succeeding crops. For an instance among many, application in wheat of sulfosulfuron and mesosulfuron + iodosulfuron affected growth and development of greengram and maize, grown in succession. More recently, devastation in soybean- crop was by triasulfuron applied to preceding wheat in farmers' fields of Dhar district (Madhya Pradesh).



Phytotoxicity symptoms and stunted growth of soybean, caused by triasulfuron residues in the soil

During *Rabi* 2014-15, triasulfuron, a recently registered wheat herbicide of the sulfonyl urea group, was applied by 36 farmers in around 64 hectares in Bidwal region of Dhar district. The recommended rate was 20 g ai per ha (100 g of 20% WDP formulation per ha). It was found effective in controlling broad-leaf weeds of wheat. In the next *kharif* season, total area was under soybean cultivation. Due to delayed monsoon, no pre/post-emergence herbicides were applied. After a good germination, soybean-plants showed severe phytotoxicity symptoms. In the adjoining fields, where soybean was grown after chickpea or garlic, there were no such symptoms. Phytotoxicity symptoms



Triasulfuron affected soybean fields

were observed only in those fields where triasulfuron was applied during *rabi* in wheat. Representative soil samples were collected from the affected fields during 4-5 August 2015; around seven months after triasulfuron application. The samples were analysed by bioassay technique and chemical method to identify herbicide residues. In bioassay, it was observed that broad- leaf plants like soybean and mungbean were affected after good germination. Collected samples contained triasulfuron residues within 1.28 to 7.48 g/ha.

Sulfonyl-urea herbicides, in general, are very much sensitive to soil pH; are stable in soil pH above 6.0. The pH of Bidwal region soil is within the range of 7.1 to 7.9. In this soil, chemical degradation, i.e. hydrolysis on sulfonyl-urea bridge of triasulfuron is not possible. Moreover, the soil is rich in clay and organic matter. Soils high in clay and organic

matter content adsorb more herbicide onto the soil colloids. Herbicides bound to soil colloids cannot be taken up by plants or moved through the soil profile or degraded easily. Crops in rotation can be injured when water displaces soil-bound herbicide residues.

During the period between wheat season and the onset of soybean cultivation, Bidwal did not receive any rainfall. Dry conditions increased triasulfuron adsorption on to soil colloids and decreased its chemical hydrolysis and microbial degradation. After first irrigation to soybean, water displaced soil-bound triasulfuron residue, which injured crop.

It was, thus, simply a case of a wrong positioning of the product. Probably, the application rate of the herbicide was at a higher side for this type of soil and

climate. In Australia, the maximum dose of triasulfuron is 26 g ai/ha (35 g of 750 WG formulation/ha) for a very light soil with the warning of replanting interval of at least 12 months and minimum rainfall requirement of 500 mm between application of the herbicide and the sowing of the following crop (Directions for Use of Triasulfuron, Titan AG Pty. Ltd.). Thus, prior to using this herbicide, careful consideration should be given to crop rotation plans. To overcome the problem of triasulfuron contamination in the soil, frequent irrigations or heavy

and frequent rainfalls are required to leach down herbicide residues from the soil surface layer. The addition of organic matter and frequent tillage of the field may increase microbial degradation or biodegradation of the herbicide residue in the soil.

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KRL 210 – Climate-resilient wheat for salt-affected ecologies

Shallow water-table (0.4-1.0 m), and moderate to high soil (EC_2 : 2.48-10.20 dS/m) and water (EC: 2.23-4.63 dS/m) salinity are common in more than 300 hectares of land in village SiwanaMaal of Jind District. These compounded vulnerabilities along with the lack of technical know-how have made agriculture in the village a non-remunerative activity, particularly, in the affected ecologies. Some of the farmers even abandoned crop cultivation and sold agriculture native lands at a very low price to look for alternative options and livelihood securities.



This village was adopted under the 'Institute Adopted Village' to intervene in reclamation and management strategies for salt-affected soils. A project on subsurface drainage (SSD) was implemented to address waterlogged saline soils. Cultivation of traditional varieties had resulted in relatively poor crop yields owing to lesser crop tolerance. Many a time, crop failed due to continuous water stagnation or submergence caused by flash flood and drought.

To test productivity potential of wheat KRL 210 under real stress, 10 frontline demonstrations (FLDs) were conducted for affected farmers in 2011-12. Within 3 years, KRL 210 gained momentum, and its cultivation started on more than 180 hectares of salt-affected lands. At present, farmers could harvest 3.5-5.2 tonnes/ha from this variety as against the average of 0.4-0.66 and somewhere of 1.0-1.5 tonnes/ha. Based on the past

performance, about 78.5% of farmers are of the opinion that during the period of high intensity rains (e.g. January to first week of March 2013 and 2014), KRL 210 performed relatively better than other varieties. This variety matures 4-5 days earlier than the dominant wheat varieties, and has been found to have high *chapati*-making quality as compared to other varieties.

Many farmers used higher seed rate due to adoption of broadcasting method (at 115-125 kg seed/ha), followed by rotavator ploughing, which mixed plough layer inherent salts, that led to uneven and poor crop germination, seed placement at deeper depths and ultimately poor crop yields. Farmers adopted 'Zero tillage' sowing method to ensure better seed placement and good germination in salty soils. This resulted in lesser soil disturbance, leading to minimum salt mixing and reduction in input costs. More than 2,000 farming families have been directly and indirectly benefitted with this integrated technological intervention, covering additional 400 hectares of land with KRL 210 variety. The adaptive attributes of KRL 210 have made farmers to form their own informal network of seed exchange, informal marketing to maintain seed supply-chain and combat location-specific ecological vulnerability to sustain their livelihood.

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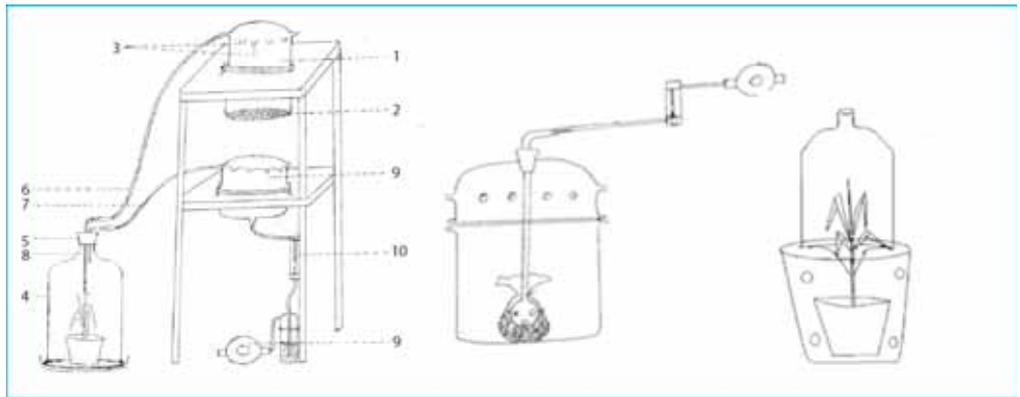
Dynamic system for sampling volatiles from multiple specimens

Breathe of a plant (green-leaf volatiles), scent of a spice, of a flower or of a fruit and scent of an animal (such as breath and pheromones of small animals say a frog) have proven to be a valuable source of information about their biology. Sampling and analysis of these volatiles would lead to identification of their exact composition and that would have tremendous applications in perfumery, food technology, disease monitoring, pheromone technology, pest management etc. Sampling of these organic volatile compounds under the natural environment can become a daunting task. A sampling system originally developed was to study volatile attractants and repellents; involved in the plant-pest-natural enemy interactions.

Most commonly used volatile- sampling systems are of 'static' type, wherein the live- specimen is enclosed in a chamber and its biology is altered under suffocation; and volatile saturation would be drawback for inert specimens such as spices. This presently developed system is ideal for sampling volatiles from live-specimens; and as it is designed for continuous air- flow, it is a 'dynamic' type. The system can be operated in a 'pull' mode where air is pulled continuously through the system as well as in a 'push-pull' mode where air is pushed in at the inlet and pulled out at the outlet. 'Push-pull' mode is ideal, especially when a part of the specimen (e.g. pot-containing soil,) is to be excluded and 'pull' mode when volatiles need to be sampled from the entire specimen. This system is also unique compared to other available systems with respect to its ability for simultaneous sampling of volatiles from multiple specimens using a single aeration or vacuum unit; which makes it simple, efficient in terms of money, time and space (a patent has been applied, Patent appl. No. 1235/DEL/2015). The system would be handy wherever the sampling of volatiles, especially from live -specimens, is to be done.

The prototype has been designed for simultaneous sampling from ten specimens; and can also be modified according to the requirement.

Technology: The 'pull' type system comprises an aeration unit (1) with an air inlet (2) (where adsorbents for purifying air are placed) and many outlet ports (3), and specimen chambers/bell-jars (4). Each chamber is being provided with a stopper (5) fitted with two tubes, one for supplying purified air (6) and the other, an outlet tube (7) with a volatile trap (8). The outlet tube is connected



to a vacuum unit (9) with many inlet ports, thus in a fluid communication with specimen chambers facilitated by a suction unit (9), where air flow of the system is monitored by a flow meter (10). The aeration unit is modified to push air to operate system in the 'push-pull' mode, where specimen is placed. The specifications are flexible keeping in view of the type, size and number of specimens to be used by the end-user.

The method of sampling volatiles requires placing the specimen in the bell- jar; purification of the air happens while it enters into the aeration chamber over adsorbent/ adsorbent mixtures during the passive air- flow in the



The system in operation

'pull mode' and active air-flow in the 'push-pull' mode; purified air passes on to the specimen, kept inside the bell-jar; and volatiles from the specimen to a volatile-collection trap, and air passes out after trapping volatiles, facilitated by a suction unit *via* a flow meter. While operating in the 'push-pull' mode, only 75-80% of the pumped air is pulled out of the bell-jar to allowing remaining air to escape through the vent on the aluminium foil, skirted around the plant canopy raised above the bucket lid/pot; this is to prevent soil volatiles mixing with plant volatiles. By pulling out less air than pumped ensures that some air will always be flushed

down through the vent; thus no air from excluded portion would enter the system.

Further, volatiles collected in the volatile-collection trap are extracted by various known methods and analyzed by standard techniques such as gas chromatography.

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Pheromone trap for paddy yellow stem-borer in tribal belt of Tapi district, Gujarat

Paddy-crop is mainly grown in *kharif* as well as in summer in Tapi district of south Gujarat. Of the twenty insect-pests recorded as major ones, five are of national importance. Among these, rice stem borers have been causing stress to the crop over years and across rice ecosystems in Gujarat and also throughout the country. It was observed that to manage *Scirpophaga incertulas*, farmers' usually opted out chemical pesticides as the first line of defense; this is often beyond the capacity of poor farmers. Biological control through natural enemies is ideal but is not yet popular, and is also not easily applicable. Moreover, this particular pest is an internal feeder and so it is not much affected by insecticides. Under these



Distribution of pheromone traps

Distribution of pheromone traps in different villages of Tapi district in collaboration with DRDA

| Sl no. | Block | Village | Total beneficiaries | No. of pheromone traps distributed/beneficiary | Total no. of traps distributed | No. of <i>Scirpo lures</i> distributed/beneficiary | Total no. of <i>Scirpo lures</i> distributed |
|--------|--------------|------------|---------------------|------------------------------------------------|--------------------------------|----------------------------------------------------|----------------------------------------------|
| 1. | Valod | Ambach | 30 | 6 | 180 | 18 | 540 |
| 2. | Vyara | Raygadh | 30 | 6 | 180 | 18 | 540 |
| 3. | Songadh | Ukhalda | 30 | 6 | 180 | 18 | 540 |
| 4. | Ucchhal | Karod | 30 | 6 | 180 | 18 | 540 |
| 5. | Nizer | Toranda | 30 | 6 | 180 | 18 | 540 |
| | Total | 150 | | | 900 | | 2,700 |

Performance of pheromone-trap technology

| Sl No. | Block | Village | Yellow stem-borer infestation | | | | Yield (q/ha) | | % increase-in yield |
|--------|----------------|---------|-------------------------------|-------------|-----------------|-------------|--------------|--------------|---------------------|
| | | | % dead heart | | % white earhead | | Demo. field | Local check | |
| | | | Demo. field | Local check | Demo. field | Local check | | | |
| 1. | Valod | Ambach | 6.4 | 9.6 | 5.8 | 8.7 | 42.5 | 39.4 | 7.87 |
| 2. | Vyara | Raygadh | 5.8 | 9.0 | 6.0 | 9.4 | 40.3 | 36.8 | 9.51 |
| 3. | Songadh | Ukhalda | 4.5 | 8.5 | 5.2 | 7.9 | 38.5 | 35.8 | 7.54 |
| 4. | Ucchhal | Karod | 6.0 | 8.8 | 5.8 | 9.0 | 40.5 | 37.4 | 8.29 |
| 5. | Nizer | Toranda | 5.5 | 8.3 | 6.2 | 9.5 | 38.4 | 35.0 | 9.71 |
| | Average | | | | | | 40.04 | 36.88 | 8.58 |



Field view of demonstrated plot

circumstances, pheromone-trap technology was tried in the villages.

In collaboration with the District Rural Development Agency, the technical guidance was given to paddy-growing farmers of Tapi district; five villages were selected from five blocks. Thirty farm-women were selected from each village. Six funnel-type pheromone traps with 18 *Scirpo lures* were distributed to each farm-woman. The total costing of pheromone trap with lures

was ₹46,800. Demonstration was carried out for operation and installation of pheromone traps. SMS (Plant Protection) guided farmers about identification of insect -pests of paddy, their bioagents, and life stages of both.

By adopting pheromone-trap technology, grain yield of paddy increased in the demonstrated field; 8.58 % increase in the yield was observed.

Use of pheromone trap as an IPM component attracts maximum number of male moths of *Scirpophaga incertulas*, and thereby lesser damage was observed in the field. Thus, pheromone-trap technology can be used as an alternative to health-hazardous chemical pesticides. Farmers from neighbouring villages were also attracted and associated with the KVK for adopting the technology.

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Partial protection for organic kiwifruit production

Kiwifruit (*Actinidia deliciosa*) is known as Chinese gooseberry and China's miracle and Wonder fruit of New Zealand.

Now kiwifruit is universally accepted name of this fruit for all export shipments, even from China. In India, it is

growing well in Himachal Pradesh and Arunchal Pradesh. Its cultivation has started in Sikkim, Darjeeling and Meghalaya as one of the viable options; like other temperate fruit-crops. In Sikkim, West Sikkim is taking lead in its area and production; it is growing well especially in Rinchenpong, Deythang and Soreng areas.



It is also growing in some pockets of East and North Sikkim. Prolonged wet seasons with high rainfall intensities along with frequent hails in the North-Eastern Hill Regions cause several biotic and abiotic stresses in its open cultivation, and have a serious negative effect on the percentage of fruit-set and kiwifruit yield. Kiwifruit flowers are extremely susceptible

Crop calendar for organic kiwifruit production

| No. | Activity | Time |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| 1. | Pruning should be done to remove excessive vegetative growth and to give proper training to kiwifruit-vine. Approximately 10-12 buds should be retained during pruning. In newly planted orchard, two shoots should be selected and tied down at both the sides to the middle wire in the second year. These are the secondary arms. In the third year, the tertiary fruiting arms which bear fruits in the forthcoming year are selected on these secondary arms. These tertiary arms should be tied down to out-trigger wire to hold them in position. | December-January |
| 2. | Clean the basin of plants and apply well decomposed FYM at 25 to 35 kg/plant, and regularly water plants at 10 days interval. Application of dolomite at 2 tonnes/ha should be done annually for maintaining soil pH and better fruit quality. | January-February |
| 3. | 50 per cent agro shade net should be erected over plants to avoid damage to flowers from hails and intense rainfall. | March-April |
| 4. | Hand pollination should be done for better fruit-set. Remove weeds, and basin of the plants should be cleaned. | April-May |
| 5. | 50 per cent agro shade net should be removed cautiously from the plants; weeding should be done and basin of the plants should be cleaned; apply neem cake at 2 tonnes/ha and spray organically permitted micronutrients at 0.2% for better fruit growth. | May-June |
| 6. | Weeding should be done and basin of plants should be cleaned. Apply well decomposed FYM at 25 to 35 kg/plant and vermicompost at 4 to 10 kg/plant for better production and fruit quality. | July-August |
| 7. | Spray organically permitted micronutrients at 0.2% for better production and fruit quality. | August-September |
| 8. | Weeding should be done and basin of plants should be cleaned. | September-October |
| 9. | Harvesting should be done in dry weather of, and protect fruits from direct sun. Harvest larger fruits first when fruit attains full maturity. The picked fruits are hard but after 10-15 days storage at room temperature become ready for table-purpose. | October - November |
| 10. | Collect dry leaves and mulch plants. | November-December |

Advantages of the partial protection

- Provide a suitable microclimate for vegetative growth, flowering, initial fruit-set and fruit development. Compared with plants grown under unprotected conditions, kiwifruit-vines with partial protection grew more rapidly, had better fruit-set, and produced larger fruits, and fruits also matured early. Hand pollination as well as natural pollination improved under partial protection.
- Reduced physical damage to vines, young-growing shoots, leaves, flowers and fruits (The new shoots, especially the young-growing tips, are very soft and tender, and are easily damaged by high rainfall and hails; flowering shoots also break easily, reducing the current season's crop. However, more serious damage can be by breakage of replacement shoots, which would carry following season's crop. These shoots usually grow almost vertically, and are subject to breakage at the junction of the shoot and the main permanent leader of the vine. This results in the loss of not only the shoot itself but also of the basal axillary buds which normally provide shoots of future years. Leaf damage implies a reduced photosynthetic area, which would lead to reduced flowering in the following season).

to damage by heavy rainfall and hail storm. Provision of adequate shelter is essential to protect them from heavy rainfall and hails for their successful organic production in Sikkim. Organic package of practices have been standardized for maximization of 'A' grade kiwifruit production along with partial protection of kiwifruit-vines with 50% agro-shade net.

Studies were undertaken on hand-pollination techniques and their effects on percentage fruit-set, fruit growth,

fruit yield and fruit quality under partial protection along with the control (C). Hand pollination significantly increased percentage of 'A' grade fruits (70-80%) under partial protection. The best time of hand pollination was observed 10-12 am to get maximum fruit set (80-90%). Pollen viability was observed up to 72 hr for hand pollination; however, maximum (100%) fruit-set was observed in hand pollination within 24 hrs after anther removal, and 90% fruit-set was observed after 48 hrs of anther removal. Hand pollination and organic nutrients'

(ON) management showed significant effect on fruit length {55.46 mm (C) to 70.26 mm (HP&ON)}, fruit breadth {40.20 mm (C) to 42.47 mm (HP&ON)}, fruit weight {50-60 g (C) to 100-120 g (HP&ON)}, and quality parameters — acidity {0.63% (HP&ON) to 1.35% (C)}, total sugars {8.23% (C) to 14.05% (HP&ON)} and total soluble solids (TSS) {10.54° Brix (C) to 18.67° Brix (HP&ON)}. For maximization of 'A' grade organic kiwifruit production, vines should be mounted with 50% agro-shade net at the end of March for about sixty days, and net

should be removed at the end of May.

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Role of socio-economic household characteristics in adoption of livestock insurance

An organized Cattle Insurance Scheme was initiated through Small Farmers' Development Agency (SFDA) in 1971. But it got a real fillip only when nationalized banks started financing for cattle purchase, and agreed to collect premium from beneficiaries under the Integrated Rural Development Programme (IRDP). Since then, livestock insurance scheme has undergone many transformations. But in spite of concerted efforts, it did not pick up the desired pace. This is of concern, as livestock acts as a security and poverty reduction instrument for majority of the marginal and small farmers in India, and lack of insurance cover would make them even more vulnerable. A serious debate is going on to strengthen agriculture and livestock insurance in the country. The latest *Pradhan Mantri Fasal Bima Yojana (PMFBY)* is indicative of the seriousness of the issue. Globally, there has been a mixed response on the adoption of livestock insurance products. In this backdrop, this study was undertaken to: (i) examine extent of livestock insurance coverage, (ii) assess determinants for farmers' participation in livestock insurance, and (iii) identify factors determining farmers' level of payment for livestock insurance. The study is based on the primary data collected in 2015 at the farm level in two states – Haryana and Rajasthan. Haryana has assured irrigation, and availability of feeds and fodders are aplenty. Rajasthan is a rainfed state, and has a challenged environment for livestock-rearing.

Socio-economic characteristics of respondents

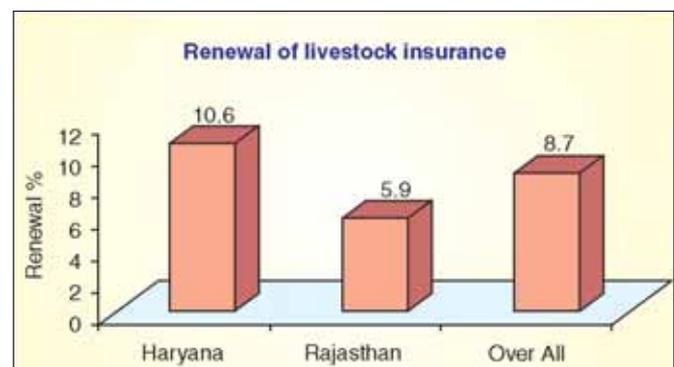
The socio-economic characteristics of adopters and non-adopters of livestock insurance did not differ significantly, except in average herd size, and in average milk yield and family income. The average herd for adopters of livestock insurance was 3.9 as against 5.3 for non-adopters. But average milk yield was significantly higher for adopters than that of non-adopters. The average

annual income of adopters was also significantly higher than non-adopters.

Livestock insurance system: In India, livestock insurance is given through public sector insurance companies, and it is available for almost all livestock species. Normally an animal is insured up to 100 % of the market value. Its premium is subsidized to 50 %. Entire cost of subsidy on premium, honorarium to veterinary practitioners and publicity and awareness is borne by the Central Govt. The balance 50 % of premium is borne by the state and beneficiaries. Premium subsidies are restricted to two animals only, and given one time insurance for three years. The premium is 4 % of the sum insured for general public and 2.25 % for the targeted beneficiaries. In spite of the concerted efforts, progress in livestock insurance was slow. It picked up, and by 2012-13, about 80 million animals were insured; nearly 16 % of livestock population in India.

Further, information on renewal of livestock insurance does not depict an encouraging scenario. Only about 9 % of the households renewed livestock insurance.

Role of socio-economic household characteristics: The data on the determinants of adoption of insurance were



Socio-economic features of households

| Indicators | Insurance adopter | Insurance non-adopter | t-test of difference |
|-----------------------------------------|-------------------|-----------------------|----------------------|
| Sample size (number) | 288 | 625 | |
| Age (years) | 50.0 | 49.6 | 0.4311 |
| Experience in livestock farming (years) | 41.9 | 41.9 | 0.0356 |
| Households headed by females (%) | 4.9 | 4.8 | 0.0016# |
| Education level (%) | | | |
| Illiterate | 50.4 | 53.0 | 6.1640#* |
| Below Primary | 8.0 | 8.8 | |
| Secondary | 16.7 | 19.8 | |
| Senior Secondary | 15.9 | 12.6 | |
| Above Sr. Secondary | 9.0 | 5.8 | |
| Main occupation status (%) | | | |
| Agriculture | 27.1 | 30.4 | 1.0458# |
| Agriculture + Livestock | 72.9 | 69.6 | |
| Average herd size (number) | 3.9 | 5.3 | 7.11*** |
| Average milk yield (liter/day) | 8.1 | 4.7 | 33.29*** |
| Average land holding size (ha) | 3.1 | 3.1 | 0.04 |
| Family income (Rs./Annum) | 1,18,738 | 1,11,403 | 1.6088** |

Source: Field survey, 2015

Note: *** represent significance at 1% level, # represent Pearson chi2 (1) and #* represent Pearson chi2 (4)

analyzed using logit regression model. Results revealed that age, education, gender, household income, experience in livestock-rearing, household size, herd size and average yield of milch animal influenced farmers' decision. Age had a positive impact. Similarly, higher education generated awareness, and reflected better understanding of the impending danger in the absence of livestock insurance. Female-headed households were better placed in terms of making decision about livestock insurance products. Only 10% of the households in the study area were headed by females. The herd size, household income and experience in livestock farming had a significant negative influence on adoption. This may be attributed to the fact that farmers having higher income and larger herd size were relatively less vulnerable and were having better risk absorption capacity, and therefore were not inclined to insurance of animals. Farmers' experience in livestock-rearing reduced probability of adopting livestock insurance. The geographical diversity too affected significantly adoption of livestock insurance.

Determinants of level of payment for premium: The bigger family size and higher milk yield influenced positively on the level of payment for livestock insurance.

And land size influenced negatively. Age, experience in livestock-rearing, having cows and higher education did not have affect. Study was also to observe any behaviour changes or any policy level impact, but did not show any variations. This may be attributed to the fact that farmers had less awareness of livestock insurance products.

The relatively low coverage and extremely low renewal of livestock insurance may cast doubts on the feasibility of livestock insurance. It is suggested that Government and other stakeholders' efforts need to be directed towards policies and programmes to create more awareness through interactional meets with farmers and insurance agencies for entire herd insurance provisions as desired by majority of livestock owners, for assessing real demand of attributes preferred by farmers in the livestock insurance products and for constant engagement with all stakeholders for designing and launching any livestock insurance products. These steps are required for giving desired momentum in adoption of livestock insurance in India.

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WAY FORWARD

Floriculture, an integral part of Indian culture, has a special mention in sacred scriptures of the Vedic time, entwining flowers with social fabric of worship and religious rituals. Globalization of Indian economy and liberalized seed policy during 1990s paved way for the advent of modern commercial floriculture with the establishment of a large number of 100% export-oriented units, mostly by the corporate sector.

The traditional-flower growing sector registered an impressive growth during 2001-2014 with a significant increase in area from 71,000 ha to 255,000 ha, and in production from 366,000 MT to 2,297,000 MT, respectively, while cut-flowers production was 543,000 MT at the end of 2014. Major flower-producing states are Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Rajasthan, West Bengal, Bihar, Jharkhand, Kerala and Telangana, while major markets are in Chennai, Bengaluru, Kolkata, Hyderabad, Kadiyam, Pune, Mumbai and Delhi. Nonetheless, marketing yards for flowers are mostly on the pavements with primitive infrastructure for post-harvest care and processing; leading to poor shelf-life.

In the country, nearly 98.5% of flowers are grown under open cultivation, and hardly 1.5% in greenhouses. The euphoria generated by the sector during 1990s for cut-flower production in greenhouses subsided after some hard lessons learned by the industry.

In Bengaluru, however, dedicated marketing infrastructure for cut-flowers is in place in the form of a flower-auction centre; but many other cities are far behind in establishing such market units.

India's position as an exporting country for cut-flowers stands at 29 among flower-exporting countries with a value of 82.27 lakh USD, which translates to a percentage share of 0.31%. On the other hand, India imports flowers like proteas, orchids, Iris, cala lily, heliconia, worth ₹38.25 crore from Thailand, the Netherlands and People's Republic of China. Explicitly, India is a leading producer and exporter (₹322 crore out of ₹455 crore) of dry flowers in the world.

To augment research needs of the floriculture sector, the ICAR had initiated strategic research work on flower-crops at the erstwhile Division of Botany at the IARI during early 1950s, and subsequently in the Division of Horticulture during 1958-59. At present, research on floriculture is concentrated in four ICAR institutes – Directorate of Floricultural Research, Pune; Indian Agricultural Research Institute, New Delhi, Indian Institute of Horticultural Research, Bengaluru; National Research Centre on Orchids, Pakyong) – and in nearly 25 State Agricultural Universities. The research on floriculture had really started with an All-India Coordinated Research Project during 1970-71 with 21



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

research centres, and its subsequent upgradation as the Directorate of Floricultural Research at Pune during 2009.

During the last four decades, efforts were made to give a technological base to floriculture. In the recent years, several improved varieties have been developed in rose (250), chrysanthemum (150), gladiolus (81), tuberose (8), jasmine (5), China-aster (8), marigold (4), crossandra (2), gerbera (2), besides several of bougainvillea varieties. A unique chocolate-brown coloured rose variety Mohini has contributed to brown pigment for global rose varieties.

Production technologies for important flower-crops (through *in-vitro* propagation also) have all been standardized for different agro-climatic regions. For instance, in carnation and chrysanthemum, programmed flower production, through artificial short day and long day conditions, has been standardized. Integrated pest and disease management modules for traditional flowers as well as cut-flower crops are effective in minimizing yield losses. And new research initiatives taken up in recent times include management of turf grass; *in-vitro* expression of nutraceutical pigments like anthocyanins, carotenoids and betalains; improved lines of marigold for extraction of nutraceutical carotenoid pigments; development of DUS test guidelines; and genetic fingerprinting.

Over all, floriculture remains an opportunity in Indian agriculture sector for continued R & D to explore science of producing bedding plants, plug plants, avenue trees, aquatic flowers and urban floriculture. While our goal is to get the best price for the farmers, viable post-harvest and packaging technologies are also being promoted. To this effect, the Council is developing mobile apps for providing information on agronomy management practices, advisories and post-harvest technologies to give a platform to enhance productivity in floriculture vis-à-vis doubling farmer's income.

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