ISSN 2394-3289
Volume 25 No. 4 ISO 9001:2015 Organization October-December 2019

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

भाकृअनुप
ICAR

ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Endemic Nicobar plant-alternative to plastic food wrappers/plates

It is high time that we should quit plastic food plates and wrappers and turn to biodegradable natural alternatives. Across the country, depending upon local availability, banana leaves, *Butea*, *sal*, teak leaves, arecanut leaf sheath, etc. are used as food plates. A multidisciplinary ICAR exploration team led by ICAR-NBPGR and collaborated by ICAR-CIARI, Port Blair has located a few vigorous *Macaranga* trees in Nicobar Islands; leaves of which can be used as dining plates and also wrappers for meat, fish, vegetables, etc. The tree, *Macaranga nicobarica* N.P. Balakr. & Chakr. (vern. name Kinhul) is endemic to Nicobar Islands and produces abundant leaves in tropical high rainfall conditions. Leaf lamina is undivided, intact and does not tear with mild pressure besides has around 70 cm diameter which is double the size of a normal food plate. Nicobaris traditionally use its leaves for serving food as plate and also to wrap pandanus cakes in its leaves for steaming. Leaves do not have any taste or offensive smell, thus, they are ideal for using as food wrapper.

Natural stand of *Macaranga nicobarica* in Champin Island, Nancowrie group of islands, Nicobar

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

Harvested leaves

Trees are medium size with plenty of branches and leaves are good source of green manure. Cut branches are erected as temporary shade and shelter by migrant labourers while working in open sun. Propagation is through seeds which mature in March-April. Seeds are orthodox in nature. Seeds have been conserved (IC626370) in the National Gene Bank ICAR-NBPGR, New Delhi and few plants have been established in the field gene bank of ICAR-NBPGR RS, Thrissur and also at ICAR-CIARI, Port Blair. This wild economic plant needs to be popularized in social forestry programmes as a potential alternative to plastic plates.

Joseph John K, K Pradheep
ICAR-NBPGR, Regional Station, Thrissur,
Kerala 680 656, I. Jaisankar,
ICAR-CIARI, AB Jerald,
ICAR-CIARI, Port Blair,
Andaman and Nicobar 744 101 and VAM Nissar,
ICAR-IISR, Peruvannamuzhy,
Kozhikode, Kerala 673 528
email: joseph.k@icar.gov.in

Slow release formulations of pheromones for management of fruit flies

Fruit flies belong to the order Diptera (true flies) with one of the largest, most diversified family called the Tephritidae. The Tephritidae are one of two fly families referred to as fruit flies due to their close association with fruits and vegetables. Fruit flies are of great economic importance as majority of them cause extensive damage to many fruits and vegetables. They are considered as high priority quarantine pests. Various types of pheromone traps have been developed in India for eco-friendly monitoring and management of fruit flies. However, these traps have limited period of efficacy in trapping the fruit flies, varying from a week to 1 month. Traps usually are more effective during first few days of their installation and their efficacy get decreased later on. To increase the trapping efficacy of the traps, slow release formulations of pheromones can play an important role. Keeping this in view, slow release formulations of pheromones of fruit flies, *Bactrocera dorsalis* and *Bactrocera zonata* were developed at ICAR-NBAIR, Bengaluru. During June 2019 field efficacy of these formulations, experiments were carried out at Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana (Punjab) during July-August 2019.

Fruit flies trapped on guava tree

Fruit flies trapped on pear tree

Slow release formulations of fruit flies pheromones

Sixteen fruit fly traps with slow-release formulations were fixed each in guava and pear orchards, along with control. It was observed that traps with slow-release pheromone were able to catch the fruit flies for about more than 2 months period as compared to about 30 days in control traps. On an average, 150 fruit flies were trapped in each trap fixed in guava orchard and 95 flies were trapped in each trap fixed in pear orchard. Thus, slow release formulations of pheromones can start a new era of eco-friendly management of fruit flies.

Deepa Bhagat[1] and **Sandeep Singh**[2]
[1]Principal Scientist, ICAR-NBAIR, Bengaluru,
[2]Asst. Professor, Department of Fruit Science, PAU, Ludhiana.

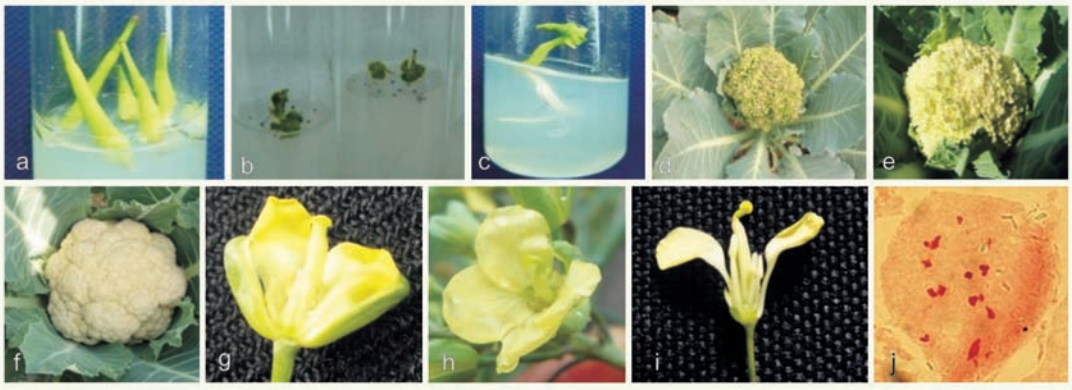
ICAR NEWS wishes all readers and contributors

A Very Happy New Year

2020

Development of NIPB-1: A promising CMS line of cauliflower (*Brassica oleracea var botrytis*)

Higher yield, greater uniformity, resistance to biotic and abiotic stresses and quality of F_1 hybrids call for heterosis breeding in cauliflower. Attempts therefore have long been made to generate CMS lines in *B. oleracea* by means of different cytoplasmic sources for hybrid production. However, not all have been successful mainly due to poor stability of CMS and/ or adverse effect on agronomic traits. At NIPB, *Erucastrum canariense* credited male sterility was successfully transferred from *B. napus* background to cauliflower to yield a CMS cauliflower line called 'NIPB-1'. In 2010, cauliflower variety Pusa Meghna (CC – 2n=2x=18) as male parent was crossed with CMS-(*Erucastrum caneriense*) *B. napus (*AACC – 2n=4x=38) to obtain F_1 plants. In subsequent backcrosses, cauliflower (Pusa Meghna) was used as recurrent male parent to recover the cauliflower genotype with male sterile flowers. Crosses at initial stages could not be obtained at field level due to embryo degeneration occurring within 12-14 days of hand pollination. Therefore, embryo rescue technique/ ovary culture has to be resorted every time after some days of pollination to recover the succeeding backcross generations. Pistils harvested at 14 days after pollination (14 DAP) for embryo rescue gave the best results (Table 1). At every cycle of crossing some crosses were always left in the field till maturity to see the possibility of any natural seed setting. Eventually, at BC4 stage some seeds were formed on hybrids plants. Plants obtained from such seeds were very healthy that formed perfect cauliflower curd. Subsequent advancement of generations never required embryo rescue.



a,b,c – % embryo rescue stages. **d,e,f** – % curd formation in BC1,BC2, and BC6 generation respectively. **g,h,i** – % sterile flower at BC1, BC3 and BC6 generation. **j** – chromosomes in BC2 plant, 8II and 2 multivalent

Summary of results of embryo rescue towards the recovery of interspecific hybrids between *B. napus* × cauliflower

Cross	Time of sampling of ovaries	No. of ovaries cultured	No. of surviving ovaries	No. of ovules obtained and cultured	No. of plants recovered
CMS (*E. canariense*) *B. napus* × *B. oleracea*	5 DAP	60	0	0	0
	9 DAP	60	28	23	2
	14 DAP	60	32	47	5

Morphoagronomic characteristics: NIPB-1 have dark green waxy leaves, light yellow sterile flowers, anthers are short with absence of pollen grains, nectaries are good making it attracted to bees, an advantage for hybrid seed production. It belongs to mid early maturity group which bears compact big circular curd not covered with young leaves and shows anthocyanin pigmentation just before its opening to flower.

Associated characters and cultivated practices: NIPB-1 is a cauliflower CMS line which by itself can be used as a very valuable CMS female parent for production of hybrid variety or can be used as a source of male sterility for integration in other female combiners. Some incidences of cabbage butterfly larvae were seen during its early growth which were secured by insecticidal spray. No major incidences of other diseases and insects were noticed during the course of development of this material. It grows well under standard cultural practices normally followed for cauliflower farming.

Rohit Chamola and **SR Bhat**
National Institute for Plant Biotechnology,
New Delhi 110 012
email: rohitchamola@gmail.com

Transplant probiotics for organic strawberry production

Strawberry is an excellent source of natural antioxidants with high capacity of scavenging free radicals. The cultivated strawberry (*Fragaria × ananassa* Duch.) is one of the most valued soft fruits (berry) of the world with unique, desirable taste and flavor. They are excellent dietary source of ascorbic acid, potassium, fiber and other secondary metabolites and are also good source of simple sugars. In organic agricultural system, the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives are avoided. Instead, the use of bio-fertilization, crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity are promoted. Recent studies have confirmed that a number of bacterial species mostly associated with the plant rhizosphere, are beneficial for plant growth, yield and crop quality, known as Plant Growth Promoting Rhizosphere microorganisms (PGPRs). PGPRs are mostly explained by the release of metabolites directly stimulating growth. The mechanisms by which PGPB promote plant growth are not fully understood, but include, (i) the ability to produce plant hormones, such as auxins, cytokinins, gibberellins, and inhibit ethylene production, (ii) asymbiotic N_2 fixation, (iii) solubilization of inorganic phosphate and mineralization of organic phosphate, (iv) antagonism against phytopathogenic microorganisms by production and synthesis of enzymes and competition with detrimental microorganisms. There have been few reports covering the use of these microorganisms in organic strawberry production.

Microbial probiotics

This study was conducted at Regional Horticultural Research and Training Station of YSP University of Horticulture and Forestry at Dhaula Kuan, Sirmour, Himachal Pradesh. Six microbial inoculants i.e. *Pseudomonas florescence, Bacillus subtilis, Azotobacter chroococcum*, K-mobilizers, PGPRs consortium and AM fungi were tested in different conjoint combinations viz., T_1-250g AMF+125*g A. chroococcum*; T_2-150g *A. chroococcum*+150g K-mobilizers; T_3-250g PGPRs consourtium; T_4-150g AMF+125g *B. subtilis*+150g K-mobilizers; T_5-150g *P. florecence*+ 125g *A. chroococcum*+125 g K-mobilizers; T_6-150g AMF+125g *A. chroococcum*+125g K-mobilizers; T_7 (Recommended dose of feriizers (N:P:K, 80:40:40)); T_8 (Uninoculated control). PGPRs inoculation was performed using dipping method in which plant roots were inoculated with the PGPRs suspensions of the concentration of 10^9 CFU (colony forming unit) ml^{-1} in sterile water about 30 min. prior to transplantation. PGPRs inoculation was performed using dipping method in which plant roots were inoculated with the PGPRs suspensions of the concentration of 10^9 CFU (colony forming unit) ml^{-1} in sterile water about 30 min prior to transplantation.

Technological intervention

Dual or triple inoculation of microbial transplant amedements used as PGPR with fruit crops mainly belong to the genus *Pseudomonas*, *Bacillus, Azotobacter,* and K-mobilizers and AM fungi have determined the beneficial effects on strawberry production and quality traits in field conditions. The data extrapolated that PGPRs inoculation

Overview of Strawberry field

Fruit development due to PGPR consortium

Leaf colour appearance in PGPR treated plantlets

Mature strawberry fruits

have a great potential to improve phenological traits including growth measurements, fruit yield, biochemical attributes and runner production. Agro-morphometric, biochemical traits and generative potential subjected to analysis of variance showed significant effect of applied PGPRs probiotics. All these traits were influenced most significantly with 250g PGPRs consortium.

Rhizosphere stochiometry

The number of total resident soil microbial population in the sample increased from the dual inoculation to triple inoculation of the PGPR probiotics compared to control irrespective of the organic and natural plots. The effect of PGPR probiotics on the total cultural microbial population had significant effect on the microbial count of the rhizosphere soil in organic (solarized) plots compared to natural (conventional) soil plots. In general, the quantity of total culturable microorganisms analyzed in terms of bacteria, fungi and actinomycetes were higher in rhizosphere soil than in non-rhizosphere soils irrespective both of organic than natural plots. The total resident microbial population in organic and natural plots varied among the different PGPR probiotics. Under favourable climatic conditions and proper use, solarization can provide excellent control of soil-borne pathogens in the field, greenhouse, nursery, and home garden. The quantitative estimation of resident soil microflora from the rhizosphere and non-rhizosphere soil obtained in the present study is in conformation with the respective microbial populations generally reported in literature. In the present study, the resident microflora were significantly benefited by their proximity to roots and the root soil (R:S) ratio exceeded 1.50. Irrespective of the organic and natural plots, compared to the rhizosphere soil, the microbial population enumerated in the control soil in this study was relatively small. However, the total microbial count obtained for bacteria, actinobacteria and fungi could be considered as a sufficiently moderate value by soil-dilution plate-count method, besides, low pH, and organic content of the soil. Although, in organic plots used in the present study, the bacterial, actinobacterial and fungal populations were less than those of natural plots which might be due to the soil samples collection from the solarized and natural cultivated conditions that accounted for the variations and differential stimulation on the rhizosphere microflora by the roots of the plantlets.

Input	Cumulative fruit number	Fruit yield (g plant^{-1})	Number of runners (per plant)
250 g PGPRs consourtium	68.1	648.5	29.7
Control	58.6	459.8	18.4

Recommendation

Root inoculation (dipping) of saplings for 10-15 min. with PGPRs consortium (1:4) in water at the time of transplanting in nursery beds increased berry yield (41.1%) and runner production (65.9%). Considering environmental pollution with excessive use of synthetic fertilizers and high costs in the production of N and P fertilizers, the PGPRs tested in our study may is a promising alternative as a bio-fertilizer for strawberry production in organic agricultural systems. This could impact on plant productivity, among the different factors involved in the management of this horticultural crop.

Beneficial effects of PGPR probiotics

- PGPR microbial products are compatible with existing farmers system, and hence are comfortably accepted by fruit growers.
- These probiotics also reduce effects of harmful organisms in the soil, such as fungi and nematodes.

Plants resist stress better and live longer.

- These multifaceted PGPRs solublize the fixed phosphorus in the soil and makes it available to fruit and vegetable crops.
- PGPR restore normal fertility to the soil and make it biologically alive.
- Biofertilizers are a cheap, easy-to-use alternative to manufactured chemical fertilizers.
- Bacteria multiply very fast in the soil and this helps to improve the texture and structure of the soil. This also helps to enhance the growth of the crops and also induces resistance against various pests and diseases.
- PGPRs are right choice to be used as probiotics as they stimulate plant growth and productivity and also protect plants from diseases and various types of stresses.

Pramod Kumar[1*] and **AK Joshi**[2]
YSPUHF (Fruit Science[1], RHRTS Dhaula Kuan[2])
Himachal Pradesh
email: *pk09sharma@rediffmail.com

Identified promising male genotype of date palm for pollen production

Date palm (*Phoenix dactylifera* L., Family -Arecaceae) is an important arid fruits known for its delicious taste and high energy value. The cultivation of date palm is spreading at fast rate in arid region of India. The date palm is a dioeceous plant in which male and female spathes/flowers are borne on separate plants. While both plants produce flowers, one plant has the male reproductive parts and the other plant has the female parts. The pollination is essential in date palm to achieve better fruiting and quality fruits production. Male palms are limited and better type of male palm is required for more pollen production. The emergence of spathes in male plant should be early type than female palms. The pollens should be viable for a long period. In general, planting of 5 % male date palm plants are essential for pollination. In date palm, manual/hand pollination is done through dusting at the opening of spathes for fruit set. The male palm variety is also limited and local type male is used for pollen collection and pollination. Fresh pollen was found more effective for fruit set than stored pollens. Under scarcity of pollens, the stored pollens (4^{0}c refrigerator) can be used for pollination. Under deep freez (-20 ^{o}c) pollen grains can be stored for more than one year period. On the basis of three years of evaluation at ICAR-CIAH, Bikaner , one male date palm germplasm (CIAH/DP/M-01) was found better with respect to early spathe emergence and more pollen production (672g / tree). The length of spathes was 80-105cm with width of 10-15cm and average pollen production was 20-23g per spathe. The IC No. 0632315 was obtained for specific traits *i.e.* early emergence of spathes, more number of spathe/tree (25-30) and production of more quantity of pollen grains (672g/tree) for pollination purpose.

Promising male date palm tree and spathes for pollens production

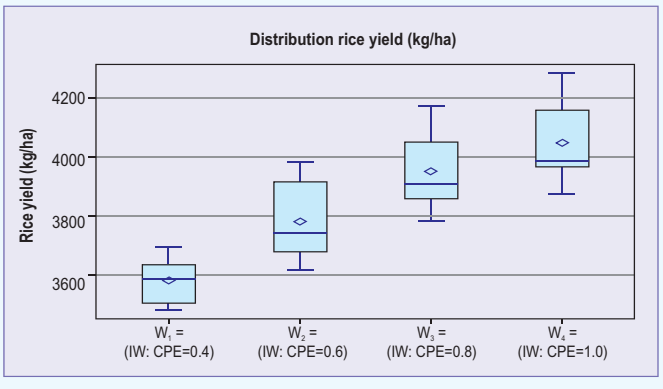
RS Singh[1] and **PL Saroj**[2]
[1]Principal Scientist (Hort) , [2]Director,
ICAR-Central Institute for Arid Horticulture,
Bikaner 334 006 (Rajasthan)

Improving rice – vegetable pea-summer maize system productivity through efficient water management practices

Under the project, Improving rice – vegetable pea-summer maize system productivity through efficient water management practices, the study was undertaken from *rabi* season 2018-19. In this experiment three genotypes of rice (V_1, V_2, and V_3) along with 4 water management levels W_1, W_2, W_3 and W_4) based on IW: CPE are being tested under cropping system mode. Total 12 treatment combinations were tested under Split Plot Design. These treatments were replicated 4 times i.e. R_1, R_2, R_3 and R_4.

Performance of *kharif* season crop

During *kharif* season 2019, three genotypes of rice namely V_1 =CR Dhan 40, V_2 = Rajendra Shweta and V_3 = Swarna Shreya were tested along with 4 water management levels (irrigation at IW: CPE) under rice – vegetable pea-summer maize system in split plot design keeping water management in main plots and genotypes in sub plots at ICAR-Research Complex for Eastern Region, Patna, Bihar. In case of rice, three genotypes namely V_1 = CR Dhan 40, V_2 = Rajendra Shweta and V_3 = Swarna Shreya were tested under 04 water regimes *i.e.* W_1 (IW: CPE= 0.4), W_2 (IW: CPE= 0.6), W_3 (IW: CPE= 0.8) and W_4 (IW: CPE= 1.0). Perusal of data presented in Table revealed that genotype Swarna Shreya produced significantly higher rice (3,979 kg/ha) as compared to other tested rice genotypes. Similarly in case of water management practices, water applied at W_4 (IW: CPE= 1.0) level produced significantly higher grain (4,047 kg/ha) than other tested levels of water management. It is worth to mention here that yield advantage was recorded with enhancement up to the highest tested level. Similar trend was noticed in case of biological yield with both the tested factors *i.e*. water management and genotypes. Maximum biological yield (12,262 kg/ha) was recorded when water was applied at W_4 (IW: CPE= 1.0) and minimum yield (10,963 kg/ha) with genotype Rajendra Shweta was recorded. None of the treatments



Box plot distribution of rice yield at four water levels

Rice performance as influenced by water and genotypes

Treatments	Grain Yield (kg/ha)	Biological Yield (kg/ha)	Harvest Index	IWP (kg/ha)
W_1 = (IW: CPE=0.4)	3580	10227	0.35	1.79
W_2 = (IW: CPE=0.6)	3780	11117	0.34	1.51
W_3 =(IW: CPE=0.8)	3951	11619	0.34	1.32
W_4 = (IW: CPE=1.0)	4047	12262	0.33	1.16
CD (±5%)	113.7	341.7	NS	0.28
V_1 = CR Dhan 40	3812	11118	0.34	1.39
V_2 = Rajendra Shweta	3728	10963	0.34	1.36
V_3 = Swarna Shreya	3979	11702	0.34	1.45
CD (±5%)	82.4	247.3	NS	0.22

has significantly influenced harvest index (HI). In case of water productivity, genotype, Swarna Shreya recorded maximum water productivity (1.45 kg/m^3), whereas in case of water management it was achieved when rice was irrigated at W_1 (IW: CPE=0.4) corresponding highest (1.79 kg/m^3) was noticed in case of water supplied with (IW: CPE=0.4). Water level has maximum influence on the rice production among all the three varieties. The mean rice yield significantly ($p<0.05$) varies at the four different levels of water applied.

Dr AK Singh
Principal Scientist (Agronomy)
ICAR-Research Complex for Eastern Region,
Patna-800 014, Bihar

YF 5-2-7: A carotenoid rich genotype of watermelon

Watermelon [*Citrullus lanatus* (Thunb.) Mansf.] is an important crop grown in different parts of the country. It is one of the most widely cultivated crops in the world and its global consumption is greater than that of any other cucurbit. Presently the red fleshed varieties are widely cultivated in India. The major nutritional components in watermelon consist of carbohydrates (6.4 g/ 100g), vitamin A (590 IU) and lycopene (4,100 µg/ 100g) in red flesh varieties. Presently the red fleshed varieties are widely cultivated in India which contain low amount of carotenoid content. Now-a-days people are very conscious of health and there is a demand of varieties that are rich in carotenoids. Therefore, breeding for specific flesh coloured varieties is often a challenge to attract consumers. Watermelon being a highly cross pollinated crop possess varying flesh colour *viz*., red, white, yellow and saffron having different profile of nutrients. Keeping in view, identified and homogenized a saffron coloured genotype of watermelon (YF 5-2-7) and evaluated over the years and seasons. YF 5-2-7 is high in carotenoid content (7.00-9.60 µg/ g FW) in comparison to popular red fleshed varieties which have 3.92-4.14 µg/ g FW carotenoid content. It is characterized by entire (non-lobed) leaves, round fruits having dark green rind with very narrow stripes, saffron flesh and blackish brown seeds. YF 5-2-7 produced round fruits weighing 2.5-3 kg, rind thickness (1.0-1.3 cm), TSS (10-11%) and bear 3-4 fruits/ plant. Fruits are ready for harvesting in 80-85 days after sowing. The developed line of watermelon (YF 5-2-7) having saffron coloured flesh with high carotenoid content will serve the purpose of nutritionally rich variety in future.

YF 5-2-7: Carotenoid rich watermelon

BR Choudhary, MK Berwal and **PL Saroj**
ICAR-Central Institute for Arid Horticulture,
Bikaner (Rajasthan) 334 006
email: choudharybr71@gmail.com

ICAR-Directorate of Cashew Research

Enhancing production, productivity and postharvest handling of cashew

ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur, Karnataka was established as National Research Centre for Cashew (NRCC) on June 18, 1986 with the mandate to take up holistic research on cashew crop, an important plantation crop of India which brings highest export earnings among horticultural crops. NRCC was upgraded and renamed as Directorate of Cashew Research (DCR) on March 23, 2009. The main campus of ICAR-DCR is situated 5 km away from Puttur town at Mottethadka village of Kemminje.

The main campus has an area of 68 ha with field experiments and laboratory-cum-administrative Block. The experimental station at Shantigodu, which also forms part of the Directorate, is 13 km away from the main campus and has an area of 80 ha. The institute is conducting and coordinating research on all aspects of cashew germplasm collection, conservation and improvement, production, protection, post harvest technology and transfer of technology. ICAR- DCR has developed 3 varieties viz. NRCC-Sel1, NRCC-Sel2, Bhaskara. Recently, H-130, a bold nut cluster bearing cashew hybrid released during 2017 is getting popular among the cashew growers and processors. Apart from crop improvement, the institute has made significant contributions in crop protection, management and processing of cashew. ICAR-DCR is an ISO certified organization(ISO 9001-2008) and functions as the headquarter of All India Coordinated Research Project (AICRP) on Cashew having 14 centres located in major cashew growing states of the country.

VISION

- Accomplishing self-sufficiency in raw cashewnut production and maintaining premier position as the largest producer, processor and exporter at the global level.

MISSION

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

MANDATES

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

Timeline of cashew research in India

1951: Ad-hoc scheme on cashew by ICAR
1971: All India Coordinated Spices and Cashew Improvement Project (AICS and CIP)
1986: National Research Centre for Cashew (NRCC)
2009: ICAR-Directorate of Cashew Research (ICAR-DCR).

Research facilities available

- Gene bank with 543 accessions,
- Meteorological observatory,
- Audio Visual laboratory,
- Cashew germplasm database,
- Soil science lab: UV visible spectrophotometer, Microwave Plasma Atomic Emission Spectrophotometer, N-Analyser, TDR Soil moisture meter,
- Biotechnology lab: PCR, Gel documentation unit, Electrophoresis unit,
- Post Harvest Technology lab: Texture profile Analyser, Colour spectrophotometer, Workshop machinery and tools, Cashew processing machinery and
- Food technology lab.

AICRP on Cashew

ICAR-DCR, Puttur is the Head Quarter for All India Co-ordinated Research Project on Cashew with 14 AICRP centres that work on the following mandates:

- To increase production and productivity of cashew through evolving high yielding varieties having tolerance to biotic and abiotic stresses and
- Standardizing agro-techniques for the crop under different agro-climatic conditions.

Coordinating Centres of AICRP on cashew are:

1. Cashew Research Station (Dr. YSRHU), Bapatla, Andhra Pradesh,
2. Cashew Research Station (OUAT), Bhubaneswar, Odisha,
3. Zonal Research Station (BAU), Darisai, Jharkhand.
4. Horticultural Research Station (UHS), Hogalagere, Karnataka,
5. SG College of Agricultural and Research Station (IGAU), Jagdalpur, Chattisgarh,
6. Regional Research Station (BCKV), Jhargram,West Bengal,
7. Cashew Research Station (KAU), Madakkathara, Kerala,
8. Agricultural Experimental Station (NAU), Paria, Gujarat,
9. Regional Agricultural Research Station (KAU), Pilicode, Kerala,
10. Regional Fruit Research Station (Dr. BSKKV), Vengurla, Maharashtra,
11. Regional Research Station (TNAU), Vridhachalam, Tamil Nadu,
12. ICAR–Central Coastal Agricultural Research Institute, Goa,
13. Horticultural Research Station (UHS), Kanabargi, Karnataka, and
14. ICAR–Research Complex for North Eastern Hilly Regions, Tura, West Garo Hills, Meghalaya.

ACHIEVEMENTS

Crop Improvement

Collection, characterisation and conservation of cashew germplasm: A total of 543 cashew germplasm accessions have been collected, characterised and maintained in the National Cashew Field Gene Bank at Puttur. It serves as largest cashew germplasm repository in the country. Hence,it is considered as National Active Germplasm Site (NAGS) for cashew. The genetic architecture of 478 germplasm accessions was assessed for 13 quantitative characters and accessions for a desirable combination of qualitative and quantitative characters were identified.

National Cashew Field Gene Bank at ICAR-DCR-Puttur

National Cashew Field Gene Bank at ICAR-DCR-Puttur

The DUS test guidelines for cashew was finalized and published in 2017. A block of thirty examples or reference varieties was established at ICAR-DCR for DUS testing. Five catalogues of minimum descriptor of cashew germplasm were published. Moreover, for the first time, a full-fledged online decision support system for cashew germplasm database management has been developed (http://cashew.icar.gov.in/dcr/). It is possible to locate accessions for any combination of characters with this decision support system.

Identification of core collection from cashew germplasm: A core collection of 61 accessions was made from 478 accessions using advanced maximisation strategy and heuristic approach.

Development of varieties/hybrids: ICAR-DCR has released three varieties *viz*., NRCC Selection-1, NRCC Selection-2 and Bhaskara, which are high yielding and medium nut types for cultivation in West Coast region. Among them, Bhaskara has gained popularity as it is less affected by tea mosquito bug (TMB) because the variety is having midseason flowering habit (Dec-Mar) with potential to escape from the attack of the TMB.

Three year old H-130 plant with profuse flowering and fruiting

During the year 2017, a new jumbonut hybrid (H-130) with superior nut yield (3kg/tree in 3 years of planting) and having cluster bearing (10-20 nuts/panicle) and bold size nuts (12-13g nut weight) and big apple (>100g) was released for cultivation and performance evaluation in farmers field. The hybrid is highly precocious, having early flowering with long fruiting duration. The plant is vigorous but with sparse canopy and having large leaves and big inflorescence with strong 8-10 rachis. High fruit set with 10-20 nuts per panicle is observed. The hybrid responds well to pruning and is suitable both for ultra-density planting and normal spaced plantations. Hybrid has high shelling (29.9%) with big kernels a rare type among released varieties and falls under W-130-150 category kernel grade. The kernel protein is 21% and fat 46% and other usual mineral contents. Another promising bold nut hybrid, H-126 was found to be promising for yield over eight harvests under un-replicated trial.

CROP MANAGEMENT

Softwood grafting:

Softwood grafting technique has been standardized at DCR, Puttur and every year about 2.5 lakhs grafts of recommended varieties are produced and distributed to farmers and other developmental agencies. The ICAR-DCR, Puttur nursery has been rated as one of the four-star nurseries by National Horticulture Board, Government of India.

High density planting (HDP): ICAR-DCR has developed a high density planting (HDP) technology with a spacing of 4m x 4m (625 plants/ha) instead of 8m x 8m (156 plants/ha) through which it is possible to increase the cashew yield by 2.5 folds in the initial ten years. The institute also standardized the nutrient and water requirements for the HDP.

Ultra density planting (UDP)

In ultra density planting, 1111 or 1600 cashew plants

Mature apple and nut

Kernels (W-130) of H-130

Quality planting materials of cashew

per hectare can be accommodated by following spacing of 3m X 3m or 2.5m X 2.5 m. The precocious type of varieties such as VRI-3, NRCC Sel-2, Ullal-1, K-22-1 and H-130 are most suitable for this technique of planting. Ultra high density planting can yield 1.5 kg/plant from the second year of planting and form third year onwards about 2-3 kg/plant can be harvested which may bring 12-18 quintals of raw nuts from an acre.

Nutrient requirement

Besides, recommended dose of fertilizer (500:125:125 g NPK/tree/year), foliar spray of major nutrients (3% urea + 0.5% H_3PO_4 + 1% K_2SO_4) and secondary and micronutrients (0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$) had positive significant effects on the number of bisexual flowers/panicle, number of panicles/tree, number of nuts/tree and nut yield/tree. Foliar spray of major nutrients resulted in a 16.1% increase in nut yield while, secondary and micronutrients spray resulted in 30.5% higher yield.

Nutrient management under organic farming

In a mature tree plantation, about 5.5 t/ha of recyclable cashew biomass will be available that can be converted into 3.5 t of compost and help to meet 50% nutrient requirement of cashew. In addition, application of 5-8 kg castor cake or 30 kg FYM or 10 kg poultry manure or 15 kg vermicompost (as per local availability) along with 50 g biofertilisers can be applied. If the external application

Ultra density planting

Foliar spraying

Intercropping

of manures is not possible, farmers can go for green manuring by planting green manure crops such as *Glyricidiamaculeata* in interspaces of cashew orchards, which yield 60 kg green biomass/ tree/ 3 cuttings in a year.

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

Intercropping: Cultivation of intercrops *viz*., pineapple, amorphophallus, turmeric, ginger, brinjal and chillies in cashew orchards is found to be profitable. Pineapple as an intercrop in cashew orchard helps in increasing the yield of cashew in addition to the pineapple yield (21 t/ha for the first five years). The trenches made for pineapple planting act as a soil and water conservation measure for cashew orchard. Shade tolerant pepper varieties can also be trailed on to cashew.

Delineation of soil nutrient constraints of cashew orchards in the country: Regional surveys were carried out in cashew plantations of Puttur, Vengurla, Bhubaneswar, Bapatla, Pilicode and Vridachalam. Soil and leaf samples were collected from 70 orchards in each location. Cashew orchards sampled were acidic and non saline. Organic carbon content of cashew growing areas was on the higher side except for Bhubaneswar, Bapatala and Vridachalam. These soils were deficient in available N, P and low to medium in K. Among the DTPA extractable micronutrients, soils were deficient in Zn and Cu. Nutrient diagnostic norms have been developed using the Diagnosis and Recommendation Integrated System (DRIS) approach.

Cashew tree infested with TMB

Crop Protection

Management of cashew stem and root borer (CSRB): In CSRB infestation, gum and frass start oozing out from the tree; which is the initial symptom of pest attack for taking up curative measures. The infested portion should be carefully chiseled off to kill the grub or pupa. Later chlorpyriphos (0.2%) solution should be swabbed or sprayed over the chiseled portion. The initial evaluation indicates the effectiveness of alternative insecticide, fipronil (2.0 ml/L) on par with the recommended insecticide chlorpyriphos for treating the affected trees. The use of two entomopathogenic nematodes (EPN) viz., *Heterorhabditis* and *Steinernema* @10 Larval Equivalents (LE)/infested tree found to be effective. Efforts are being made to develop kairamones to control CSRB. The components of fresh frass from CSRB infested cashew trees, viz., phenols, ketones, polyphenols, naptha-derivatives and aldehydes were identified and formulated using synthetic formulation and is being evaluated.

Management of tea mosquito bug (TMB): Both adult and nymph of TMB suck the sap from tender shoots, panicles and immature nuts and apples which results in the formation of black necrotic lesions. These lesions on shoots and panicles coalesce causing shoot blight or blossom blight. In outbreak situations, timely spraying should be taken up to manage the pest.

The insecticides recommended are Monocrotophos (0.05% i.e., 1.5 ml/l), Imidacloprid 17.8 SL (0.6 ml/L), Acetamiprid 20 SP (0.5 g/L), L-Cyhalothrin (0.003%),

Profenophos 50 EC (0.05%) during flushing stage and L-Cyhalothrin (0.003%), Triazophos 40 EC (1ml/L), Profenophos 50 EC (0.05%) during flowering/fruiting stage. Recent studies indicate that the efficacy of thiamethoxam (0.2 g/L) was on par with the recommended insecticide, L-cyhalothrin. Efforts are being made for the development of sex-pheromone traps for monitoring and decimating the pest populations of TMB in field situations.

Record of pollinators and other fauna: The hymenopteran bees (*Pseudapis oxybeloides, Lasioglossum* sp., *Braunsapis* sp. and *Homalictus* sp.) are major pollinators in cashew. The predatory fauna recorded includes 115 species of spiders, 17 species of reduviids, 49 species of ants, 16 species of praying mantids, 3 species of coccinellids, anthocorid bugs, geocorid bugs, lace wing flies, mantispid flies, pentatomid bugs, syrphids, robber flies etc. Among them, *Oecophyllasmaragdina* (red ant), *Panthousbimaculatus* (reduviid), Salticidae spiders and *Euantissapulchra* (praying mantid) are predominant. Among the pollinator species visiting cashew flowers, *Braunsapis picitarsus* was the dominant (18.0%), followed by *Pseudapis* sp. (16.7%) and *Apiscerana* (15.1%). It was observed that *Braunsapis* sp. was most active and abundant between 9.00 am - 1.30 pm, followed by *Pseudapis* sp., *A. cerana* and *Ceratina* sp. while, *A. cerana* was active during afternoon.

Investigations on semio-chemicals for management of TMB

The TMB virgin females of 4 - 5 days after emergence had higher response from the males under field condition. The activity of the sex pheromone compounds *in vitro* was confirmed by macerating the virgin females aged 4-5 days in di-Chloromethane / n-hexane or methanol. The whole body extracts (WBE) when used as baits in sticky traps could elicit similar response compared to live virgin TMB females under field conditions. The maximum cumulative number of TMB male catches/traps was 94 when the TMB virgin females were used as live-bait and it was 100 when WBE was used as the bait at 30 days after extraction. This indicates the stability of pheromone components to be characterized for developing traps.

Post Harvest Machinery developed

Radial arm type cashew kernel extractor: The machine was designed to operate in sitting posture thereby reducing the operator's drudgery experiences in the existing sheller. It has 9.3 kg/h operational capacity and 88.1% quantitative efficiency.

Rotating drum type roasting machine: It is a compact machine developed for processing of raw cashewnuts. Processing parameters required for the production of better kernel quality were optimized.


Apis cerana


Braunsapis picitarsus


Braunsapis sp. 1.


Pseudapis oxybeloides


Ceratina hieroglyphica


Ceratina binghami


Seledonia sp.


Lasioglossum sp.


Tetragonula sp.

Dual mode dryer: It is suitable for drying the rain-affected raw cashewnuts. The time required to reduce the moisture level from 20.4% (dry basis) to a safer level (8%) varies between 3.0 and 4.5 h and the energy utilized during drying process was worked out as 32.93 MJ/kg for electrical power and 201.71 MJ/kg for thermal power.

Hydraulic type cashew apple juice extractor

The hydraulic juice extractor is developed to extract the juice from the cashew apple and it can be operated easily. Upto 80-85% juice could be

extracted during the first pass and around 60 to 65% of the residual juice remaining after the first pass can be extracted in the second pass.

Updraft gasifier for cashew shell cake

A cashewnut shell cake based updraft gasifier suitable for applications needing thermal requirement in the range of 10 to 12 kW is developed and it consists of a reactor serving as gasifying media, blower, ash outlet and gas burner. Producer gas generated from cashew shell cake passes through the conduit and reaches the burner.

Concentric drum type rotary sieve grader for raw cashewnuts: Operational capacity of the grader is around 300 kg $h^{-1}$and the grading efficiency is 95.2%. Cost of grading is worked out to be 0.70/kg of raw cashewnuts.

Hydraulic type cashew apple juice extractor

Cashew apple products

The cashew apple is a good source of vitamin C. Cashew apple not economically utilized in the country, expect in Goa for alcoholic beverage, feni. The value-added products of cashew apple such as cashlime, jam, jelly, cider, chew and crisp have been developed by ICAR-DCR.

- **Cashlime:** A ready to serve (RTS) beverage prepared from cashew apple with lime flavour.
- **Cashew apple jam and jelly:** Jam prepared from cashew apple having TSS of 68.5ÚBrix and jelly having TSS of 65ÚBrix.
- **Cashew apple cider:** It is an alcoholic beverage prepared from cashew apple with an alcohol content of 3-6%.
- **Cashew apple chew:** Cashew apple slices is processed with sweet and spice mixture to prepare chew, that can be taken as such like a mouth freshener or along with betel leaves.
- **Cashew apple crisp**: It is an extruded product prepared out of cashew apple powder.

Transfer of technology

The Directorate is always in the forefront to disseminate technology and scientific know-how for the benefit of farmers, industrialists and all stakeholders in the field of cashew. It is being carried out through front line demonstration in farmer's fields, on-farm and off-farm training, field exposure visits, guided tours, cashew days, farmer's days and field days. The Directorate also acts as nodal centre to implement different flagship programmes of Government of India such as World Soil Day, PM-Kisan Samman Nidhi, TSP/NEH/SCSP programmes. Apart from regular extension efforts, the scientists of the Directorate also undertake farmer participatory research and training external funding from agencies like RKVY, DCCD etc. The Directorate also uses ICTs for effective transfer of technologies to the clients. It is done through websites, facebook page, twitter handle and Whatsapp group. In 2018, two mobile Apps were developed by ICAR-DCR.

The Android App named "Cashew Cultivation" gives information on various aspects of cashew cultivation, market and stakeholders involved in cashew. The app is multilingual and available in 4-languages, Hindi, English, Marathi and Kannada. Efforts are being made to make it available in Malayalam, Tamil, Telugu, Oria and Bengali languages also. This App provides all information related to cashew. The second mobile App is "Cashew Nutrient

Dual mode dryer for raw cashewnuts

Updraft gasifier for cashew shell cake


Cashlime


Cashew apple jelly

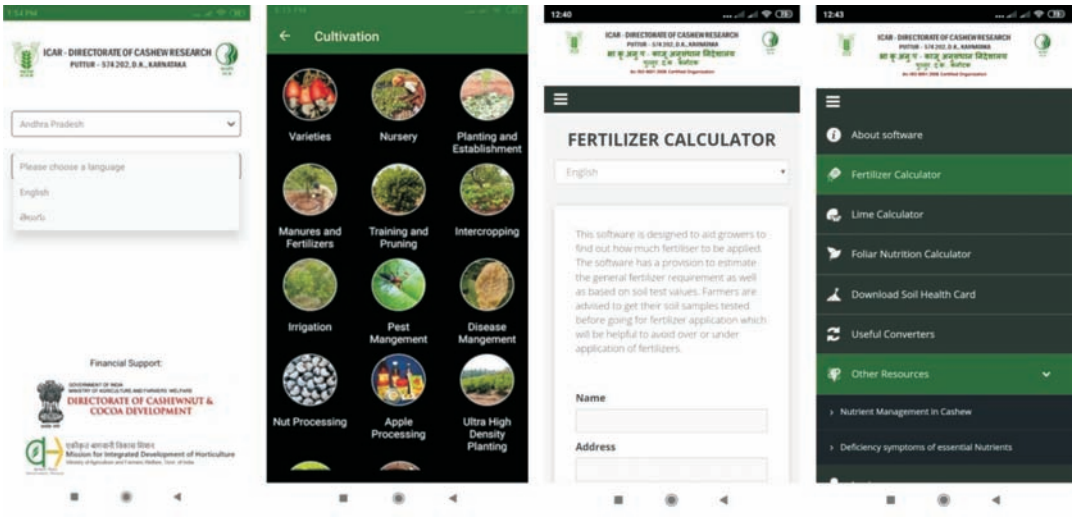

Cashew apple cider


Cashew apple crisp

Manager" and is available in English and Kannada languages. It can be used for calculating fertilizer requirement, lime requirement, foliar application of major and micronutrients. The deficiency symptoms of major and micronutrients commonly observed in the field are also included to understand the symptoms and find out the options to correct the deficiency. The App allows farmers to download soil health card issued by ICAR-DCR, Puttur.

Patents and trademarks

The Directorate has filed two applications for patents. One patent on Radial arm type cashew kernel extractor (Patent No. 272371) has already been granted to the Directorate. Institute logo of ICAR-DCR is registered as a trademark (Trade Mark No. 3217680) at Trade Marks Registry, Mumbai.



Cashew Apps

Licensing of Technologies

ICAR-DCR has developed six different machinery for processing of cashew and are given license for the fabrication of these machinery is given to following machine manufacturers, viz M/s Pro B Products, Bengaluru, Karnataka; M/s Newtech Industries, Mangalore, Karnataka and M/s Rotex Transmission, Pune, Maharastra.

Future thrust

- Development of varieties tolerance to biotic stresses (major pests and diseases) and abiotic stresses (drought, salinity) and dwarf high yielding cultivars.
- Enrichment of cashew germplasm repository and its utilization in cashew breeding.
- Identification and utilization of molecular markers for genetic diversity studies and crop improvement programmes.
- Identification of promising rootstocks and their clonal multiplication.
- Improving productivity and quality of cashew by increasing input use efficiency in different agro-ecological regions.
- Development of cashew based cropping systems for better resource use efficiency.
- Development of Integrated Pest Management (IPM) strategies for major pests of cashew involving semio-chemicals and bio-control agents.
- Monitoring of new pests and diseases in the scenario of climate change and devising management strategies.
- Focusing on solar based cashewnut processing system, value-added products and biofuel from cashew apples, and enhancement of industrial application of cashew nut shell liquid.

Dr M G Nayak
Director (Acting)
ICAR-Directorate of Cashew Research
Puttur 574 202,
Karnataka
email: director.dcr@icar.gov.in
Website: https://cashew.icar.gov.in/

Gazette Notification of Indigenous Animal Breeds and New Animal Varieties

India is a mega biodiversity rich country and further rearing of domesticated animals of different species viz., cattle, buffalo, sheep, goat, pig, camel, equines (horse, donkey, pony, mule, ass), yak, mithun, poultry (chicken, duck, geese) by animal keepers have been in practice since ages. India possesses huge and diverse animal population distributed over a large range of geographical, ecological and climatic regions which play a vital role in improving the socio-economic conditions of rural masses.

The indigenous animal genetic resources are characterized involving different agencies in the country under the programmes of ICAR-National Bureau of Animal Genetic Resources (NBAGR), Karnal and further registered following a due process through a Breed Registration Committee constituted by ICAR. So far, 184 indigenous breeds of livestock and poultry have been registered which include 43 of cattle, 16 of buffalo, 34 of goat, 43 of sheep, 7 of horses and ponies, 9 of camel, 8 of pig, 2 of donkey, 19 of chicken, and one each of yak, duck and geese. This mechanism is the sole recognized process for registration of livestock and poultry breeds at national level.

The advent of new era of national sovereignty over genetic resources under Convention on Biological Diversity (CBD) requires a new approach to describe and catalogue animal and poultry breeds. India is party to several international treaties like CBD, WTO, TRIPS, Nagoya Protocol, Interlaken Declaration on AnGR, etc. and is committed to, 1) Protect the local animal genetic diversity; 2) Provide recognition to the developers/ breeders of animal breeds; 3) Implement the Global Plan of Action on AnGR; and 4) Ensure that the animal diversity is utilized to promote food security and remains available to future generations. All these require an authentic national documentation system of valuable sovereign genetic resources with well-defined characteristics.

The Gazette Notification will provide legal support to Intellectual Property Rights (IPRs) of the registered breed and the varieties released and for developing mechanism for sharing benefits among the animal keepers.

Director,
NBAGR, Karnal 132 001,
Haryana
email: director.nbagr@icar.gov.in

New Fish Species *Barilius torsai* (Teleostei: Cypriniformes: Cyprinidae) identified by ICAR-CIFRI

ICAR-Central Inland Fisheries Research Institute (CIFRI), Barrackpore identified a new freshwater fish species *Barilius torsai* (Teleostei: Cypriniformes: Cyprinidae), from Torsa River, Brahmaputra drainage (**DOI:** https://doi.org/10.11609/jott.4746.11.14.14808-14815).

Barilius torsai is distinguished from all its congeners by the presence of a complete lateral line with 52–53 scales, 29 pre-dorsal scales, pectoral fin notched, two well-developed pairs of barbels (rostral and maxillary), length of rostral barbel slightly larger than maxillary, which reaches the orbit. Tubercles on snout and lower jaw absent, 9–11 blue vertical bars along the body, dorsal fin hyaline with dark pigment concentrated along lower two-third of the dorsal-fin rays.

Theses fishes are highly relished as food and fetches maximum market price (₹400-₹600/kg) in the Dooars region of West Bengal. Many of the *Barilius* species is having ornamental value and being exported from India.

Director,
CIFRI, Barrackpore,
West Bengal 700 120
email: director.cifri@icar.gov.in

Pusa Soumya – A new bunching onion variety

Bunching onion (*Allium fistulousum*, 2n = 16) is a non bulb forming member of Alliaceae family. It has typical onion like flavor. It is a popular vegetable in China, Japan and other South East Asian countries. The whole plant part is edible; the foliage has high demand as leafy vegetable during April- July when other leafy vegetables are in short supply. The underground portion can be used as a possible partial supplement to onion during September -January when there is less supply of onion and subsequent high prices of onion.

Field View of Pusa Soumya

The bunching onion variety Pusa Soumya was developed from materials collected from HPKV, Palampur. The variety is suitable for round the year green onion production and it is least affected by major pests and disease of *Alliums* and thereby it can be considered as suitable candidate crop for organic farming too. Being Alliaceae vegetable, it posses good antioxidant properties and phytochemicals. The phytochemical and nutritional value of Pusa Soumya is presented in table.

Nutritional and antioxidant value of Pusa Soumya

	TSS (^{0}Brix)	Pungency (µ mole pyruvic acid/ml)	CUPRAC (µ mole Trolox/g)	FRAP (µ mole Trolox/g)	DPPH (µ mole Trolox/g)	Total Phenols (mg Gallic Acid Eqiv./100g)	Sulphur (g/kg)	Fe (mg/kg)	Zn (mg/kg)	Ca (g/kg)
Pusa Soumya	13.37	19.45	10.08	4.40	14.12	163.03	1.66	24.78	17.69	1.46

How to grow

The main advantage of the variety is that it is very easy to grow. It can be propagated by basal tillers or seed. Seed sowing is done during October- November. Approximately 6-7 kg seed is sufficient to produce seedlings for 1 ha. Seed beds of around 400-500 m^2 is required for 1 ha.

The basal tillers are separated from mother plants and can be planted round the year except very hot and dry weather (April-June). The seedlings are ready for transplanting in 50-60 days and transplanted during last week of December or early fortnight of January. To ensure continuous supply and avoid market glut planting should be done at fortnightly interval.

Basal Tillers

Marketable stage

Basal dose of 50: 50:50:50 kg NPK and S is applied in well prepared field. The seedlings can be transplanted during winter in flat beds at the spacing of 15 × 10 cm or the basal tillers can be separated and planted at ridges during onset of monsoon season at a spacing of 45 × 20 cm. A spray of pendimethalin 30%EC @3-4 ml/l of water followed by flood irrigation and hand weeding is done to keep weed free at initial stages. The remaining dose of nitrogen (50 kg) is given in 2 equal splits at 35-40 and 55-60 days after transplanting. Adequate moisture is maintained during crop growth while during hot summer months, irrigation may be required at 5-6 days interval.

The crop is comparatively free from pests and diseases.

The first harvesting can be done 70-75 days after transplanting. It does not have summer dormancy and remains green round the year. The flowering occurs in second year of planting during February-March and should be isolated from onion seed production plot. The crop fetches better market price during April-August. This can also be popularized as possible supplement to onion. It is good for spring onion too and fetches better market return.

Drs Sabina Islam, Subodh Joshi, P Kalia and **BS Tomar**
Division of Vegetable Science,
ICAR-IARI, New Delhi
email: head_veg@iari.res.in

Pusa Oishiki: A new high yielding variety of brinjal

Pusa Oishiki, a new brinjal variety released for cultivation in Zone VI (Rajasthan, Gujarat, Haryana and Delhi) and VII (Madhya Pradesh and Maharasthra) during the *kharif* season.

- It has been developed by hybridization (Pusa Purple Long × DBL-21) followed by selection.
- It is an early maturing variety (50-55 days from transplanting to first fruit harvest).
- Plants are non-spiny with semi-erect branches, having purple pigmentation on the stem.
- Leaves are large with purple pigmentation on both mid-rib and veins.
- The plant attains a height of 60-65 cm at peak fruiting stage.
- Flowers are medium in size and purple in colour
- Fruits are long (18-20 cm length), cylindrical (3.5-4.5 cm diameter), shiny purple in colour with non-spiny green calyx and borne in solitary as well as in cluster.
- Average fruit weight is 100-125 g.
- It is responsive to both high and normal fertile soil with an average seed requirement of 350-500 g per hectare for raising nursery.
- Potential yield of variety is 390q/ha with an average yield of 320q/ha. The performance of variety is given in the Table.

Pusa Oishiki

Average yield (q/ha) of Brinjal variety Pusa Oishiki at different locations under All India Coordinated Research Projects (Vegetable Crops)

Entry	IARI	Hisar	Jabalpur	Parbhani	Akola	Mean	% increase over check
Pusa Oishiki (DBL–175)	392.38	263.63	327.75	354.67	266.33	320.95	
Punjab Sahabahar (Check)	294.06	221.84	313.19	285.83	262.92	275.56	16.47
KashiTaru/IVBL-9 (Check)	242.80	233.73	310.98	339.32	227.63	270.89	18.47
CD at 5%	69.05	9.0	11.91	23.03	49.66	-	-
CV (%)	11.40	11.46	5.55	7.25	14.18	-	-

- It is resistant to *Fusarium* wilt under field condition.

Partha Saha, AD Munshi, TK Behera, BS Tomar and **Y A Lyngdoh**
Division of Vegetable Science,
ICAR-Indian Agricultural Research Institute,
New Delhi 110 012
email: hortparth@gmail.com

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

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

WAY FORWARD

RICE, the staple food for about half of the world population, is economically, socially and environmentally important to achieve the sustainable development goals (SDGs). More than 100 countries grow rice with the third highest worldwide production of 740 million tons of rough rice, after sugarcane and maize. It accounts for 35-75% of the calories for more than 3 billion Asians. Globally, it provides 27% of dietary energy, 20% of dietary protein and 3% of dietary fat.

Rice, an intensively cultivated crop worldwide, has direct linkage with sustainable resource consumption, greenhouse gas emission, global warming, climate change and environmental pollution, which are related to most SDGs. Investing in rice research and development is, thus crucial to attain the SDGs pertaining to reducing poverty (SDG 1: No Poverty), eliminating hunger (SDG 2: Zero Hunger) and improving health (SDG 3: Good Health and Well-being). Intensive rice production system with non-judicious use of pesticides and fertilizers, however, could be a potential threat to environment due to leakage of these reactive species to air and water with a negative impact on SDG 3 and SDG 6 (Clean Water and Sanitation).

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

Rice production consumes considerable energy for performing various operations starting from land preparation to transport of produce and also for manufacture, storage and transport of inputs like seed, fertilizer and pesticides. In developing countries around 2 billion people are small and marginal farmers, for whom rice is the main crop.

Rice being a major source of methane a potent greenhouse gas (GHG), contributes significantly towards global warming and climate change. Development and adoption of improved management package of practices for mitigating GHG emission from rice field is an integral component of climate smart agricultural practices, which are directly related to SDG 13 (Climate Action).

Leakages of pollutants from rice system to aquatic ecosystem not only contaminate drinking water supplies but also contribute to eutrophication, resulting in harmful algal booms and dead zones in marine ecosystems, posing a challenge for attaining SDG 14 (Life below water). Increased production of rice with improved varieties and agro-technologies could be an incentive for agriculture expansion and releasing degraded land for nature, which links to SDG 15 (Life on Land). Increased production of biofortified rice can also be used as livestock feed to enhance livestock productivity, connecting this again with SDG 1, SDG 8 and SDG 15. There is a close link between sustainable rice production and various SDGs. Being the most important crop globally for food, nutrition, livelihood, income and environment, investing in rice research for developing improved agro-technologies for higher productivity, profitability and climate resilience is crucial for ensuring sustainability of rice farming and attaining the SDGs.

We need to manage rice farming in an environment-friendly way to sustain the food and nutritional security of the country with enhanced income and resilience to environmental degradation and climate change. To achieve sustainable and environment-friendly rice farming, the crop should be cultivated in the region where environmental damage due to rice is minimum. This can be accomplished with ecoregional approach of rice farming. Ecoregions are geographical regions with similar ecological, soil and climatic conditions. Rainfall, temperature and soil are the three most important biophysical factors determining ecoregions for growing rice. For crop planning and delineating suitable ecoregions for rice in the country, such analysis considering rainfall, temperature and soil texture as the major contributing factors should be carried out. Once suitable ecoregions of rice farming are delineated, site-specific improved technologies should be deployed for enhancing productivity, profitability, climate resilience and sustainability of rice farming.

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