वार्षिक प्रतिवेदन
Annual Report
2023

भाकृअनुप
ICAR

भा.कृ.अनु.प.–पुष्पविज्ञान अनुसंधान निदेशालय

ICAR-Directorate of Floricultural Research

(An ISO 9001: 2015 Certified Institute)

Zed Corner, Mundhwa Manjri Road, Mundhwa,
Pune 411036, Maharashtra, India.

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जेड कॉर्नर, मुंडवा–मंजरी रोड, मुंडवा, पुणे 411 036, महाराष्ट्र, भारत

Z-Corner, Mundhwa-Manjri Road, Mundhwa, Pune 411036, Maharashtra, India

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Director
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Near Z Corner, Mundhwa-Manjri Road, Mundhwa, Pune-411036
Telephone: 020-29997184
E-mail: director.dfr@icar.gov.in, directordfr@gmail.com
Website : http://dfr.icar.gov.in

Compiled and edited by

Dr. K.V. Prasad, Dr. D.V. S. Raju, Dr. Tarak Nath Saha, Dr. Dnyaneshwar M. Firake Dr. Md. Basit Raza, Dr. Madhavan, Dr. Ganesh B. Kadam, Dr Rahul Yadav, Mr Girish K.S., Dr. Sanjay Kad, Dr. S.P. Jeevan Kumar, Dr Kiran Bhagat, Dr. Prashant Kawar, Dr Shiva Kumar, Dr. Prabha K, Dr. Narendra Gajbhiye, and Mrs. Poornima Gaikwad

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Preface

K.V. Prasad, Director

I have great pleasure in presenting the Annual Report of ICAR-Directorate of Floricultural Research for the year 2023. Significant research accomplishments, outreach programmes are summarised hereunder.

Based on multi location trials, gladiolus Hybrids DFR-Amrit (DFR Glad-1) and DFR Soham (DFR-Glad-3) were identified for release by AICRP on Floriculture. The Institute Variety Identification Committee recommended these two varieties for release at the institute. Three newly developed hybrids DFR Glad-4 (No 74), DFR Glad -2, DFR Glad-5 (23W) and DFR Glad-6 (23P) were identified for further evaluation and multiplication.

The tuberose line AN 37, a single type tuberose suitable for lose flower was given as entry under AICRP on Floriculture for multi location testing. Half-sib population from tuberose cultivars Phule Rajani (06 nos.), Mexican Single (3 nos.), Sikkim Selection (1 nos.), Arka Prajwal (21 nos.) and Bidhan Ujjwal (3 nos.) were planted, besides 675 crosses. A unique dwarf tuberose, Sahyadri Vaman was evaluated for pot culture along with other entries of AICRP (F) and it is found to be suitable.

Based on multi location trials, three chrysanthemum varieties namely DFR-Pallavi, DFR-Megha and DFR-Swarna were identified by AICRP on floriculture for release. Electron beam mutants of chrysanthemum- three from Pusa Chitraksha, one from Pusa Aditya, one from Thai Chen Queen were evaluated. One new mutant each from Punjab Mohini suitable for pot culture and Acc.5 for loose flowers was found stable for the desired trait.

Forty chrysanthemum genotypes were evaluated for drought stress tolerance at the flowering stage. On the basis of preliminary investigation genotypes viz. Coimbatore Semi-double (171%), Gauri (103%), Silk Brocade (111%) and Cherabu (41%) were identified as a drought tolerant genotypes.

In rose, the potential of Deep Eutectic Solvents (DES) has been assessed for the delignification of rose seed pericarp. DES treatment with ChCl: oxalic acid for 5 hr results in maximum fold reduction (61%) in pericarp thickness.

In marigold, one apetalous male sterile line (DFROAPMs-1) and one petalous male sterile line (DFROPMs-1) were identified. Homozygous Inbred line in marigold for orange and yellow flower colour was developed by repeated selfing and 5 inbred lines namely DFR OPP-1, DFR OPP-2, DFR OPP-3, DFR OPP-4 and DFR OPP-5 were developed.

One species of Fusarium causing wilt in crossandra was identified at molecular level through multi locus sequence typing i.e. sequencing of i) internal transcribed spacer (ITS), ii) translation elongation factor 1-alpha (Tef-1α) and iii) RNA polymerase II second largest subunit (RPB2).

Antioxidant potential of 21 marigold cultivars was assessed utilizing various extraction methods and found that Sonication had superior extraction efficiency, yielding higher amounts of carotenoids and total phenols, along with exhibiting greater antioxidant potential compared to both microwave and conventional extraction methods.

A comparative analysis of transcriptome and volatile organic compounds (VOCs) was performed on scented (Double Delight) and non-scented (Pusa Bahadur) rose cultivars, primarily focusing on terpenoid biosynthesis pathways.

Five different varieties of Aglaonema namely- i) Aglaonema Maria ii) Aglaonema Commutatum iii) Aglaonema Silver Queen, iv) Aglaonema Tigress and v) Aglaonema Pink Dalmatin were assessed for oxygen releasing efficiency and leaf anatomical variations. Among Aglaonema species, Aglaonema Pink Dalmatian was found to contain higher total phenols (112 µg/ml), whereas Aglaonema Silver Queen was found to have lower (76 µg/ml) phenols. Similarly, the total oxygen liberation by leaf was observed to be higher in Aglaonema Maria (21.50%), whereas Aglaonema Silver Queen had lower oxygen liberation (21.44%). Aglaonema Maria had shown higher number of vascular bundles among all the five varieties followed by Aglaonema silver queen whereas least number of vascular bundles was observed in Aglaonema Pink Dalmatian. Similar studies were conducted in Draceana, Sanke Plant, Chlorophytum, and Palms.

Biodiversity Enhancement Kit has been developed by ICAR-DFR to improve faunal biodiversity not only on farmland but also in gardens, parks, and roadsides in urban and peri-urban areas.

Pollinator Habitat Restoration Kit has been developed to boost the abundance and ecosystem services of pollinators on farmland, leading to improved productivity and quality of produce in pollinator-dependent crops.

A total of 120 chrysanthemum lines were chemically screened for essential oil (EO) content. On fresh weight basis, the highest oil yield was observed in Liliput (0.3061±0.0074 %) and lowest content of oil was noticed in ACC-11 (0.061±0.0037 %). On dry weight basis, five genotypes Liliput (1.5565 ± 0.0197 %), Preet Shringar (1.046 ± 0.0755), Charlie (0.7652 ± 0.0087), Garden Beauty and Karnal Pink (0.5725± 0.0203) were found to contain higher essential oil content.

Comprehensive analysis of Essential oils across varied C. morifolium genotypes depicted rich tapestry of phyto-constituents shedding light on the chemical diversity. Major compounds noticed were camphor (45.9 %, DFR-OPCH-12-7), borneol (40.38 %, NBRI-Little Orange), trans-chrysanthenyl acetate (23.15 %, Magenta), cis- chrysanthenyl acetate (18.67, OPCH-13-2), (+)-α-pinene (17.83 %, Charlie) and eucalyptol (12.85 %, Basanti).

Evaluation of the heatmap of 23 genotypes of chrysanthemum depicted the relative abundance of 47 major phytochemicals across the genotypes. These genotype-specific compounds have varied applications in industries ranging from perfumery to herbal medicine (aromatherapy).

A comparative analysis of VOCs and gene expression was conducted on eight popular single-type tuberose cultivars using HS-SPME-GC×GC-ToF/MS. Sixty-four significant VOCs were identified, comprising of terpenoids, alcohols, esters, aldehydes, ketones, and phenols. Cultivar Prajwal displayed the highest relative expression of these genes.

Protocols for microwave vacuum drying technology for Rose flower petals, process for making of Rose candy and optimized microwave assisted extraction of bioactive compounds from rose flowers were standardised.

Through Externally funded projects, Process for a. ROMIHO (Rose-Millet-Honey) cookies, b. Bee wax Lip-balm enriched with rose extracts c. Rose Infused Honey d. Honey-Rose Gulkand e. protocol for Microwave Vacuum dried Honey Powder were standardised.

During the year, ICAR-DFR had the privilege of receiving the Honorable MoS, Agriculture and Farmers Welfare, Shri Kailash Choudhary ji on 19 January 2023 and the Honorable Secretary DARE and DG ICAR on 21 August 2023. During the visit Honorable DG has reviewed the progress of work and interacted with all the staff members.

ICAR-DFR organized a number of outreach programmes under Azadi Ka Amrut Mahotsav, MGMG, SCSP, TSP, besides World Soil Day, Chrysanthemum Day, Annual Day, Gladiolus Day, Vigilance awareness week, Agricultural Education Day, International Women's Day, World Bee Day, Pollinators Week, Hindi Pakhwada etc. A number of seminars, trainings, interactions were also organised at Pune and Vemagiri.

ICAR- DFR is indebted to Hon'ble Secretary DARE and DG, ICAR for his constant encouragement and support extended from time to time. The support and cooperation received from the Secretary, ICAR and FA (DARE) are gratefully acknowledged.

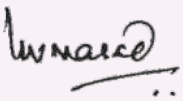
ICAR-DFR places on record its gratitude to Dr.T.R.Sharma, DDG (HS) for his support and encouragement.

Constant guidance and encouragement from Dr. Sudhakar Pandey ADG (FVSM) and Dr.V.B.Patel ADG (FPC) has been a boon for ICAR DFR. We place our sincere acknowledgments for their untiring efforts to help ICAR-DFR to re-establish itself at Pune.

Help rendered from time to time by Dr. Vikramaditya Pandey from SMD is sincerely acknowledged. Support and help received from other members from SMD is duly acknowledged.

The editorial team comprising of Dr. K.V. Prasad, Dr. D.V. S. Raju, Dr. Tarak Nath Saha, Dr. Dnyaneshwar M. Firake Dr. Md. Basit Raza, Dr. Madhavan, Dr. Ganesh B. Kadam, Dr. Rahul Yadav, Mr Girish K .S., Dr. Sanjay Kad, Dr. S.P. Jeevan Kumar, Dr. Kiran Bhagat, Dr. Prashant Kawar, Dr. Shiva Kumar, Dr. Prabha K, Dr. Narendra Gajbhiye, and Mrs. Poornima Gaikwad. Deserve special appreciation for their involvement and commitment in bringing out this publication.

Support and timely help from all the scientific, administrative and finance staff is fittingly acknowledged.



(K.V.Prasad)

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Executive Summary

The research focus at ICAR-DFR is mainly on crop improvement, crop production, crop protection and post-harvest management and value addition. The institute has a multidisciplinary team of scientists who conducted a total number of twenty-one experiments pertaining to inhouse projects, two inter-institutional projects, and four external funded projects. Significant findings of these experiments are summarized hereunder.

Crop Improvement

- 88 gladiolus varieties are maintained at ICAR-DFR research farm. 18 indigenously developed gladiolus varieties were evaluated for the morphological traits. Extensive hybridization in gladiolus was attempted with more than 570 crosses among newly collected parents.
- Three newly developed hybrids DFR Glad-4 (No 74), DFR Glad -2, DFR Glad-5 (23W) and DFR Glad-6 (23P) were identified for further evaluation and multiplication.
- Based on multilocation trial, Hybrids DFR-Amrit (DFR Glad-1) and DFR Soham (DFR-Glad-3) were identified at AICRP on Floriculture and also recommended for release at institute.
- In tuberose a total of 35 tuberose germplasm consisting of single (21 nos.) and double types (14 nos.) are being maintained at DFR, Pune.
- Among single type of tuberose the variety Bidhan Snigdha and *cv.* Arka Prajwal were found to be significantly high yielders, whereas in double type Phule Rajat and Bidhan Pearl was found to be very attractive.
- The cultivars, GKTC-4, Arka Nirantara, Bidhan Ujjwal, Bidhan Snigdha and Arka Keerthi were early flowering based on days to spike emergence and opening of first floret whereas, cultivars Arka Sugandhi, Sikkim Selection, Kahikuchi Single and Hyderabad Single were categorised as late flowering.
- Half-sib population from tuberose cultivars Phule Rajani (06 nos.), Mexican Single (3 nos.), Sikkim Selection (1 nos.), Arka Prajwal (21 nos.) and Bidhan Ujjwal (3 nos.) were planted, besides 675 crosses.
- The tuberose line AN 37, a single type tuberose suitable for lose flower was given as entry under AICRP on Floriculture for multilocation testing.
- The performance of Sahyadri Vaman for pot-culture were evaluated along with the entries of AICRP (F) and was found to be suitable.
- A total of 155 germplasm of chrysanthemum were maintained, besides promising lines (15 nos), electron beam mutants (7 nos), gamma mutants (2 nos) and local collections (4 nos).
- Based on multilocation trial, three chrysanthemum varieties namely DFR-Pallavi, DFR-Megha and DFR-Swarna were identified by AICRP on floriculture for release.
- Electron beam mutants of chrysanthemum- three from Pusa Chitraksha, one from Pusa Aditya, one from Thai Chen Queen were evaluated. Also, one mutant each suitable for pot culture (from Punjab Mohini) and loose flowers (Acc.5) were found stable for the desired trait.

- Forty chrysanthemum genotypes were evaluated for drought stress tolerance at the flowering stage. On the basis of preliminary investigation genotypes viz. Coimbatore Semi-double (171%), Gauri (103%), Silk Brocade (111%) and Cherabu (41%) were identified as a drought tolerant genotypes.
- A total of 212 genotypes of rose under different category are maintained at ICAR-DFR Research Farm. Eight wild species *Rosa brunonnii, Rosa bournoniana, Rosa canina, Rosa damascena, Rosa indica, Rosa multiflora, Rosa moschata* and *Rosa sericea*. *Rosa indica, Rosa multiflora*, Rose Nishikant are being used as a rootstock.
- In rose, genotypes Rose Sherbet, Pusa Alpana, Acc. No-3, Acc. No-5 and Kakinada were found to be suitable for loose flower production owing to perpetual flowering.
- Ten genotypes of rose namely Local Accession-1, Local Accession-3, Local Accession-4, Edward, Rose Sherbet, Neptune, Night Time, Royal Canadian, Pusa Bahadur and Christian Dior were identified for their suitability for value addition purpose.
- In marigold, identified one apetalous male sterile line (DFROAPMs-1) and one petalous male sterile line (DFROPMs-1).
- Homozygous Inbred line in marigold for orange and yellow flower color was developed by repeated selfing and 5 inbred lines namely DFR OPP-1, DFR OPP-2, DFR OPP-3, DFR OPP-4 and DFR OPP-5 were developed.
- In Aster (*Callistephus chinensis*) 17 genotypes including 13 varieties and 4 newly identified genotypes (DFR AA No.1, DFR AA No.11, DFR AA No.14, and DFR AA No.17) were maintained.
- In crossandra, five varieties viz., Local Orange-1, Local Yellow -1, Soundarya, Arka Shravya and Arka Chenna were evaluated for loose flower production. Highest flower yield was recorded in Soundarya followed by Arka Shravya. Mutation breeding was initiated using the popular variety Local Orange.
- One species of *Fusarium* causing wilt in crossandra was identified at molecular level through multi locus sequence typing i.e. sequencing of i) internal transcribed spacer (ITS), ii) translation elongation factor 1-alpha (Tef-1α) and iii) RNA polymerase II second largest subunit (RPB2).
- In rose, the potential of Deep Eutectic Solvents (DES) has been assessed for the delignification of rose seed pericarp. DES treatment with ChCl: oxalic acid for 5 h results in maximum fold reduction (61%) in pericarp thickness.
- Standardized the seed testing protocols in chrysanthemum and aster.
- SRAP fingerprinting of 30 gladiolus accessions revealed two main clusters: Cluster-I and Cluster-II. Cluster-I, comprising ten genotypes, was further divided into subclusters, Cluster-I-a and Cluster-I-b, with approximately 41.80% similarity.
- ISSR fingerprinting on ten Chrysanthemum genotypes revealed a similarity coefficient range of 0.79 to 0.55. Bidhan Shweta emerged as an outlier, distinguished by a similarity coefficient of 0.55.
- SRAP fingerprinting analysis of 29 Heliconia accessions revealed the presence of two primary clusters with approximately 68% similarity.
- Antioxidant potential of 21 marigold cultivars was assessed utilizing various extraction methods and found that Sonication was having superior extraction efficiency, yielding higher amounts of carotenoids and total phenols, along with exhibiting greater antioxidant potentials compared to both microwave and conventional extraction methods.

- A comparative analysis of transcriptome and volatile organic compounds (VOCs) was performed on scented (Double Delight) and non-scented (Pusa Bahadur) rose cultivars, primarily focusing on terpenoid biosynthesis pathways.

Crop Production

- Five different varieties of Aglaonema namely- i) *Aglaonema* Maria ii) *Aglaonema Commutatum* iii) *Aglaonema* Silver Queen, iv) *Aglaonema Tigress* and v) *Aglaonema* Pink Dalmatin were assessed for oxygen releasing efficiency and leaf anatomical variations.
- Among *Aglaonema* species, *Aglaonema* Pink Dalmatian was found to contain higher total phenols (112 µg/ml), whereas *Aglaonema* Silver Queen was found to have lower (76 µg/ml) phenols. Similarly, the total oxygen liberation by leaf was observed to be higher in *Aglaonema* Maria (21.50%), whereas *Aglaonema* Silver Queen had lower oxygen liberation (21.44%).
- *Aglaonema* Maria had shown higher number of vascular bundles among all the five varieties followed by Aglaonema silver queen whereas least number of vascular bundles was observed in Aglaonema Pink Dalmatian.
- In *Dracaena*, the total oxygen liberation by leaf was observed higher in *Dracaena massangeana* (21.49%), whereas *Dracaena* Green was found lower in oxygen liberation by leaf (21.36%).
- In indoor palms, the total oxygen liberation by leaf was observed to be higher in areca palm (21.19%), it was found lower in oxygen liberation by leaf (21.17%) in table palm.
- In Snake plant, the total oxygen liberation by leaf was observed to be higher in *Senservieria laurentii* (20.92%), whereas lower oxygen liberation by leaf (20.83%) was observed in Bacularis.
- In *Chlorophytum,* the total oxygen liberation by leaf was observed to be higher in *Chlorophytum comosum* (21.47%), whereas *Chlorophytum hawaiian* had lower oxygen liberation capacity (21.31%).

Crop Protection

- The predatory mite *Neoseiulus longispinosus* exhibits increased predatory potential with higher densities of its prey, *Tetranychus urticae*. Out of 151 chrysanthemum genotypes screened, Bidhan Rupanjali and Bidhan Agnisikha showed moderate to high resistance to *Spodoptera litura*. Entomopathogenic fungus *Cladosporium cladoproides* and an unidentified rove beetle were recorded as major natural enemies of the tuberose mealybug, *Dysmicoccus neobrevipes* in fields. Among 22 tuberose varieties, Arka Prajwal and Pune local double were highly susceptible to the mealybug, while Bidhan Snigdha, Swarna Rekha, and Phule Rajat were found to be tolerant. Blossom midge specimens collected across India were identified as *Contarinia maculipennis*, representing the first documented infestation of tuberose buds by this species. IPM package developed for tuberose midge significantly reduced blossom midge incidence and increased tuberose yield at Pune and Vemagiri farms of ICAR DFR, demonstrating economic benefits with an Incremental Benefit Cost Ratio (IBCR) of 2.35 to 2.84. Molecular and grower-friendly diagnostic tools were developed for rapid diagnosis of important bud borer species infesting jasmine.
- Bee pollination significantly increased seed yield and quality in aster flowers, enhancing germination rates and test weight compared to non-pollinated plots. Three chrysanthemum genotypes (OPCH 12-7, OPCH Double white, and DFR C-2) were identified as bee-friendly due to their favorable foraging parameters and floral rewards. Flower-pollinator interaction studies in Chrysanthemum revealed

significant variations in floral traits; disk floret diameter and number of florets correlated positively with bee abundance and foraging speed. DNA barcoding of various butterfly species revealed the presence of *Spindasis* (*Cigaritis*) *elima* on ornamental crops, especially on balsam, cosmos, and aster. This species is endangered and protected under Schedule II of the Wildlife Protection Act of 1972. Based on Shannon-Wiener and Simpson's diversity indices, four Aster genotypes (DFR-Ento-9, DFR-Ento-11, DFR-Ento-12, DFR-Ento-13), seven Balsam genotypes, along with Gomphrena, Cosmos, Calendula, Celosia, Goldenrod, Rantulas (Kenyan Basil), Salvia, and periwinkle were found to be excellent for conserving and enhancing pollinator biodiversity. In studies on the floral rewarding potential of selected ornamental plants, two gladiolus varieties (DFR-Glad-3 and Candyman) were found to be the largest nectar producers (75 µl/flower each). Among tuberose genotypes, the variety Mexican Single produces a higher amount of nectar (15.5 µl/flower) compared to others. Pollen samples from 63 ornamental plant species indicated that gladiolus, chrysanthemum, aster, and ornamental sunflowers produced larger quantities of pollen than other ornamentals. Addressing the global decline of pollinators, the "Pollinators on Flower Crops: A Database" has been developed, serving as a vital resource for researchers and policymakers. Recognizing the importance of insect pollination for global crop production, a "Pollinator Habitat Restoration Kit" was developed to enhance pollinator abundance and ecosystem services in farmland. To combat the lack of floral resources in agricultural landscapes, a "Biodiversity Enhancement Kit" was developed to support vital ecological services such as pollination and biological pest control, optimizing crop yields.

- Fluopyram 34.48% SC at 750 ml/ha and 500 ml/ha, and Fluensulfone 2% GR were tested against root-knot nematodes (RKN) in tuberose. Fluopyram treatment significantly reduced nematode populations and gall index, resulting in higher flower yields and improved plant growth compared to other treatments and untreated controls. The combination of Bacillus pumilus + Fluopyram and Bacillus amyloliquifaciens + Fluopyram found promising in reducing root knot nematodes populations in tuberose. Tuberose variety 'Suvasini' was identified as resistant to root-knot nematodes (gall index <1). Chrysanthemum foliar nematodes showed sexual size dimorphism and a few structural differences in both sexes.
- Bacterial blight in *Anthurium adreanum* was identified as caused by *Xanthomonas phaseoli* pv. *dieffenbachiae.* A fast and easy direct colony PCR protocol for *Xanthomonas* sp. was developed, bypassing DNA isolation. This method reduces cost and time for molecular detection by allowing DNA amplification directly from bacterial cultures. Complete draft genome of *Candidatus phytoplasma asteris* infecting Marigold and causing phyllody symptoms was deciphered through whole metagenome shotgun sequencing. Identified *Bacillus* sp. as the predominant endophyte associated with healthy marigold plants, while those from phytoplasma-infected plants included enterobacteriales, specifically *Pantoea* sp. These findings indicate their potential as indicators of phytoplasma infection in marigold crops. An ecological niche model using Maxent developed to predict the current and future distribution of Impatiens necrotic spot tospovirus (INSV) and its vector *Frankliniella occidentalis* in India under climate change scenarios. The UV sterilization protocol established for the sterilization of marigold flowers ensures effective sterilization of marigold flowers. *Fusarium falciforme* causing wilt in Spathiphyllum was identified through multi-locus sequencing. Chemical control with carbendazim and tebuconazole effectively managed wilt disease under both prophylactic and curative treatments. Native antagonistic fungi, bacteria, and yeast were evaluated for biocontrol against soil-borne pathogens in flower crops, with promising results observed for *Trichoderma* and certain bacterial isolates.

Post Harvest Technology and Value Addition

- A total of 120 chrysanthemum lines were chemically screened for essential oil (EO) content. On fresh weight basis, the highest oil yield was observed in Liliput (0.3061±0.0074 %) and lowest content of oil was noticed in ACC-11 (0.061±0.0037 %). On dry weight basis, five genotypes Liliput (1.5565 ± 0.0197 %), Preet Shringar (1.046 ± 0.0755), Charlie (0.7652 ± 0.0087), Garden Beauty and Karnal Pink (0.5725± 0.0203) were found to contain higher essential oil content.
- Comprehensive analysis of EOs across varied *C. morifolium* genotypes depicted rich tapestry of phyto-constituents shedding light on the chemical diversity. Major compounds noticed were camphor (45.9 %, DFR-OPCH-12-7), borneol (40.38 %, NBRI-Little Orange), trans-chrysanthenyl acetate (23.15 %, Magenta), cis- chrysanthenyl acetate (18.67, OPCH-13-2), (+)-α-pinene (17.83 %, Charlie) and eucalyptol (12.85 %, Basanti).
- Evaluation of the heatmap of 23 genotypes of chrysanthemum depicted the relative abundance of 47 major phytochemicals across the genotypes. These genotype-specific compounds have varied applications in industries ranging from perfumery to herbal medicine (aromatherapy).
- Analysed flowers of fragrant and non-fragrant rose hybrid teas (*Rosa hybrida*) and one scented cultivar Edward (*Rosa bourboniana*) for chemical volatile compounds and corresponding gene expression using HS-SPME-GC×GC-ToF/MS and quantative real time PCR respectively at full bloom stage.
- A comparative analysis of VOCs and gene expression was conducted on eight popular single-type tuberose cultivars using HS-SPME-GC×GC-ToF/MS. Sixty-four significant VOCs were identified, comprising of terpenoids, alcohols, esters, aldehydes, ketones, and phenols. Cultivar Prajwal displayed the highest relative expression of these genes.
- Variability in salt tolerance levels was evaluated and observed among the genotypes, Bidhan Lalima and Bidhan Sabita exhibiting high salt tolerance, while Vanity Pink and Bidhan Jayanti expressed high susceptibility.
- Protocols for microwave vacuum drying technology for Rose flower petals, process for making of Rose candy and optimized microwave assisted extraction of bioactive compounds from rose flowers were standardised.
- Modifications were done in the prototype of hand-held transplanter for enhancing the performance. Efforts required for transplantation of seedlings with the help of hand-held transplanter are less as compared to the manual transplantation of seedlings.
- The plucking rate (g/min) was more while harvesting of marigold flowers with the help of modified loose flower plucker than the hand plucking of marigold flowers.

Social Science

- Calculated the cost economics of chrysanthemum and marigold flower crops in Pune district. The B: C ratio for cultivation of chrysanthemum was 1.35 whereas it was 1.65 for marigold.

Externally funded project

- Process for a. ROMIHO (Rose-Millet-Honey) cookies, b. Bee wax Lip-balm enriched with rose extracts c. Rose Infused Honey d. Honey-Rose Gulkand e. protocol for Microwave Vacuum dried Honey Powder were standardised.

Introduction

The second advanced estimates of area and production of floricultural crops indicate that an area of 297000 lakh ha is under floricultural crops across the states contributing 22.36 lakh tonnes of loose flowers and 9.58 lakh tonnes of cut flowers. The sector contributed Rs 771.83 crores of forex through exports mostly to USA, Netherlands, UAE, UK and Canada. Cursory glance at the records clearly shows that the area under floriculture is more or less stagnant around 3.00 lakh ha for the last six years. However, the silver lining is that the production is increasing indicating the productivity levels have increased owing to improved varieties, farmer friendly technologies, quality inputs and proactive policies of the government.

During the year ICAR-DFR got a unique opportunity to showcase the enormous diversity of floricultural wealth of our country during G20 summit on 9th September 2023. With the help of ICAR-NRC on Orchids, AICRP centres and Flower Council of India, ICAR-DFR exhibited the floricultural wealth including that of Orchids. The agricultural prowess of the country was showcased in honour of the Spouses of the visiting leaders. The display included traditional flowers, cut flowers, speciality flowers, foliage and filler and, value added products (glimpses on back cover). The special display on a round platform with four levels of 12, 10, 6, 8 feet diameter provided a perfect platform to showcase the wealth. The display was admired by all the global dignitaries and the general public.

During the 16th Agricultural Science Congress organised by the National Academy of Agricultural Sciences and ICAR-CMFRI at Cochin, ICAR-DFR stall was adjudged Third Best Agri Expo Stall. The display organised in association with the AICRP centre at KAU, Vellanikkara comprised of traditional flowers, cut flowers, cut foliage, speciality flowers and value added products.

During the year the institute was reviewed by Honorable Union Agricultural Minister on 29.05.2023 and Honorable Secretary, DARE and DG, ICAR on 15.12.2023. Important suggestions for the growth of floriculture sector were offered by the Honourable Minister and the Secretary DARE and other distinguished members.

Based on continuous evaluation over three years ICAR-DFR developed a unique Pollinators on Flower Crops: A Database documenting a wide range of beneficial insects on a wide range of ornamental plants. Based on the information collected on a wide range of commercial flower crops, seasonal flowering annuals, shrubs, hedges, edges, creepers etc., ICAR-DFR developed two kits for the First time in the country namely Pollinators Habitat Restoration Kit comprising of flower crops that attract wide range of pollinators to enrich the natural habitats. Similarly another kit namely Biodiversity Enhancement Kit comprising of flower crops that favour the enhancement of biodiversity in totality. These two kits will offer crucial ecosystem services to the stakeholders like bee keepers, orchardists, institutions, farmers to maintain and enhance the diversity of flora and fauna across different landscapes.

ICAR-DFR embarked on cutting edge new technologies that included genome editing of marigold, photochemical profiling of rose, marigold, tuberose and chrysanthemum besides expanding the range of plants to improve indoor air quality. Whole Genome Sequencing of phytoplasma that causes phyllody in marigold was completed successfully during the year.

Vision

To harness the research and development activities in flower crops and landscape gardening for promotion of domestic and export markets.

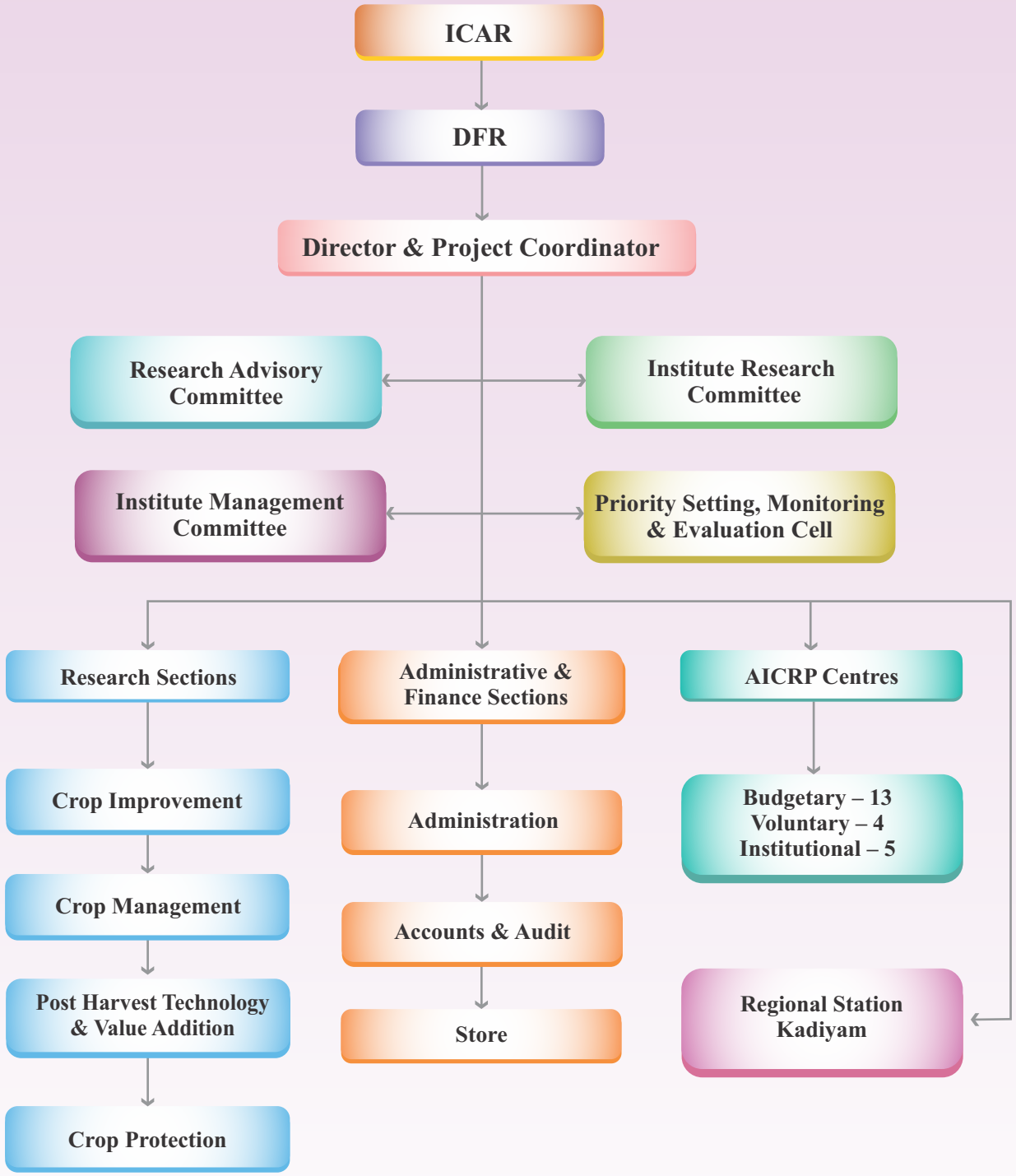
Mission

To carry out research, impart education, conduct outreach programmes in floriculture and landscaping with national and international partners for enhancing the production, productivity, profitability besides alleviating the rural poverty

Mandate

- To conduct basic, strategic and applied research to enhance sustainable productivity, quality and utilization of ornamental crops.
- To develop a repository of genetic resources and scientific information on ornamental crops.
- To transfer technology, capacity building and impact assessment of technologies.
- To coordinate research and validation of technologies through AICRP on Floriculture.

Organizational Structure of ICAR-Directorate of Floricultural Research, Pune



Research Achievements

1. Crop Improvement

1.1 Project 01 (ICAR Project code: IXX 14257): Improvement of Gladiolus for Commercial Traits

1.1.1 Germplasm Collection:

A total of 88 gladiolus varieties are maintained at ICAR-DFR research farm. Efforts were also made to evaluate the performance under Pune condition for various economical traits. The germplasm evaluated and maintained is presented in Table 1.1.

Table: 1.1 Germplasm maintained at Pune conditions

S. No.	Name of varieties	S. No	Name of varieties	S. No.	Name of varieties	S. No.	Name of varieties
1.	Arka Aayush	23.	Eurovision	45.	P.S. Hybrid	67.	Pusa Sinduri
2.	Arka Amar	24.	Flavo Breezer,	46.	Panibica Beauty	68.	Pusa Suhagan
3.	Arka Darshan	25.	Flavo Souvenir	47.	Peter Pear	69.	Red Majesty
4.	Arka Gold	26.	Flevo Effect	48.	Phule Ganesh	70.	S. Lady
5.	Arka Kesar	27.	Fortuna	49.	Phule Neelrekha	71.	Shahanoda
6.	Arka Kum Kum	28.	Friendship	50.	Pink Lady	72.	Snow Board
7.	Arka Manoroma	29.	Pusa Rajat	51.	Plumtart	73.	Snow Princess
8.	Arka Naveen	30.	Gulal	52.	Priscilla	74.	Solan Shringar
9.	Arka Poonam	31.	Gunjan	53.	Psittacinus Hybrid	75.	Souvik Biscuts
10.	Arka Pratham	32.	Hunting Song	54.	Punjab Down	76.	Suchitra
11.	Arka Ranjani	33.	HYAC No.7	55.	Punjab Glad-1	77.	Summer Sunshine
12.	Arka Sapna	34.	Jessica	56.	Punjab Glad-2	78.	Suryakiran
13.	Arka Shobha	35.	Jester	57.	Punjab Glad-3	79.	Swarnima
14.	Arka Sinduri	36.	Joska	58.	Punjab Glance	80.	Sweta
15.	Arka Telak	37.	Lemon Cello	59.	Punjab Lemon Delight	81.	Sylvia
16.	Arti	38.	Magma	60.	Punjab Pink Elegance	82.	Tambri
17.	Bindiya	39.	Manhattan	61.	Pusa Kiran	83.	Traderhorn
18.	C.P.G	40.	Melody Open	62.	Pusa Manmohak	84.	UHFS Glos HB-11-10
19.	Candyman	41.	Dhanvantari	63.	Welding Creamby	85.	Urmi
20.	Chandani	42.	Urmi	64.	White Prosperity	86.	Yellow Stone
21.	Cheops	43.	Vicki's Lin	65.	Pusa Shanti	87.	Amithyst
22.	Dhanvantari	44.	Novalux	66.	Pusa Shubham	88.	Kalima
23.	DFR Amrit	45.	DFR Soham				

1.1.2 Germplasm evaluation

18 indigenously developed gladiolus varieties were evaluated for the morphological traits (Table 1.2). These varieties are adopted to local climatic conditions and are performing better for various agronomical traits. Significant differences were observed for spike length and rachis length. The spike length of varieties studied ranged from 64.20 cm to 103.67 cm. The maximum spike length was recorded in variety Punjab Lemon Delight (103.67cm) followed by Punjab Gold-3 (103.11 cm) and Punjab Flame (103.12 cm). The rachis length is an important trait and overall appearance of spike depends on the length of rachis and florets arrangement. The rachis length ranged from 32.43 cm to 56.24 cm. Highest rachis length was recorded in variety Punjab Gold-3 (56.24 cm) followed by Punjab Flame (56.02cm) and Phule Neelrekha (52.16 cm) whereas shortest was recorded in variety Arka Naveen (32.43 cm). Number of florets per spikes was found significantly higher in varieties Arka Sinduri (22.22) followed by Pusa Manmohak (19.33) and Punjab Gold-3 (18.00). The corm weight was found significantly higher in Phule Ganesh (95.39 g) followed by Arka Tilak (84.94 g). Corm diameter was recorded maximum in Pusa Sinduri (7.24 cm) followed by Phule Ganesh (7.06 cm). Maximum cormels weight (6.09 g) and bigger sized (2.64 cm) cormels were found in variety Pusa Manmohak. Based on the overall performance, varieties Phule Neelrekha (purple), Pusa Manmohak(red), Phule Ganesh (white), Pusa Rajat (white), Punjab Gold-3 (yellow) were found to be suitable for commercial cultivation under Pune conditions. The colour and spike quality are also at par with the commercial varieties accepted in the market.

Table: 1.2 Performance of indigenously developed gladiolus varieties for morphological traits under pune conditions.

Sr No	Variety Name	Plant Height (cm)	Spike Length (cm)	Rachis Length (cm)	Leaf Length (cm)	Leaf Width (cm)	No. of Leaves	Bud open at a Time	No. of florets per spike	Flower Dia. (cm)	Corms weight (g)	Corm Dia. (Cm)	Cormels Weight (g)	Cormels Dia. (cm)
1	Pusa Rajat	106.89	91.08	47.11	51.64	7.31	8.00	2.89	17.22	9.60	63.71	6.30	0.90	0.98
2	Pusa Shanti	94.22	83.27	42.96	54.73	3.67	7.56	4.56	15.11	8.22	48.51	6.10	0.92	1.28
3	Arka Naveen	70.28	64.20	32.43	45.04	2.64	8.00	2.78	17.44	9.37	53.76	5.69	3.52	1.70
4	Pusa Sinduri	96.87	80.83	37.29	48.59	2.64	8.11	3.33	14.11	8.40	83.91	7.24	1.62	1.77
5	Punjab Gold-3	118.52	103.11	56.24	57.41	3.51	8.00	3.11	18.00	11.40	83.08	6.91	2.78	1.60
6	Pusa	99.27	87.27	46.58	50.39	3.62	7.00	3.44	19.33	11.26	61.99	6.76	6.09	2.64
7	Gulal	95.24	86.23	37.18	48.63	2.93	7.33	2.78	10.55	7.99	62.44	6.34	2.26	1.54
8	Arka Sinduri	81.12	69.68	34.90	42.83	2.86	8.11	3.33	22.22	8.91	46.70	5.53	3.31	1.86
9	Arka Tilak	109.92	97.10	49.56	48.92	3.41	6.89	4.56	13.22	10.93	84.94	6.59	2.43	1.76
10	Arka	90.61	76.73	38.83	40.39	3.30	8.00	3.78	13.44	10.13	50.13	5.70	3.41	2.07
11	Punjab	121.18	103.67	49.67	52.04	3.52	7.56	4.67	16.22	10.71	47.90	6.28	1.81	1.40
12	Punjab Flame	118.16	103.12	56.02	56.77	3.71	7.44	7.11	15.55	12.90	61.43	6.34	1.17	1.06
13	Phule	114.91	99.99	52.16	51.53	3.08	6.89	4.44	17.33	10.50	75.39	6.58	2.28	1.38
14	Phule Ganesh	115.06	99.48	48.72	50.39	3.86	7.89	4.11	16.77	10.39	95.39	7.06	2.51	1.66
15	Punjab Down	104.13	78.36	43.34	44.23	2.90	8.11	3.44	13.22	11.34	44.46	5.30	1.96	1.39
16	Arka Ayush	100.38	86.48	42.01	48.96	3.10	9.00	4.89	16.44	9.41	68.62	6.36	1.99	1.39
17	Arka Amar	103.02	92.50	45.34	45.57	3.72	6.67	4.89	14.44	10.54	53.11	5.68	2.18	1.82
18	Pusa Suhagan	106.03	88.92	43.66	46.31	3.82	6.44	5.11	15.33	9.29	36.54	5.27	4.28	1.99
	SE(m)	3.45	3.36	2.16	1.97	0.89	0.13	0.34	0.76	0.32	3.93	0.20	0.38	0.12
	CD (P)=0.05	9.91	9.66	6.21	5.65	2.55	0.38	0.97	2.21	0.93	11.29	0.56	1.10	0.34

1.1.3 Hybridization

Hybridization in gladiolus was initiated by selecting the best performing parents. The crosses were made among selected parents in all possible combinations and more than 570 crosses were attempted. The hybrid seeds were harvested and stored. Some of the crosses attempted are given in the Table no.1.3. The seeds sown from previous years were grown and some of the hybrids started flowering under Pune conditions. Morphological description of these hybrids are mentioned in Table 1.4.

Table. 1.3 Hybridization of selected parents

Sr no.	Female parent	Male parent	Sr no.	Female parent	Male parent
1.	Arka Pratham	Manhattan	20.	Arka Amar	Arka Pratham
2.	Arka Kesar	Manhattan	21.	Manhattan	Arka Amar
3.	Arka Sinduri	Arka Gold	22.	Arka Gold	Manhattan
4.	Pricilla	Arka Gold	23.	Arka Kumkum	Arka Gold
5.	Arka Pratham	Arka Amar	24.	Arka Naveen	Manhattan
6.	Pricilla	Pusa Suhagan	25.	Jaska	Arka Amar
7.	Snow Princess	Pusa Suhagan	26.	Shubhangi	Arka Pratham
8.	Pusa Suhagan	Arka Naveen	27.	Pusa Suhagan	White Prosperity
9.	Arka Amar	Manhattan	28.	Pusa Suhagan	Arka Gold
10.	Pusa Suhagan	Snow Princess	29.	Arka Gold	Arka Amar
11.	Punjab Frame	White Prosperity	30.	Arka Gold	Arka Sinduri
12.	Arka Gold	Arka Naveen	31.	Flora Effect	Arka Amar
13.	Arka Pratham	Flavo Effect	32.	Manhattan	Arka Pratham
14.	Arka Gold	Arka Pratham	33.	Pusa Suhagan	Arka Rajani
15.	Arka Amar	Flavo Effect	34.	Arka Pratham	Arka Amar
16.	Arka Poonam	Arka Pratham	35.	Pusa Suhagan	Pricilla
17.	Arka Gold	Arka Sinduri	36.	Arka Gold	Arka Pratham
18.	Joska	Arka Pratham	37.	Arka Naveen	Manhattan
19.	Punjab Flame	Phule Ganesh	38.	Arka Pratham	Manhattan

1.1.4 Evaluation of promising gladiolus hybrids/genetic stock

Based on the field performance the hybrids DFR Glad-4 (No 74), DFR Glad -2, DFR Glad-5 (23W) and DFR Glad-6 (23P) were identified for further multiplication and various morphological traits were recorded. Hybrids DFR-Amrit (DFR Glad-1) and DFR Soham (DFR-Glad-3) were identified based on the three years data for spike length, rachis length, florets arrangement on spike, floret size and number of florets, propagation rate, number of florets opened at a time on spike, unique flower colours, etc. These hybrids were released at institute by IVIC. The data for 59 DUS descriptors was collected and presented in Table 1.4. The florets arrangement for selected hybrids were One row (Straight) (DFR Glad-4-No 74), Zig-zag (DFR Glad -2), Two rows (DFR Glad-5-23W), Zig-zag (DFR Glad-6 -23P), Zig-zag (DFR-Amrit), Irregular (DFR-Soham). The main florets colour recorded were Red (Red Group 38 B) in DFR Glad-4-No 74, Orange (Orange Red N 30 A) in DFR Glad -2, White (White Group 155 A) in DFR Glad-5-23W, Red Purple (Red Purple 59 C) in DFR Glad-6 -23P, Yellow (Yellow Group 4 B) in DFR-Amrit and Yellow (Yellow Group 2 D) in DFR-Soham. The selected hybrids are in advanced stage of multiplication.

Table 1.4. DUS descriptor data of selected promising gladiolus hybrids

Sr no	Characteristics	DFR Glad-4 (No 74)	DFR Glad -2	DFR Glad-5 (23W)	DFR Glad-6 (23P)	DFR-Amrit (DFR Glad-1)	DFR Soham (DFR-Glad-3)
1.	Plant height (cm)	74.37	58.55	70.35	65.83	73.33	62.67
2.	Leaf Blade: Length (cm)	67.93	53.10	61.67	51.83	64.03	54.33
3.	Leaf Blade: Width (cm)	3.60	2.60	3.07	3.43	3.33	4.27
4.	Leaf Blade: Main colour	Light Green 137 B	Light Green 137 B	Light Green 137 B	Light Green 137 B	Light Green 137 B	Light Green 137 B
5.	Leaf: Curvature of distal Half	Weak	Absent	Weak	Weak	Weak	Weak
6.	Inflorescence: Lateral branches (Secondary Spike)	Absent	Absent	Absent	Absent	Absent	Present
7.	Rachis: Length (cm)	45.40	42.20	45.20	38.40	51.40	37.57
8.	Spike: No. of flowers/spike	15.33	15.50	15.00	11.67	16.00	13.67
9.	Spike: No. of open flowers	3.67	4.00	7.00	3.00	5.00	4.33
10.	Spike: Arrangement of flowers	One row (Staright)	Zig-zag	Two rows	Zig-zag	Zig-zag	Irregular
11.	Spike: Length of Second Internodes (cm)	5.43	3.53	3.80	4.50	4.30	3.63
12.	Bract: Shape of Apex	Obtuse	Acute	Acute	Acute	Obtuse	Obtuse
13.	Bract: Length (cm)	6.93	7.20	7.27	6.03	7.27	5.87
14.	Bract: Anthocyanin colouration	Medium	Absent	Absent	Medium	Absent	Absent
15.	Flower: Shape in front view	Triangular	Triangular	Triangular	Triangular	Star shaped	Triangular
16.	Flower: Attitude	Semi-upright	Semi-upright	Semi-upright	Semi-upright	Upright	Semi-upright
17.	Flower: Length (excluding first flower) (cm.)	11.57	10.83	10.33	10.37	10.87	10.60
18.	Flower: Width (excluding first flower) (cm.)	10.33	9.50	8.63	10.17	10.17	9.87
19.	Flower: Main Colour	Red (Red Group 38 B)	Orange (Orange Red N 30 A)	White (White Group 155 A)	Red Purple (Red Purple 59 C)	Yellow (Yellow Group 4 B)	Yellow (Yellow Group 2 D)
20.	Flower: Secondary Colour (shading)	Yellowish-Green (Yellow-Green 150 D)	Orange (Orange Red 31 B)	None	None	None	Yellow (Yellow Group 6 A)
21.	Perianth Tube: Length (cm.)	4.13	3.37	2.77	2.87	3.20	3.13

Sr no	Characteristics	DFR Glad-4 (No 74)	DFR Glad -2	DFR Glad-5 (23W)	DFR Glad-6 (23P)	DFR-Amrit (DFR Glad-1)	DFR Soham (DFR-Glad-3)
22.	Perianth Tube: Colour	Red (Red Group 51 B)	Yellowish-Green (Yellow-Green 150 B)	Yellowish-Green (Yellow-Green 145 C)	Yellowish-Green (Yellow-Green 150 D)	Yellowish-Green (Yellow-Green 145 C)	Yellowish-Green (Yellow-Green 145 C)
23.	Tepal: Length (cm.)	6.13	5.57	5.87	6.10	6.37	6.23
24.	Tepal: Width (cm.)	5.67	4.70	5.67	4.63	4.63	5.77
25.	Tepals Reflexing	Medium	Medium	Weak	Strong	Medium	Medium
26.	Outer Whorl: Shape	Elliptic	Ovate	Elliptic	Ovate	Ovate	Ovate
27.	Outer Whorl : Undulation	Medium	Weak	Medium	Weak	Medium	Strong
28.	Inner Whorl Undulation	Medium	Weak	Medium	Weak	Medium	Strong
29.	Tepal: Texture	Leathery	Leathery	Papery	Papery	Leathery	Leathery
30.	Inner Tepal: Stripe	Present	Present	Present	Present	Absent	Absent
31.	Inner Tepal: Colour of stripe	Yellow	Red	Red Purple	White	NA	NA
32.	Inner Tepal: Stripe Length (cm)	2.9	3.23	2.63	2.67	NA	NA
33.	Inner Tepal: Macule	Present	Absent	Present	Present	Absent	Absent
34.	Inner Tepal: Size of macule in relation to size of inner tepal	Small	NA	Small	Medium	NA	NA
35.							
36.							
37.	Inner Tepal: Position of Macule	Between base and centre	NA	Between base and centre	Base	NA	NA
38.	Inner Tepal: Shape of macule	Type 2	NA	Type 2	Type 4	NA	NA
39.	Inner Tepal: Main colour of macule*	Red (Red Group 54 A)	NA	Red (Red Purple 67 C)	Red (Red Purple 60 A)	NA	NA
40.	Inner Tepal: Secondary colour of macule	Yellow	NA	White	White	NA	NA
41.	Inner Tepal: Margin of macule	Regular/Slightly-irregular	NA	Very irregular	Moderately-irregular	NA	NA
42.	Inner Tepal: Different colour of marginal zone	Absent	Absent	Absent	Absent	Absent	Absent
43.	Inner Tepal: Width of marginal zone	NA	NA	NA	NA	NA	NA
44.	Inner Tepal: Border of marginal zone	NA	NA	NA	NA	NA	NA
45.	Inner Tepal: Colour of marginal zone'	NA	NA	NA	NA	NA	NA

Sr no	Characteristics	DFR Glad-4 (No 74)	DFR Glad -2	DFR Glad-5 (23W)	DFR Glad-6 (23P)	DFR-Amrit (DFR Glad-1)	DFR Soham (DFR-Glad-3)
46.	Median inner Tepal: Attitude	Semi-erect	Semi-erect	Semi-erect	Semi-erect	Semi-erect	Semi-erect
47.	Median inner Tepal: Attitude of apex	Straight	Straight	Straight	Moderately-reflexed	Straight	Straight
48.	Androecium: Length (cm)	4.23	4.83	4.23	5.10	5.23	4.67
49.	Filament: Length (cm)	2.97	3.43	2.87	3.57	4.07	3.37
50.	Filament: Main colour	White (White Group 155A)	Orange (Orange Group 29 D)	White (White Group NN 155C)	White (White Group NN 155C)	White (White Group 155A)	White (White Group 155A)
51.	Filament: Small spots at base	Present	Present	Absent	Absent	Absent	Present
52.	Filament: Colour of apex compared to main colour	Slightly different	Slightly different	Same colour	Slightly different	Same colour	Same colour
53.	Anther: Length (cm.)	1.43	1.67	1.43	1.80	1.70	1.67
54.	Anther: Colour of stomium	Violet (Violet Group 84 A)	Violet (Violet Group 83 A)	Violet (Violet Group 84 A)	Violet (Violet Group 83 A)	Violet (Purple Violet Group N82 A)	Violet (Purple Violet Group N82 A)
55.	Style: Length (cm.)	6.7	6.0	5.87	6.43	7.27	6.57
56.	Style: Main colour	White (White Group 155A)	Orange (Orange Group 29 D)	White (White Group NN155 C)	White (White Group NN155 C)	Light Yellow (Green Yellow 1C)	Light Yellow (Yellow Group 2 D)
57.	Style: Colour of base	White (White Group 155A)	White (White Group 155A)	White (White Group 155A)	White (White Group 155A)	White (White Group 155A)	White (White Group 155A)
58.	Stigma Lobe: Colour	Pink purple	Red	White	Pink purple	Yellow	Yellow
59.	Stigma Lobe: Length (cm)	0.63	0.73	0.77	0.43	0.97	0.40

1.1.5 Identification and release of gladiolus hybrids

Gladiolus hybrids DFR-Glad-31 and DFR-Glad-46 were evaluated for three seasons at ICAR-DFR research farm. Based on the performance for three seasons the hybrids DFR-Glad-31 and DFR-Glad-46 were recommended for release at institute and proposals were submitted to Institute Variety Identification Committee (IVIC). Accordingly, IVIC reviewed the application and claims were verified in the field on January 23, 2023. Hybrid DFR-Glad-31 produces medium yellow (Yellow Group 4 B as per R.H.S colour chart) coloured florets with reddish spots at the base of inner tepals on background of pale yellow coloured florets make it more attractive. The hybrid produces taller plants with 107.58 cm plant height, longer spikes (91.23 cm), takes only 48.12 days for spike initiation with more number of florets per spike (15.38). It has good rachis length (48.12 cm) on which flowers arranged in symmetrical manner. The hybrid 'DFR-Glad-46' produces light yellow (Yellow Group 2 D R.H.S colour chart) coloured florets with light yellow coloured

inner tepals which makes it more attractive. The plant height recorded was 96.87 cm. The hybrid started spike initiation in 63.66 days with robust and compact spikes. Florets are arranged in two rows with semi-upright position on long spikes (81.97 cm), longer rachis length (47.24 cm) and more number of florets per spike (15.81). The florets are ruffled with undulating inner and outer tepals and compact with 9.61 cm diameter. The committee verified the claims and proposed to name the hybrids, DFR-Glad-31 was named as DFR-Amrit (Fig. 1.1) and DFR-Glad-46 as DFR-Soham (Fig. 1.2). These hybrids are under multilocation testing under AICRP on floriculture.

Fig. 1.1 DFR-Amrit

Fig. 1.2 DFR-Soham

Visit of IVIC to gladiolus breeding block

1.1.6 Effect of thiourea, potassium nitrate and BAP on gladiolus corms and cormels production

The corms of gladiolus variety Pusa Suhagan was treated with thiourea (T1) and potassium nitrate (T2), BAP (T3) and control (T4) to overcome the dormancy of corms. Application of BAP at the 100 ppm not only reduced the period of dormancy but also increased the corm and cormel production. The treatment comprising of BAP found to have maximum corms (3.08) number per plant followed by thiourea (1.77). The cormels production was recorded maximum in treatment thiourea (10.6) followed by potassium nitrate (9.90) (Fig. 1.3). These are the initial observations and shall be validated in second year data of experiment.

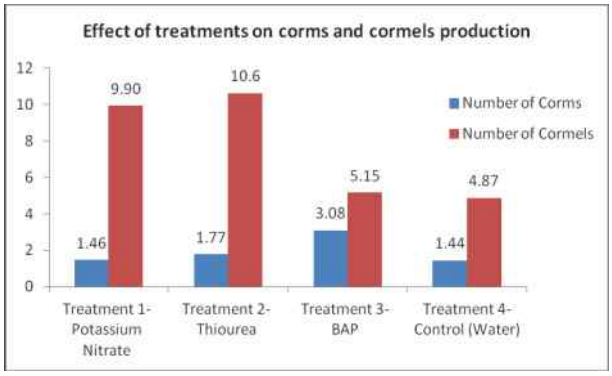


Fig 1.3: Effect dormancy breaking chemicals on corms and cormels production in gladiolus

1.1.7 Evaluation of gladiolus germplasm for fusarium wilt resistance through artificial inoculation

20 varieties of gladiolus were screened for fusarium wilt resistance under artificial inoculation. Based on the results it was observed that wilting of 77.77% was noticed in variety Priscilla followed by Pusa Shrinjana and White Prosperity (50.00%) whereas, the lowest wilting percentage was observed in Snow Board (11.11%) followed by Arka Amar and Red Magistrate (22.22%). The experimental data shall be validated in next season.

Table 1.5 Percent wilt infection in gladiolus

Sr no	Variety	Plant height (cm)	Wilt %
1.	Jester	49.86	38.88%
2.	Snow Board	50.45	11.11%
3.	Red Magistrate	55.66	22.22%
4.	Flavo Souvenir	55.33	33.33%
5.	Priscilla	50.00	77.77%
6.	White Prosperity	50.55	50.00%
7.	Psittacinus Hybrid	46.86	27.77%
8.	Punjab Flame	49.23	33.33%
9.	Arka Naveen	42.58	38.88%
10.	Shahanoda	52.53	38.88%
11.	Arka Amar	55.20	22.22%
12.	Yellow Stone	38.98	22.22%
13.	Souvik Biscuts	50.81	33.33%
14.	Arka Pratham	41.17	22.22%
15.	Punjab Down	43.217	27.77%
16.	Pusa Suhagan	43.36	27.77%
17.	Manhattan	46.52	38.88%
18.	Dhanvantari	51.21	33.33%
19.	Phule Neelrekha	46.30	38.88%
20.	Pusa Shrinjana	41.41	50.00%
21.	C.D.	7.273	
22.	SE(m)	2.531	
23.	SE(d)	3.579	
24.	C.V.	9.119	

1.2 Project 2 (ICAR Project Code: IXX 14261): Breeding of Tuberose for Quality and Yield

1.2.1 Evaluation of Tuberose Germplasm

A total of 35 tuberose germplasm consisting of single (21 nos.) and double types (14 nos.) are being maintained at DFR, Pune. Four genotypes *cv.* Arka Keerthi, Pratap Rajani 7, Pratap Rajani 7 (1), Yellow Baby were added to the germplasm collection. All genotypes were evaluated for growth, flowering and yield characteristics.

Among 21 single type varieties evaluated during 2023 (Table 1.6), cv. Bidhan Snigdha (Fig. 1.4) and cv. Arka Prajwal (Fig. 1.5) were found to be significantly high yielders. The highest loose flower yield per plant was recorded in cv. Bidhan Snigdha (1082.18 gm) followed by *cv.* Arka Prajwal (1073.14 gm), whereas, least yield per plant was recorded in case of cv. Kahikuchi Single (113.59 gm).

Based on morphological characteristics, cv. Bidhan Snigdha was found superior with respect to leaf length (56.48 cm), bud length (6.47 cm), flower length (7.58 cm), flower diameter (5.47 cm), rachis length (36.09 cm) and weight of 10 florets (30.03 gm). Whereas, cv. Arka Prajwal ranked second with respect to bud length (6.44 cm), weight of 10 florets (23.70 gm) and number of spikes per plant (8.07). The maximum number of flowers per plant (56.75) and number of spikes per plant (8.40) was recorded in cv. Bidhan Ujjwal. The minimum flower diameter (3.01) was recorded in cv. Yellow Baby. The bud length (4.63 cm) and flower length (5.41) were minimum in case of cv. Arka Sugandhi. The least number of flowers per spike (33.10) is recorded in case of cv. Nilkottai Local.

The cultivars, GKTC-4, Arka Nirantara, Bidhan Ujjwal, Bidhan Snigdha and Arka Keerthi were identified as early flowering based on days to spike emergence and opening of first floret whereas, cultivars Arka Sugandhi, Sikkim Selection, Kahikuchi Single and Hyderabad Single were categorised as late flowering.

Fig. 1.4. Bidhan Snigdha

Fig. 1.5. Arka Prajwal

Fig. 1.6 Sahyadri Vaman

Among 14 double type varieties evaluated during 2023 (Table 1.7), Phule Rajat (Fig. 1.7) was found to be more attractive with a greater number of florets that are closely spaced on the spike and recorded maximum peduncle thickness (12.71 mm). Maximum numbers of florets per spike was recorded in *cv.* BRH-19 (62.70) followed by Bidhan Star (60.08) and Phule Rajat (59.65). The cultivar Bidhan Star was found to be superior

Table 1.6: Evaluation of Single Type Tuberose Genotypes for Morphological, Flowering and Yield Characteristics

S.N.	Variety	Leaf Length (cm)	Leaf Breadth (cm)	Bud Length (cm)	Flower Length (cm)	Flower Diameter (cm)	Rachis Length (cm)	Spike Length (cm)	Peduncle Thickness (mm)	No of flowers/ spike	Days taken for flowering	Wt. of 10 florets (gm)	No. of spike/ clump	Yield/ plant (gm)
1	Arka Prajwal	54.53	2.76	6.44	6.78	4.78	27.83	107.16	13.44	56.30	90.15	23.70	8.07	1073.14
2	Arka Nirantara	48.28	2.20	6.18	7.14	4.84	27.63	93.16	11.76	55.55	84.95	16.20	7.00	628.16
3	Arka Shringar	46.80	1.81	5.40	5.75	4.33	26.60	78.81	10.63	48.40	90.55	19.05	4.60	427.35
4	Arka Sugandhi	42.20	2.17	4.63	5.41	3.70	21.84	55.55	8.16	46.45	110.25	10.50	3.70	180.95
5	Arka Keerthi	45.05	1.28	5.65	6.73	4.33	33.00	112.35	12.61	55.85	89.85	14.22	6.03	477.86
6	Bidhan Snigdha	56.48	2.23	6.47	7.58	5.47	36.09	96.13	13.43	55.45	88.45	30.03	6.50	1082.18
7	Bidhan Ujjwal	43.96	1.43	5.30	5.84	4.21	23.33	63.77	11.01	56.75	87.30	13.30	8.40	634.31
8	Phule Rajani	37.07	1.68	5.63	6.44	4.37	28.04	67.89	11.16	49.85	108.10	14.53	5.10	369.27
9	Sahyadri Vaman	38.48	2.03	5.26	6.39	5.19	21.29	49.58	11.58	49.45	95.00	15.42	4.60	350.92
10	GKTC 4	36.00	1.76	5.62	6.83	4.53	18.93	67.44	8.43	39.50	83.25	13.70	7.20	387.82
11	Pratap Rajani 7	41.63	2.34	5.53	5.89	4.43	21.27	50.42	9.85	55.13	108.00	12.05	2.00	133.40
12	Pratap Rajani 7 (1)	45.06	1.96	5.44	6.61	4.44	28.17	69.22	10.07	49.40	95.00	13.50	4.60	306.32
13	Mexican Single	45.85	1.45	5.47	6.50	4.18	16.20	98.07	8.19	34.50	107.25	13.25	6.60	301.46
14	Yellow Baby	44.63	2.74	4.82	5.87	3.01	24.19	74.71	9.57	45.30	95.50	12.10	5.10	279.48
15	Sikkim Selection	46.29	1.67	5.43	6.30	3.86	25.08	125.80	9.64	44.65	112.95	11.95	3.80	203.29
16	Hyderabad Single	44.61	2.07	5.46	6.24	4.26	25.16	83.22	8.63	47.30	109.80	13.95	4.60	301.38
17	Nilkottai Local	42.76	1.42	5.80	7.03	4.27	21.68	86.13	7.66	33.10	93.00	12.10	3.15	126.10
18	STR 501	45.98	1.79	5.34	5.93	4.21	23.12	70.60	9.50	45.00	94.50	13.33	3.80	227.67
19	Kahikuchi Single	45.58	1.65	5.67	6.81	4.16	15.90	97.18	8.38	37.00	110.50	13.93	2.20	113.59
20	Variegated Loc. Single	55.12	1.64	5.49	6.23	3.83	24.99	126.99	10.48	43.85	87.50	12.40	3.00	163.39
	C.V.	2.257	3.677	1.683	1.783	1.818	5.672	4.130	2.179	3.033	1.772	8.481	10.960	12.596
	C.D. (0.01)	2.909	0.198	0.266	0.326	0.223	3.913	9.841	0.629	4.074	4.881	3.573	1.551	136.325
	C.D. (0.05)	2.133	0.145	0.195	0.239	0.164	2.869	7.216	0.461	2.987	3.579	2.620	1.137	99.956

Table 1.7: Evaluation of Double Type Tuberose Genotypes for Morphological, Flowering and Yield Characteristics

S.N.	Variety	Leaf Length (cm)	Leaf Breadth (cm)	Bud Length (cm)	Flower Length (cm)	Flower Diameter (cm)	Rachis Length (cm)	Spike Length (cm)	Peduncle Thickness (mm)	No of flowers/ spike	Days taken for flowering	No. of spike/ clump
1	Arka Suvasini	42.31	2.28	5.28	6.43	4.63	43.08	109.27	9.38	57.75	92.25	5.00
2	Arka Vaibhav	43.11	2.24	4.70	6.39	4.30	38.86	84.33	8.71	48.35	116.10	3.80
3	Phule Rajat	37.41	1.86	4.87	5.84	4.37	39.32	80.26	12.71	59.65	115.45	6.17
4	Pink Sensation	35.54	3.25	5.20	6.17	4.87	40.57	83.26	10.53	55.50	105.85	5.83
5	Bidhan Star	45.21	1.99	6.47	7.66	5.74	34.29	84.28	10.90	60.08	104.00	8.17
6	Bidhan Pearl	47.32	2.19	4.45	6.10	4.18	27.84	73.71	11.04	48.57	97.30	5.17
7	BRH 19	43.27	2.79	5.59	6.76	5.21	35.90	70.27	11.57	62.70	100.30	4.83
8	Swarna Rekha	44.85	1.83	5.23	6.26	3.63	36.89	97.32	9.62	56.45	137.00	3.30
9	Pearl Double	37.53	2.12	5.23	6.26	3.85	36.72	109.68	10.49	54.60	93.45	3.50
10	Hyderabad Double	42.76	2.11	5.37	6.27	4.96	35.96	108.40	10.59	46.30	117.60	2.87
11	Calcutta Double	43.01	2.18	5.19	5.86	4.20	35.36	96.85	10.87	47.60	95.05	2.88
12	Kahikuchi Double	44.33	2.02	5.49	6.37	4.84	40.48	103.72	11.39	52.60	106.50	3.00
13	Local Nimhans	45.30	1.85	5.20	6.23	3.73	36.68	105.02	9.68	45.67	107.45	2.50
14	Pune Local Double	44.88	2.18	5.19	6.38	4.24	45.23	108.27	11.77	53.55	96.45	3.00
	C.V.	2.731	2.869	1.734	1.286	1.957	4.114	1.648	2.096	4.042	2.637	9.161
	C.D. (0.01)	3.506	0.191	0.274	0.246	0.264	4.666	4.661	0.673	6.516	8.422	1.183
	C.D. (0.05)	2.514	0.137	0.196	0.176	0.189	3.346	3.343	0.483	4.673	6.040	0.848

with respect to maximum bud length (6.47 cm), floret length (7.66 cm), floret diameter (5.74), and number of spikes per clump (8.17). Arka Suvasini (92.25 D.A.P.) was found to attain the earliest flowering whereas, cv. BRH-19 was categorized as late flowering with maximum days to flower (137 D.A.P.). The cultivar Bidhan Pearl (Fig. 1.9) was found to have minimum bud length (4.45 cm) and rachis length (27.84 cm). The maximum rachis length (45.23 cm) and spike length (109.68 cm) were recorded in cv. Pune Local Double and Pearl Double respectively.

Fig. 1.7. Phule Rajat

Fig. 1.8. Pink Sensation

Fig. 1.9. Bidhan Pearl

1.2.2 Evaluation of Promising Selections of Tuberose

Half-sib population from cultivars Phule Rajani (06 nos.), Mexican Single (3 nos.), Sikkim Selection (1 nos.), Arka Prajwal (21 nos.) and Bidhan Ujjwal (3 nos.) were planted and are being maintained at ICAR-DFR, Research Farm.

During the year 2023, half-sib population of 13 promising selections (Table 1.8) derived from cv. Arka Nirantara were planted at ICAR-DFR, Research Farm and evaluated for consistency for growth and flowering. The results indicated that the selection AN 37 exhibited highest loose flower yield potential (672.44 gm/plant) based on weight of 10 opened florets (15.7 gm), number of florets per spike (56), and number of spikes per plant (6.10). In addition, AN 18 (441.80 gm), AN 28 (438.40 gm), AN 32 (433.05 gm) and AN 23 (380.29 gm) were found to exhibit higher loose flower yield potential. The selection AN 18 was found superior with respect to bud length (5.98 cm), flower length (6.97 cm), and flower diameter (4.98 cm). The maximum rachis length was recorded in AN 32 (37.49 cm) while spike length was recorded maximum in AN 19 (129.13 cm).

Additionally, a hybrid population of 675 nos. raised from nine different controlled crosses (Table 1.9) is planted during 2023 and being maintained in field.

Table 1.8: Evaluation of Promising Selections of Tuberose for Morphological, Flowering and Yield Characteristics

S.N.	Variety	Leaf Length (cm)	Leaf Breadth (cm)	Bud Length (cm)	Flower Length (cm)	Flower Diameter (cm)	Rachis Length (cm)	Spike Length (cm)	Peduncle Thickness (mm)	No of flowers/ Spike	Wt. of 10 floret	No. of spike/ clump	Yield/ plant (gm)
1	AN 7	43.27	1.61	5.34	6.40	4.62	16.03	56.07	8.38	45.40	13.55	5.70	351.66
2	AN 11	42.30	1.35	5.42	6.82	4.55	25.26	110.67	11.03	47.60	12.15	4.60	266.10
3	AN 14	50.00	1.35	5.84	6.77	4.63	23.53	73.63	8.76	47.80	13.83	5.50	363.65
4	AN 18	43.10	1.45	5.98	6.97	4.98	27.37	79.23	9.61	46.47	16.70	5.70	441.80
5	AN 19	40.90	1.35	5.49	6.25	4.69	26.55	129.13	9.52	39.17	12.10	5.00	236.87
6	AN 23	41.40	1.45	5.64	6.46	4.20	31.52	81.83	10.75	55.00	12.55	5.50	380.29
7	AN 26	43.50	1.50	5.61	6.51	4.84	25.48	81.84	10.82	47.53	15.05	4.80	343.73
8	AN 27	44.20	1.50	5.31	5.97	4.70	22.10	65.68	8.89	44.50	14.55	5.90	381.53
9	AN 28	42.85	1.45	5.48	6.23	4.38	28.03	95.67	11.02	49.23	15.65	5.70	438.40
10	AN 30	33.90	1.35	5.48	6.22	4.74	22.08	65.49	10.44	54.90	14.75	5.00	404.92
11	AN 32	36.68	1.55	5.56	6.84	4.18	37.49	89.26	11.30	55.50	13.00	6.00	433.05
12	AN 36	45.65	1.50	5.23	6.15	4.22	21.21	66.26	7.53	44.80	11.70	5.10	267.23
13	AN 37	42.57	2.03	5.53	6.65	4.89	28.96	81.53	11.29	56.00	19.65	6.10	672.44
	C.V.	2.833	5.772	1.312	0.797	1.151	5.249	2.463	1.826	2.967	4.905	5.610	8.819
	C.D. (0.01)	3.664	0.264	0.222	0.158	0.161	4.140	6.230	0.555	4.421	2.135	0.931	103.238
	CD (0.05)	2.613	0.188	0.158	0.113	0.115	2.953	4.443	0.396	3.153	1.523	0.664	73.635

Table 1.9: Details of hybrid population of tuberose derived from Conventional hybridization

S.N.	Parentage	No of Hybrid seedlings
1	Phule Rajani X Arka Shringar	200
2	Phule Rajani X Arka Nirantara	8
3	Arka Shringar X Phule Rajani	32
4	Bidhan Ujjwal X Phule Rajani	16
5	Arka Shringar X Arka Nirantara	33
6	OP Selection Arka Keerthi	7
7	Arka Nirantara X Pink	25
8	Arka Nirantara X Yellow	150 (15 Isolations)
9	Phule Rajani X Yellow	50 (47 Isolations)
10	Sikkim Selection X Yellow	154 (3 Isolations)
	Total Hybrids	675

Fig. 1.10. AN 37

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for cut & loose flower
- Bud Length : 5.53 cm
- Bud Color : Pink
- Flower Length : 6.65 cm
- Flower Diameter : 4.89 cm
- Rachis Length : 28.96 cm
- Spike Length : 81.53 cm
- No of flowers/ Spike : 56.00
- Wt. of 10 floret : 19.65 gm
- Yield/ plant : 672.44 gm

Fig. 1.11. AN 32

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for cut & loose flower
- Bud Length : 5.56 cm
- Bud Color : Pink
- Flower Length : 6.84 cm
- Flower Diameter : 4.18 cm
- Rachis Length : 37.49 cm
- Spike Length : 89.26 cm
- No of flowers/ Spike : 55.50
- Wt. of 10 floret : 13.00 gm
- Yield/ plant : 433.05 gm

Fig. 1.12. AN 30

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for pot culture
- Bud Length : 5.48 cm
- Bud Color : Pink
- Flower Length : 6.22 cm
- Flower Diameter : 4.74 cm
- Rachis Length : 22.08 cm
- Spike Length : 65.49 cm
- No of flowers/ Spike : 54.90
- Wt. of 10 floret : 14.75 gm
- Yield/ plant : 404.92 gm

Fig. 1.13. AN 28

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for cut & loose flower
- Bud Length : 5.48 cm
- Bud Color : Pink
- Flower Length : 6.23 cm
- Flower Diameter : 4.38 cm
- Rachis Length : 28.03 cm
- Spike Length : 95.67 cm
- No of flowers/ Spike : 49.23
- Wt. of 10 floret : 15.65 gm
- Yield/ plant : 438.40 gm

Fig. 1.14. AN 18

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for cut & loose flower
- Bud Length : 5.98 cm
- Bud Color : Pink
- Flower Length : 6.97 cm
- Flower Diameter : 4.98 cm
- Rachis Length : 27.37 cm
- Spike Length : 79.23 cm
- No of flowers/ Spike : 46.47
- Wt. of 10 floret : 16.70 gm
- Yield/ plant : 441.80 gm

Fig. 1.15. AN 23

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for cut & loose flower
- Bud Length : 5.64 cm
- Bud Color : Pink
- Flower Length : 6.46 cm
- Flower Diameter : 4.20 cm
- Rachis Length : 31.52 cm
- Spike Length : 81.83 cm
- No of flowers/ Spike : 55.00
- Wt. of 10 floret : 12.55 gm
- Yield/ plant : 380.29 gm

Fig. 1.16. AN 26

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for cut & loose flower
- Bud Length : 5.61 cm
- Bud Color : Pink
- Flower Length : 6.51 cm
- Flower Diameter : 4.84 cm
- Rachis Length : 25.48 cm
- Spike Length : 81.84 cm
- No of flowers/ Spike : 47.53
- Wt. of 10 floret : 15.05 gm
- Yield/ plant : 343.73 gm

Fig. 1.17. AN 7

- Half-sib progeny derived from *cv.* Arka Nirantara
- Suitable for pot & loose flower
- Bud Length : 5.34 cm
- Bud Color : Pink
- Flower Length : 6.40 cm
- Flower Diameter : 4.62 cm
- Rachis Length : 16.03 cm
- Spike Length : 56.07 cm
- No of flowers/ Spike : 45.40
- Wt. of 10 floret : 13.55 gm
- Yield/ plant : 351.66 gm

1.2.3 Identification and release of variety

During the year under report, AN 37 (Fig. 1.18) a single type tuberose line was identified by the Germplasm Identification Committee of the Institute as well as by the Institute Variety Identification Committee based on the performance during the last three years. The variety was evaluated for DUS characteristics. The selection was found to have significantly higher loose flowers yield than its parent and was suitable for cut and loose flower purpose.

Fig. 1.18. AN 37

Table of Characteristics	
Leaf Variegation	Absent
Pigmentation at leaf base on abaxial side	Medium
Bud colour	Pink
Flower type	Single
Flower shape	Broad Funnel
Iinflorescence length (cm)	Medium
Stigma type	Thrum
Stigmatic lobes	Trifid
Pigmentation on peduncle	Weak
Days taken for flowering	Early
Fruit Locule	Trilocular

1.2.4 Evaluation of Tuberose Genotypes for Pot-Culture

During 2023, the performance of Sahyadri Vaman was evaluated for pot-culture along with the new promising entries of AICRP (F). The experiment included eight genotypes consisting of 5 single and 3 double types (Table 1.10). These entries were planted in a pot size of 30 cm filled with soil with basal nutrient dosage. Based on the morphological growth and flowering characteristics, *cv.* Sahyadri Vaman was found to be superior for dwarfness with short spike length (42.72 cm). The minimum rachis length was recorded in *cv.* Arka Sugandhi (15.43 cm) whereas, maximum rachis length was recorded in *cv.* Pratap Rajani 7(1) (27.98 cm). BRH-17 was found superior with respect to number of florets per spike (50.75) whereas minimum number of florets per spikes were recorded in *cv.* Pratap Rajani 7 (40.83). The minimum days to opening of floret were recorded in case of *cv.* Arka Keerthi (84 D.A.P.) followed by *cv.* Sahyadri Vaman (99.50 D.A.P.).

1.2.5 Evaluation of Sahyadri Vaman for pot-culture

The performance of Sahyadri Vaman was determined for pot-culture. Growing media (four combinations, FA + Pressmud + Coconut husk + Vermicompost (15: 35: 40: 10); Cocopeat + Soybean husk compost + Perlite (1: 1: 0.5); Soil + Cocopeat + FYM (1:1:1) and soil alone) and Pots of four sizes (15.5 cm, 20.0 cm, 30 cm and 35.5 cm) were used. Media combinations were found to be not effective in influencing the vegetative growth parameters. A pot size of 30 cm or 35.5 cm was found to result in best growth and flowering (Table 1.11).

Table 1.10: Evaluation of Tuberose Genotypes for Pot-Culture

S.N.	Variety	Days to Spike Emergence	Days to Opening of first floret	Spike Length (cm)	Rachis Length (cm)	No. of Florets/ Spike	Flower Length (cm)	Flower Diameter (cm)	Wt. of 10 florets (cm)	No. of spikes/ plant
1	Arka Sugandhi	91.63	105.25	44.46	15.43	40.88	5.00	3.60	9.45	3.58
2	Sahyadri Vaman	84.00	99.50	42.72	20.87	43.00	5.68	4.35	12.20	4.25
3	Pratap Rajani 7	91.38	105.00	43.92	18.28	40.83	5.60	4.24	10.65	2.42
4	Pratap Rajani 7(1)	87.13	105.00	64.43	27.98	45.75	5.85	3.67	11.90	3.42
5	Arka Keerthi	74.50	84.00	93.64	25.87	43.00	5.96	4.34	12.25	5.42
6	BRH-17	90.13	105.00	69.60	24.50	50.75	5.88	4.26	29.90	4.42
7	BRH-18	84.17	103.17	61.65	23.70	45.25	4.92	3.29	35.30	4.58
8	BRH-19	97.00	103.33	64.30	26.90	44.00	6.32	5.15	35.00	4.17
	C.V.	4.56	6.405	4.714	8.25	4.237	3.846	2.783	15.57	4.688
	C.D. (0.01)	NS	NS	9.993	6.622	NS	0.760	0.401	10.668	0.661
	CD (0.05)	9.435	NS	6.755	4.476	4.427	0.514	0.271	7.21	0.447

Fig. 1.19. View of Pot Experiment of tuberose

Table 1.11: Effect of growing media and pot size on the growth and flowering of tuberose cv. Sahyadri Vaman

Treatment	Days to sprout	Leaf Length (cm)	Leaf Width (cm)	Days to Spike Emergence	Opening of First Floret	Flower Length (cm)	Flower Diameter (cm)	No. of florets/spike	Rachis Length (cm)	Spike Length (cm)	Plant Height (cm)	Wt. of 10 opened flowers (gm)	Wt. of 10 unopened flowers (gm)	Avg. No. of spikes/ plant
M1P1	42.8	25.2	1.6	142.2	156.0	6.0	4.7	24.2	17.0	30.3	33.0	12.2	7.7	1.0
M1P2	41.5	32.0	1.8	152.5	167.5	5.9	4.7	27.8	20.3	38.0	40.8	10.3	6.4	1.0
M1P3	37.3	32.9	1.7	126.0	140.3	6.0	5.0	33.8	23.6	38.2	43.0	14.4	7.4	2.7
M1P4	35.3	35.0	1.8	131.7	144.7	6.0	5.0	30.0	22.3	35.1	40.7	13.1	6.8	3.2
M2P1	43.0	21.8	1.4	143.5	155.5	4.9	4.4	36.0	15.2	33.6	35.8	10.5	6.0	1.3
M2P1	44.0	23.3	1.5	136.5	153.0	5.0	4.1	30.0	17.1	36.8	41.9	10.6	5.0	1.0
M2P3	37.5	24.4	1.6	127.0	139.3	6.1	5.1	32.3	21.6	33.3	37.8	11.0	7.3	2.0
M2P4	41.5	27.5	1.7	136.5	151.3	5.4	4.6	30.5	20.3	34.6	37.5	10.9	6.5	2.8
M3P1	44.0	18.5	1.2	149.5	163.5	4.6	4.1	26.5	19.2	23.2	24.7	9.8	5.1	1.5
M3P2	41.5	23.6	1.4	139.5	153.8	5.1	4.0	30.0	15.0	26.2	30.1	9.7	5.0	1.5
M3P3	44.8	22.7	1.5	131.5	143.5	5.1	4.1	40.0	15.8	27.1	31.3	9.7	5.6	2.0
M3P4	41.5	22.7	1.3	122.0	144.0	5.4	4.2	37.5	15.9	29.0	34.4	9.9	7.0	2.0
M4P1	45.0	20.4	1.4	139.5	153.5	4.9	4.2	36.0	16.4	33.7	38.5	10.2	6.9	1.5
M4P2	41.0	24.8	1.5	144.0	159.5	5.3	4.2	36.3	15.2	30.6	34.7	11.0	6.4	1.5
M4P3	42.3	29.2	1.6	126.5	147.8	5.6	4.4	38.9	17.1	34.9	39.3	11.4	6.4	2.5
M4P4	40.0	29.2	1.6	131.5	138.0	5.8	4.6	42.8	20.1	37.5	42.3	16.9	6.7	3.0
C.V.	9.634	8.315	5.953	6.035	5.709	6.194	6.144	10.701	12.400	9.505	8.418	23.820	17.360	23.650
C.D. (0.05) Media	4.254	2.287	0.098	8.761	9.165	0.359	0.293	3.794	2.411	3.305	3.283	2.877	1.178	0.477
C.D. (0.05) Pot size	4.254	2.287	0.098	8.761	9.165	0.359	0.293	3.794	2.411	3.305	3.283	2.877	1.178	0.477
C.D. (0.05) Media X Pot size	8.507	4.574	0.196	17.522	18.331	0.719	0.585	7.588	4.822	6.610	6.566	5.753	2.356	0.954

1.3 Project 03 (ICAR Project code IXX 14254): Breeding of Chrysanthemum for novel Traits

1.3.1Germplasm Collection

A total of 155 germplasm of chrysanthemum were maintained, besides promising lines, electron beam mutants, gamma mutants and local collections Table 1.12.

Table 1.12 List of chrysanthemum germplasm at ICAR-DFR.

Sl. No.	Types	Varieties
1.	Spray (124)	Akitha, Anjali, Anupama, Autumn Joy, BC-32-20, BC-6-11, Bidhan Agni, Bidhan Agnishika, Bidhan Bishanupriya, Bidhan Gold, Bidhan Jayanti, Bidhan Lalima, Bidhan Madhuri, Bidhan Neeta, Bidhan Poonam, Bidhan Purna, Bidhan Rajat, Bidhan Rupanjali, Bidhan Sabita, Bidhan Shova, Bidhan Swapna, Bidhan Sweta, Bidhan Tarun, Brown Spoon, Chandrika, Charlie, Cherabu, Classic, Coffee, Coimbatore Semi Double, Crocon Small, Daity White, Dark Eyes, Decoction, Devi, Dignity, Discovery, Draguma, Fire Ball, Fish Tail, Gaity, Garden Beauty, Gitanjali, Gouri, Gulmohar, Halud, Himani, Honey Comb, Houston, HYDC Local Yellow, HYDC-17, HYDC-19, HYDC-20, HYDC-26, HYDC-29, HYDC-30, HYDC-31, HYDC-38, HYDC-4, HYDC-41, HYDC-42, HYDC-55, HYDC-56, HYDC-7, HYDC-77, HYDC-8, I.A.H. Red, Jafari, Jaya, Jayanti, Jubilee, Kargil-99, Karnal Pink, Kirthi Gold, Kushum, Magenta, Maghi White, Mauve Sarah, Meera, Mountainer, Naughty Yellow, Navy Pride, NBRI Fish Tail, NBRI Kusum, NBRI Shanti, NBRI Yellow Delight, Palpitta (HYDC-2), Paragon Yellow, PAU D 11, PAU-147-11, PAU-35, PAU-58, PAU-66-2, Pink Cloud, Purnima Red, Purnima Yellow, Preet Shringar, Punjab Gold, Purple Quill, Pusa Aditya, Pusa Anmol, Pusa Chitraksha, Pusa Guldasta, Pusa Kesari, Pusa Sweth, Rajahmundry, Ratlam selection, Ravi Kiran, Red Gold, Red Stone, Royal Purple, Sabita, Sadwin Yellow, Salmon, Seema, Shanti, Shintome, Sugandha White, Texas Gold, UHFS-CRY-126, Vanity pink, Veena, Vijay and Yellow Delight
2.	Pot culture (17)	Anmol (PAU), Arka Pink Star, Basanti, Bidhan Chitra, Bidhan Manasi, Bidhan Mum, Himanshu, IIHR-2-16, IIHR-4-8, Lalpari, Liliput, Mini Jassie, Mother Teresa, NBRI Little Orange, NBRI Little Pink, Punjab Mohini and Pusa Sona.
3.	Standard (14)	CSIR IHBT CH-14-1, CSIR IHBT CH14-18, CSIR IHBT CH14-2, CSIR IHBT CH14-4, CSIR IHBT CH14-8, NBRI Kundan, NBRI Pornima, Punjab Shyamali, Pusa Arunodaya, Pusa Centenary, Reagan Emperor, Silk Brocade, Thai Chen Queen and UHFS-CRY-123.

1.3.2 Evaluation of spray Chrysanthemum varieties

34 spray type of chrysanthemum were evaluated under field condition for agromorphic traits.

A perusal of data from Table 1.13 revealed that the variety DFR Pallavi recorded maximum height (103.22 cm) followed by Purple Quill (72.98 cm); whereas it was minimum in Himani (39.44 cm) and Bidhan Jayanti (41.29 cm). The plant spread was found maximum for Purple Quill (65.11 cm) followed by Charmish (63.44 cm); and least in Haldighati (32.00 cm). Regarding days to bud initiation, it ranged from 75.00-99.78 days. The variety Bidhan Shova is late flowering type (138.56 days for flower opening) followed by Halud and Karnal Pink (135.22 days). Whereas, Bidhan Jayanti (107.78 days) and Bidhan Purna (110.22 days) were early flowering type. Regarding number of flowers per plant, IAH Red produced maximum (385.78) followed by Vanity Pink (341.33) and least in Bidhan Madhuri (105.89). The flower diameter of Himani was maximum (6.25 cm) and minimum in Halud (3.14 cm). In the present study Veena recorded maximum flower weight per plant (981.10 g) followed by Vanity Pink (753.21 g) and minimum in Bidhan Purna (158.62

g). The single, semi-double and small flowered varieties outperformed in terms of numbers of flowers produced per plant. But their individual flower weight is very less than double flower types. Based on the evaluation most of the varieties (especially IAH Red, Magenta, Gauri, Fire Ball, Vanity Pink, Purple Quill, Bidhan Lalima, DFR Pallavi) are suitable for spray type, which can very well be incorporated in beds, border, garden and cut branches.

In another set of experiment on evaluation of spray type of chrysanthemum varieties (41 nos.) in pots, the perusal of data from Table 1.14 revealed that maximum plant height was recorded in Ratlam Selection (86.29 cm) followed by Ravikiran (85.52 cm), whereas it was minimum in Lalpari (52.71 cm). Similarly the plant spread was also maximum in Ratlam Selection (63.12 cm) followed by Jafri (61.00 cm).The number of secondary branches were also maximum in Red Stone, Coffee, HYDC-7 and Shintome (3.78). The variety Bidhan Lalima (151.33 days) was late in flowering, followed by Kargil-99 (147.48 days) and Lalpari (146.22 days); whereas it was early in Autumn Joy (106.00 days). Similarly, maximum number of flowers per plant was recorded in Kargil-99 (96.44) followed by Ratlam Selection (85.89) and least in HYDC-7 (52.33). The flower size of Ravikiran was more (8.61cm), followed by Garden Beauty (7.16 cm) and minimum in Seedling Red (3.20 cm). Based on the evaluation, it can be inferred that the selected spray types (Ravikiran, Ratlam Selection, PAU-66-2, Bidhan Gold, Kargil-99, Autumn Joy and Preet Shringar) can also be grown in pots.

Table 1.13. Evaluation of spray type chrysanthemum in field (2023-24)

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant
Bidhan Jayanti	41.29	42.61	1.33	4.56	75.00	96.67	107.78	130.56	128.22	4.33	42.77	274.20
Bidhan Lalima	58.00	53.50	1.56	4.22	96.11	122.67	133.56	246.22	244.44	4.70	33.71	412.08
Bidhan madhuri	43.32	41.56	1.22	4.89	99.78	126.00	135.56	106.00	105.89	4.18	30.34	160.92
Bidhan Neeta	42.30	41.39	1.33	4.33	84.11	106.78	117.22	145.00	143.67	4.11	36.33	260.82
Bidhan poonam	52.51	51.33	1.33	4.56	78.67	101.00	111.11	179.22	177.56	5.15	34.17	303.58
Bidhan purna	44.11	42.50	1.44	4.56	76.56	99.11	110.22	132.22	130.33	4.16	24.30	158.62
Bidhan shova	60.03	51.83	1.33	4.33	97.00	128.33	138.56	162.56	160.89	5.16	25.99	209.15
Charmish	60.76	63.44	1.44	3.11	84.78	112.78	121.56	242.44	241.00	3.38	27.71	334.15
Coffee	41.78	51.61	1.56	4.89	92.44	119.56	129.00	140.89	139.00	4.18	36.84	256.18
Crocon small	45.22	42.28	1.33	4.00	92.89	115.44	126.89	135.78	135.67	4.13	33.43	226.60
DFR-C-1	103.22	45.56	1.67	4.33	85.78	108.11	117.78	127.56	126.78	4.21	45.33	287.35
Discovery	58.59	56.94	1.33	4.22	95.44	126.11	136.11	232.11	230.67	3.28	30.69	353.96
Draugma	51.68	47.33	1.44	4.56	93.44	122.78	132.22	271.22	269.44	4.17	34.74	468.07
Fire ball	42.36	44.89	1.33	4.44	94.33	116.33	126.56	271.56	269.11	3.24	19.88	267.71
Garden Beauty	61.80	57.56	1.22	4.00	97.00	115.44	125.11	205.22	204.22	4.18	24.36	248.88
Gouri	59.77	52.56	1.33	3.89	85.89	113.89	123.11	263.00	262.11	4.18	33.49	438.94

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant
Haldighati	40.53	32.00	1.56	3.00	80.11	116.67	126.00	129.11	127.89	5.19	33.91	217.18
Halud	42.47	41.72	1.33	4.22	94.56	125.33	135.56	107.22	107.11	3.14	31.22	167.19
Himani	53.33	52.78	1.67	4.22	80.44	101.44	112.78	176.11	174.33	6.25	45.19	393.74
Himani	39.44	42.22	1.33	4.33	84.67	103.11	112.11	191.33	190.00	5.51	42.03	399.44
IAH Red	59.72	53.17	1.44	4.22	91.00	116.00	125.22	387.11	385.78	4.16	34.71	669.16
Karnal pink	41.94	41.78	1.44	4.67	93.78	124.56	135.22	125.44	122.89	4.55	41.42	254.52
Magenta	60.80	52.11	1.33	4.22	81.56	102.89	111.56	215.11	213.67	4.20	20.69	221.09
PAU-35	58.26	52.17	1.22	4.67	78.44	100.78	112.33	255.11	252.22	4.24	43.81	552.38
PAU-66-2	60.90	55.11	1.44	4.22	93.67	120.11	129.00	257.11	256.00	5.16	34.28	438.57
Pink cloud	51.60	52.17	1.33	3.89	90.22	115.11	125.11	116.00	115.11	4.73	31.98	184.12
Preet shringar	42.00	32.39	1.33	3.89	84.33	104.22	113.78	133.78	131.89	4.11	30.98	204.37
Puple qill	72.98	65.11	1.44	4.44	90.44	111.33	122.44	323.22	321.89	5.14	36.00	579.89
sadwin yellow	42.78	41.33	1.33	4.44	83.44	104.78	115.44	129.22	128.56	4.12	35.59	228.50
Scent white	45.88	42.39	1.44	4.67	84.44	102.44	111.22	135.44	133.89	5.15	44.41	297.29
Seema	42.10	42.00	1.33	4.11	96.11	125.00	134.22	142.44	140.00	3.63	49.83	352.16
Vanity pink	60.47	52.50	1.33	4.22	84.56	103.89	112.78	343.44	341.33	4.16	44.13	753.21
Veena	58.94	52.56	1.33	4.78	85.11	105.89	115.00	282.89	280.67	4.73	69.91	981.10
Yellow delight	56.57	45.13	1.33	4.33	85.89	107.00	118.33	243.56	241.67	4.13	24.52	296.32
CV	48.80	2.46	37.11	21.86	1.96	1.52	1.41	2.12	1.95	2.78	32.65	24.38
CD 0.05	23.84	1.10	NS	0.86	1.59	1.58	1.60	3.85	NS	0.11	10.73	78.50

Table 1.14. Evaluation of spray type chrysanthemum for suitability in pots (2023-24)

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)
Anjali	81.82	56.94	1.44	3.33	96.00	120.56	130.67	84.11	82.78	3.94
Anupama	60.44	44.86	1.33	3.44	93.89	116.11	127.44	65.22	63.33	4.70
Autumn joy	72.58	43.78	1.56	3.44	125.44	145.67	155.22	77.22	76.00	6.18
Basanti	61.73	45.27	1.44	3.11	84.78	106.56	118.78	76.78	75.67	4.27
Bc-32-20	58.20	41.08	1.44	3.44	97.89	125.00	134.33	58.44	56.89	4.12
Bidhan gold	62.61	46.39	1.44	3.56	98.11	125.89	136.56	63.56	62.22	6.39
Bidhan lalima	72.59	38.82	1.33	3.44	118.56	140.67	151.33	62.56	61.11	4.58
Brown spoon	82.56	55.57	1.33	3.56	94.33	114.89	124.89	77.56	76.22	5.61
Coffee	62.04	48.53	1.44	3.78	99.67	121.56	132.56	65.00	63.89	5.61

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)
Crocon small	62.29	52.80	1.56	3.33	98.78	119.44	130.44	57.00	55.22	5.56
Garden beauty	72.64	51.94	1.33	3.33	89.78	112.22	123.44	71.89	71.11	7.16
Halud	85.50	56.67	1.44	3.56	95.89	118.00	128.56	67.33	65.22	4.17
Houston	57.08	41.14	1.56	3.56	81.11	103.56	113.78	73.44	71.56	4.76
HYDC 2	66.58	48.64	1.44	3.44	96.11	116.78	126.89	67.22	66.33	3.23
HYDC 4	68.02	52.02	1.33	3.44	96.44	117.33	128.00	77.67	75.78	4.14
HYDC 7	63.33	45.11	1.56	3.78	98.00	123.67	134.22	54.56	52.33	3.33
HYDC 8	69.88	54.39	1.44	3.67	95.44	116.33	127.56	76.22	75.00	5.08
IAH red	62.18	43.33	1.44	3.67	93.44	116.00	126.67	73.67	72.00	4.50
Jafari	83.77	61.00	1.33	3.22	97.44	121.56	135.33	68.22	66.89	4.27
Kargil 99	56.11	43.54	1.44	3.56	111.67	137.67	147.78	98.00	96.44	4.63
Kirti gold	61.89	39.93	1.33	3.33	91.78	113.33	124.22	57.00	55.67	4.58
Lalpari	52.71	41.24	1.33	3.44	115.89	135.67	146.22	55.89	54.78	3.69
Liliput	42.80	33.71	1.44	3.33	83.44	104.89	116.00	74.67	73.44	1.63
Meera	57.26	43.01	1.44	3.44	94.67	115.22	126.11	56.00	54.67	4.16
Paragon yellow	63.33	41.88	1.44	3.44	97.22	118.44	128.56	62.89	61.22	5.31
Pau 66-2	81.20	63.29	1.44	3.44	88.56	116.00	126.89	86.56	85.11	6.78
Purnima red-1	60.81	42.60	1.44	3.22	97.67	121.00	130.56	65.78	64.67	4.18
Preet shringar	65.10	56.72	1.44	3.44	86.44	108.89	120.22	83.78	81.89	4.14
Punjab gold	56.36	37.58	1.56	3.67	93.33	114.89	125.56	69.00	68.11	4.62
Rajahmundry	55.04	46.49	1.44	3.44	93.56	115.67	126.89	75.78	74.44	3.19
Ratlam	86.29	63.12	1.44	3.44	101.33	126.11	136.67	86.78	85.89	5.40
Ravikiran	85.52	53.99	1.44	3.44	92.56	115.67	126.11	72.89	71.78	8.61
Red gold	63.88	40.89	1.33	3.44	95.78	116.78	127.22	66.22	65.00	5.30
Red stone	69.87	51.16	1.44	3.78	93.67	115.11	126.00	76.11	74.56	4.24
Royal purple	72.99	54.72	1.44	3.44	95.89	117.33	127.67	75.44	74.11	5.61
Sabita	66.24	42.14	1.44	3.33	93.78	115.44	126.33	82.22	80.56	5.27
Seedling red	63.84	52.78	1.33	3.56	94.11	116.11	127.56	85.11	82.44	3.20
Seema	62.11	35.90	1.44	3.67	78.67	101.11	110.89	81.67	80.11	4.96
Shintome	65.78	50.72	1.44	3.78	94.11	120.22	130.33	55.67	54.00	4.15
Sugandha	73.38	54.89	1.44	3.78	98.11	123.56	133.44	75.78	74.89	4.17
Yellow SID	85.24	58.54	1.33	3.00	98.22	124.00	134.11	73.89	71.89	7.76
CV	1.89	2.85	13.14	10.04	1.07	1.34	1.39	1.76	1.95	1.20
CD 0.05	2.06	2.23	NS	NS	1.67	2.60	2.93	2.05	2.22	0.09

1.3.3 Pot Chrysanthemum

With increased urbanization, there is a steady increase in demand for chrysanthemum which can be grown in pots. Pot mums, owing to short height that bears more number of flowers per plant is a popular choice. Seven pot mums were evaluated for suitability and a perusal of data from Table 1.15 revealed that the variety Anmol (PAU) (34.11 cm) followed by Pusa Sona (38.28 cm) recorded minimum height. Whereas maximum plant height and plant spread was recorded in Pusa Aditya (84.64 cm and 55.04 cm) followed by Little Pink (59.93 cm and 51.56 cm). Number of secondary branches were more in Little Pink (4.56) followed by Liliput and Pusa Aditya (3.44). The variety Little Pink was early to initiate buds (84.11 days) as well as flower opening (114.67 days), whereas it was late in Mother Teresa (115.56 days and 154.56 days). However number of flowers per plant was recorded maximum in Pusa Sona (226.89) followed by Punjab Mohini (132.22). Pusa Aditya bears attractive large flowers (5.60 cm) and Liliput bears smaller flowers (1.67 cm). All the varieties were highly floriferous. However, based on the compact growth habit, number of flowers per plant, etc the genotypes, Anmol (PAU), Liliput, Punjab Mohini, Pusa Sona, Little Pink, Pusa Aditya and Mother Teresa were suitable for pot culture.

Table 1.15. Evaluation of Potted Chrysanthemum varieties for Growth and Flowering Traits

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)
Anmol (PAU)	34.11	34.50	1.33	2.89	97.00	118.22	128.00	97.44	96.44	3.60
Liliput	44.44	37.07	1.33	3.44	97.22	119.44	131.00	95.33	93.78	1.67
Mother Teresa	58.56	27.77	1.44	3.22	115.56	138.22	154.56	74.11	73.22	3.02
NBRI Little Pink	59.93	51.56	1.33	4.56	84.11	104.78	114.67	91.00	89.78	3.74
Punjab Mohini	42.59	25.77	1.44	3.56	108.44	131.11	144.11	134.00	132.22	2.19
Pusa Aditya	84.64	55.04	1.44	3.44	95.67	117.00	127.56	76.11	75.11	5.60
Pusa Sona	38.28	36.39	1.56	3.22	88.11	115.89	128.33	264.11	262.89	3.98
CV	4.15	4.82	34.40	21.07	1.96	1.82	1.54	4.08	3.88	2.59
CD 0.05	2.04	1.75	NS	0.69	1.82	2.08	1.94	4.60	4.33	0.08

1.3.4 Evaluation of Local collections

Among the collected local accessions for loose flowers, four genotypes were evaluated for growth and flowering. The perusal of data from Table 1.16 revealed that maximum plant height was recorded in Accession 16 (115.12 cm) followed by Accession 11 (71.27 cm) and least in Accession 3 (64.39 cm). The plant spread was more in Accession 16 (54.16 cm) and least in Accession 15 (44.69 cm). Among them the accession 3 was early for bud initiation as well as flowering (86.00 and 117.11 days respectively) and late in Accession 15 (132.67 days and 165.33 days). In terms of flower yield (565.84 g) and number of flowers per plant (176.00), accession 3 was found better compared to others. Therefore, based on evaluation, Accession 3, 11 and 16 were found better for loose flower purpose (Fig. 1.20).

Table 1.16. Evaluation of local accessions of chrysanthemum for growth and flowering (2023-24)

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant
Acc.11 (Purnima)	71.27	51.22	1.44	3.56	101.78	124.00	134.56	174.67	172.44	5.01	49.43	426.03
Acc.3 (Scent white)	64.39	51.53	1.33	3.44	86.00	108.22	117.11	177.00	176.00	5.09	64.31	565.84
Acc 15 (White gem)	67.73	44.69	1.44	3.44	132.67	154.89	165.33	162.78	160.44	5.14	44.49	356.93
Acc 16 (Yellow gem)	115.12	54.16	1.56	3.78	126.00	154.11	162.22	177.44	175.22	5.79	50.92	446.18
CV	2.15	3.86	32.47	13.87	1.54	1.56	1.47	1.31	1.19	1.50	8.99	8.85
CD 0.05	1.67	1.89	NS	NS	1.67	2.05	2.08	2.21	1.98	0.08	4.57	38.63

Acc. 3

Acc. 11

Fig. 1.20. Chrysanthemum Local Accession

DFR Swarna

DFR Megha

Fig. 1.21 DFR Variety

1.3.5 Mutation Breeding in Chrysanthemum

1.3.5.1 Induction of Novel Variation Using Gamma Irradiation

Seven varieties of chrysanthemum were subjected to gamma irradiation (15 Gy) at the facility of BARC, Trombay. One single dose was chosen owing to its maximum mutation capability during our previous years study. The mutated plants were evaluated in comparison with their parents. The data from Table 1.17 clearly revealed restricted vegetative parameters across all the varieties when subjected to irradiation. Also there is delay in bud initiation to flower opening/ flowering. The number of buds produced were also less with small flower size. Colour variation was only observed in Pusa Anmol (Yellow group -11-D : light purple tinge at inner core of petals). The plants are being maintained and observation shall be continued for second year.

Table 1.17. Effect of Gamma Irradiation (15 Gy) on different chrysanthemum varieties for novel trait (2023-24)

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Flower colour	Colour change, if any
Coimbatore semi double (parent)	63.42	44.13	1.33	2.83	60.33	71.17	77.83	61.50	59.50	6.68	Yellow Group -8-B	-
Coimbatore semi double (15 Gy)	55.57	40.30	1.17	2.33	122.00	143.67	152.33	28.33	26.50	6.57	Yellow group-8-A	No change
IAH red (parent)	81.08	43.37	1.33	3.67	93.00	116.50	127.50	74.00	72.17	4.52	RED GROUP-60-A	-
IAH red (15 Gy)	74.25	40.32	1.33	2.67	121.00	142.00	149.67	27.67	26.17	4.08	Red group 60-A	No change
Mother teresa (15 Gy)	42.82	31.08	1.00	2.17	125.17	147.67	155.67	28.50	27.33	2.82	White group -NN-155-A	No change
Mother teresa (parent)	57.37	35.35	1.50	3.17	116.00	138.83	148.67	72.83	72.00	3.15	WHITE Group -NN-155-A	-
Pusa aditya (15 Gy)	43.03	30.58	1.17	2.33	121.00	142.33	150.83	35.17	34.17	4.82	Yellow group -6-B	No change
Pusa aditya (parent)	55.70	44.77	1.33	3.33	95.67	117.17	127.50	75.50	74.50	5.60	Yellow Group -6-B	-
Pusa anmol (15 Gy)	50.05	32.70	1.00	1.50	117.33	139.17	148.33	26.67	25.17	4.75	Red purple group-65-A	Yellow group -11-D (light purple tinge at inner core of petals)

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Flower colour	Colour change, if any
Pusa anmol (parent)	59.80	35.57	1.33	3.17	97.17	119.33	129.00	87.17	85.83	5.25	Red Purple Group -65-A	-
TQP 06 (15 Gy)	61.35	33.20	1.00	1.67	111.17	132.17	141.00	47.17	46.00	6.28	Red Purple Group -70-A	no change
TQP 06 (parent)	72.93	58.55	1.33	3.33	96.67	120.00	129.50	71.00	69.00	6.73	Red Purple Group -70-A	-
Pusa chitraksha (15 Gy)	83.52	31.53	1.00	1.67	142.67	163.33	171.50	41.83	40.83	5.63	Red Purple Group-64-A	no change
Pusa chitraksha (parent)	92.53	49.42	1.50	3.67	118.83	136.50	150.67	85.67	85.17	6.13	Red Purple Group-64-A	-
CV	5.92	3.06	10.18	11.76	0.81	0.74	0.68	2.40	2.42	1.83		
CD 0.05	8.10	2.58	0.27	0.68	1.91	2.07	2.03	2.81	2.76	0.20		

1.3.5.2 Evaluation of isolated Electron Beam mutants

a. Mutants from Pusa Chitraksha

The electron beam induced (EB) mutants were evaluated for consistency of growth and flowering. Analysis of data from Table 1.18 revealed that all the three mutants were stable and consistently performed well. Regarding plant height and plant spread, the mutant DFR-C-EB-1 recorded 66.20 cm and 51.76 cm respectively. Whereas, it was least in DFR-C-EB-3 (55.32 cm and 42.07 cm respectively). DFR-C-EB-1 was early in flower bud initiation (115.11 days), bears more number of flowers per plant (568.78) with flower size of 6.23 cm. The lines DFR C EB-1, DFR C EB-2 and DFR C EB-3 with single type of flowers and have the ability to attract more pollinators are suitable for garden and pot purpose.

Table 1.18. Evaluation of isolated electron beam mutants from cv. Pusa Chitraksha

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
DFR-EB- C-1	66.20	51.76	1.56	3.56	115.11	134.89	146.22	575.44	568.78	6.23	31.68	900.92	RED PURPLE GROUP -72-A
DFR-EB- C-2	64.30	49.64	1.56	3.78	120.00	136.33	149.56	501.44	497.22	6.08	32.82	816.59	RED GROUP-53-A (Red colour flower during opening ,outer petals looks yellowish,inner petals red colour)

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
DFR-EB- C-3	55.32	42.07	1.56	3.67	119.56	135.00	146.22	524.00	520.56	6.07	31.68	823.14	WHITE GROUP -NN-155-C (purple tinge at the tip of the petals)
Pusa Chitraksha	63.70	48.97	1.56	3.78	119.44	135.56	149.67	505.11	502.78	6.12	34.01	855.07	Red Purple Group-64-A
CV	1.87	1.91	12.37	6.38	0.70	0.93	1.32	1.71	1.72	0.70	2.78	3.74	
CD 0.05	2.20	1.73	NS	NS	1.57	NS	NS	16.97	16.90	0.08	1.71	59.83	

b. Mutants from Pusa Aditya

The EB mutants from Pusa Aditya were evaluated for ascertaining the stability of the variations observed. The agromorphic traits are presented in Table 1.19 clearly revealed the stability of flower colour and other traits. Although, the plant height was recorded minimum in DFR EB-C-4 (65.13 cm), but number of flowers per plant (92.11) and flower diameter (6.19cm) was more. It is almost resembling with the parent vegetatively except flower colour which is red with yellow tinge at the end of petal, whereas parent was yellow. It was found suitable for pot culture as well as garden use.

Table 1.19. Evaluation of isolated electron beam mutants from cv. Pusa Aditya

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
DFR-EB-C-4	65.13	53.04	1.67	3.67	115.33	134.22	145.44	93.22	92.11	6.19	36.29	167.09	RED GROUP -42-C (RED PETALS, LITTLE YELLOW TINGE AT THE END OF PETAL)
Pusa Aditya (Parent)	84.64	55.04	1.44	3.44	95.67	117.00	127.56	92.78	90.67	5.60	36.09	163.66	Yellow Group -6-B
CV	1.34	2.47	17.50	7.66	1.14	1.22	0.79	2.49	2.41	0.23	3.17	3.94	
CD 0.05	2.28	NS	NS	NS	2.72	3.48	2.43	NS	NS	0.03	NS	NS	

c. Mutants from Thai Chen Queen

The electron beam mutant, DFR-EB-C-5 isolated from Thai-Chen-Queen were evaluated in pot to ascertain the stability. Both the parent and mutant are almost resemble each other, but mutant is early in flowering (145.11 days) and bears a greater number of flowers per plant (72.78 nos.) (Table 1.20). The mutant is suitable as standard chrysanthemum.

Table 1.20. Evaluation of isolated electron beam mutants from cv. Thai Chen Queen

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
DFR-EB-C-5	62.72	54.03	1.56	3.78	109.56	132.22	145.11	74.44	72.78	8.60	121.56	442.34	Yellow orange group - 19-A
Thai-Chen-Queen (Parent)	69.73	57.57	1.56	3.56	142.56	165.00	175.33	62.11	60.22	8.76	121.26	365.11	Orange group - 26-B
CV	2.29	1.54	12.37	5.25	1.37	0.62	0.78	1.23	1.10	0.31	0.61	1.36	
CD 0.05	**3.44**	**1.95**	**NS**	**NS**	**3.91**	**2.09**	**2.84**	**1.90**	**1.66**	**0.06**	**NS**	**12.41**	

d. Mutants from Accession 5

Three EB mutants isolated from Accession 5 were evaluated and presented in Table 1.21. Though the plant height (58.51 cm) and plant spread (71.50) was more in parents but number of flowers per plant was minimum (52.89). The mutants resemble almost with the parents except for flower colour, which is yellow. The flowers are suitable for loose flower production.

Table 1.21. Isolation and evaluation of Electron Beam Mutants suitable for loose flower from Acc. 5

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
Acc 5 (parent)	58.51	71.50	1.56	3.00	92.00	117.11	128.89	55.67	52.89	8.03	44.72	118.29	White Group -NN-155-B (Inner central petals yellow colour tinge)
Acc. 5 (20 Gy EB)	53.78	43.69	1.56	3.11	95.11	118.11	127.78	56.00	54.78	6.49	44.83	122.90	Yellow Group-6-B
Acc 5 (25Gy EB)	54.79	42.48	1.56	3.11	96.22	118.67	128.67	56.11	55.22	6.49	45.11	124.57	Yellow Group-6-B
Acc. 5 (15 Gy EB)	54.79	42.48	1.56	3.11	96.22	118.67	128.67	56.22	54.33	6.49	49.00	132.98	Yellow Group-6-B
CV	**2.11**	**2.46**	**12.37**	**12.09**	**1.44**	**2.18**	**1.44**	**4.81**	**3.50**	**1.80**	**2.90**	**4.69**	
CD 0.05	**2.20**	**2.31**	**NS**	**NS**	**2.57**	**NS**	**NS**	**NS**	**NS**	**0.23**	**2.06**	**NS**	

EB Mutant from Acc 5 (20 Gy)

EB Mutant from Acc 5 (25 Gy)

DFR-EB-C-4

DFR-EB-C-3

Bud Sport from DFR-EB-C-1

Bud Sport from DFR-EB-C-1

Fig. 1.22A Mutants from chrysanthemum

EB mutant (25 Gy) from Punjab Mohini

Gamma Mutant (15 Gy) from Pusa Anmol

Fig. 1.22B Mutants from chrysanthemum

e. Mutants from cv. Punjab Mohini

The data presented in Table 1.22 revealed that the isolated mutant resembles with the parent except the flower colour. The mutant has good plant spread (34.31 cm), number of secondary branches (3.11) and early in flower opening (141.11). Regarding number of buds and flowers, it is non-significant. Based on overall assessment the plants are suitable for pot culture.

Table 1.22 Isolation and evaluation of Electron Beam Mutant suitable for pot culture from Punjab Mohini

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branch	No. of secondary branch	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Flower Colour
Punjab mohini (25 Gy-EB)	45.38	34.31	1.44	3.11	109.56	130.89	141.11	59.44	58.00	2.23	Yellow Group-9-A
Punjab Mohini (parent)	42.59	25.77	1.44	3.56	108.44	131.11	144.11	62.00	58.56	2.19	White Group - NN-155-A
CV	1.77	0.92	13.32	13.54	0.41	0.71	0.27	2.59	2.84	0.62	
CD 0.05	1.76	0.63	NS	NS	1.02	NS	0.87	NS	NS	0.03	

f. Mutants from cv. Bidhan Lalima

The EB mutants from Bidhan Lalima (at 25 Gy) was stable (Flower colour). However, all other traits resembling with that of parent. The plant height of the mutant is 1.6 cm less that of parent. However, it was early in bud initiation (85.44 days), days to flower opening (121.44 days) and bears more number of flowers per plant (62.11) (Table 1.23). Based on the evaluation, it was found suitable for cut spray as well as garden display.

Table 1.23. Isolation and evaluation of Electron Beam Mutant suitable for Landscaping from Bidhan Lalima

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
Bidhan lalima 25 Gy EB)	63.91	45.67	1.56	3.33	85.44	106.89	121.44	63.56	62.11	5.34	31.24	97.01	Yellow orange group 15- B
Bidhan lalima (parent)	65.51	53.66	1.33	3.22	98.33	119.78	131.44	62.33	58.00	5.37	31.06	90.13	Red Group - 42-C
CV	0.77	1.89	9.42	8.30	1.41	0.97	1.19	6.48	6.70	1.82	0.65	7.12	
CD 0.05	1.13	2.13	NS	NS	2.94	2.49	3.41	NS	NS	NS	NS	NS	

1.3.5.3 Evaluation of isolated Gamma mutants

The gamma ray induced mutant (DFR-GM-C-1) isolated from Accession 3 was evaluated and the data is presented in Table 1.24 revealed that plant height (73.19 cm), plant spread (55.86 cm), number of secondary branches per plant (4.44) and flower diameter (5.22 cm) were more in mutant. However, flowering was late (163.22 days) in mutant. The yield of flower is 526.29 g per plant which is comparable with that of parent. Thus based on evaluation the said mutant is suitable for loose flower purpose.

Table 1.24. Evaluation of isolated Gamma ray induced mutants from Acc. 3

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Weight of flowers (20 nos.)	Yield of flowers per plant	Flower Colour
DFR-GM-C-1	73.19	55.86	1.56	4.44	134.67	154.67	163.22	203.56	200.67	5.22	52.44	526.29	YELLOW GROUP - 9-A
Acc. 3 (Parent)	64.72	51.71	1.44	3.56	86.56	108.67	117.00	207.22	202.67	5.11	52.67	533.59	White Group - NN-155-B (Inner central petals yellow colour tinge)
CV	2.24	2.75	12.83	4.81	1.19	0.36	0.19	3.57	3.28	1.09	1.04	3.61	
CD 0.05	3.50	3.35	NS	0.44	2.99	1.07	0.62	NS	NS	NS	NS	NS	

1.3.6 Evaluation of bud sports

The bud sports isolated from the variety DFR-Pallavi (parent) was evaluated and found that plant height (78.03 cm), plant spread (55.89 cm), number of secondary branches per plant (3.22) and number of flowers per plant were found better in DFR-BS-C-1 when compared to its parent. However, the parent is early in flowering (115.11 days) with flower size (4.58 cm) (Table 1.25). The flower of bud sport is pompon type which is suitable for cut spray/ cut flower.

Table 1.25. Evaluation of bud sport from DFR Pallavi

Particulars	Plant Height (cm)	Plant Spread (cm)	No. of primary branches	No. of secondary branches	Days to bud initiation	Days to colour Break	Days to flower opening	No. of buds per plant	No. of flowers per plant	Flower diameter (cm)	Flower Colour
DFR-C-BS-1	78.03	55.89	1.56	3.22	133.44	150.33	165.22	191.89	187.89	4.39	ORANGE RED GROUP -N - 34-C
DFR Pallavi (Parent)	73.97	55.72	1.22	2.67	81.22	101.78	115.11	181.56	174.56	4.58	Purple Group - 77-B
CV	0.75	3.18	13.86	18.49	1.33	4.41	0.36	2.56	2.52	1.82	
CD 0.05	1.30	NS	NS	NS	3.24	12.61	1.15	NS	10.34	0.18	

1.3.7 Evaluation of chrysanthemum genotypes for drought tolerance at the flowering stage

Drought is one of the major abiotic stresses that negatively affect chrysanthemum growth and development, thus reducing its yield and productivity. In the current study, we aimed to evaluate the drought tolerance of thirty-seven chrysanthemum genotypes based on the phenotypic, physiological and yield contributing traits.

Fig. 1.23 Abiotic Stress Study in Chrysanthemum at rain-shelter facility of DOGR

The experiment was conducted under controlled rainout condition facility available at ICAR-DOGR, Pune. In this study, cuttings of each genotype (one month old) were exposed to two treatments (well-watered and water deficit stress). Rooted cuttings were planted in a randomized block design in three replications with two plants per replication. The plants were exposed to drought stress at 50% flowering stage for 25 days continuously. Throughout the stress period plants were monitored for their growth and survival under deficit irrigation condition. Based on plant mortality as the stress period progresses, it was found that the genotype Bidhan Gold was found to be highly sensitive to drought stress with 100% plant mortality followed by genotype Vanity Pink (33% plant mortality), DFR-EB-2 (17% plant mortality), OPCH Pink Double (17% plant mortality), among the studied genotypes. The above mentioned sensitive genotypes failed to produce flowers and the buds and flowers that are already produced before imposing stress also got withered as the drought stress progressed. Whereas, about 65% of the studied genotypes recorded 100% survival under drought stress. The genotypes were also evaluated based on the number of flowers produced and their weight after imposing water deficit stress compared to well water condition.

In this study, certain genotypes were categorized as drought tolerant genotype as they produce more number of flowers with high flower weight under drought stress compared to control condition. Based on this the

genotypes viz. Coimbatore Semi-double (171%), Gauri (103%), Silk Brocade (111%) and Cherabu (41%) were identified as a drought tolerant genotypes with maximum flower weight under drought stress condition compared to control (well-watered condition). The method established in the current study provides a reference for the rapid identification of drought tolerance in chrysanthemum genotypes, and the highly drought-tolerant genotype identified herein helps in widening the genetic base for breeding chrysanthemum cultivars with desirable drought tolerance traits.

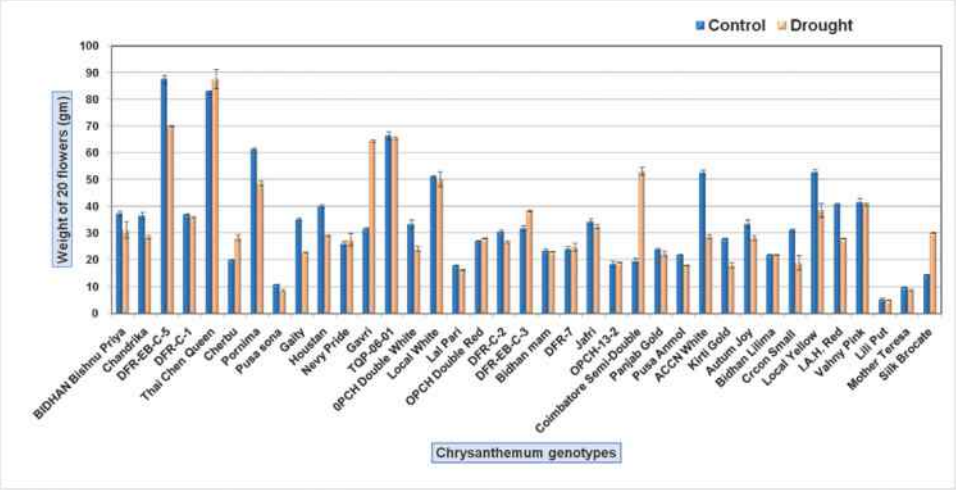


Fig.1.24: Effect of drought stress on chrysanthemum flower yield

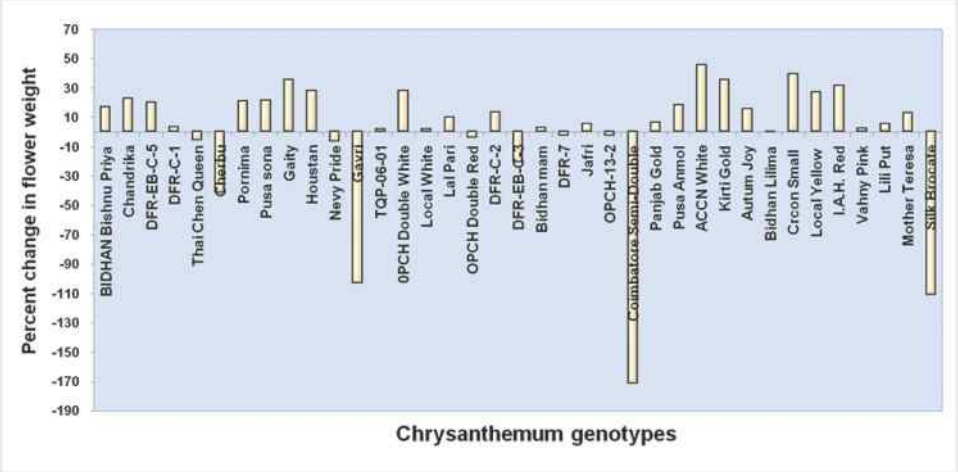


Fig. 1.25: Effect of drought stress on chrysanthemum flower weight

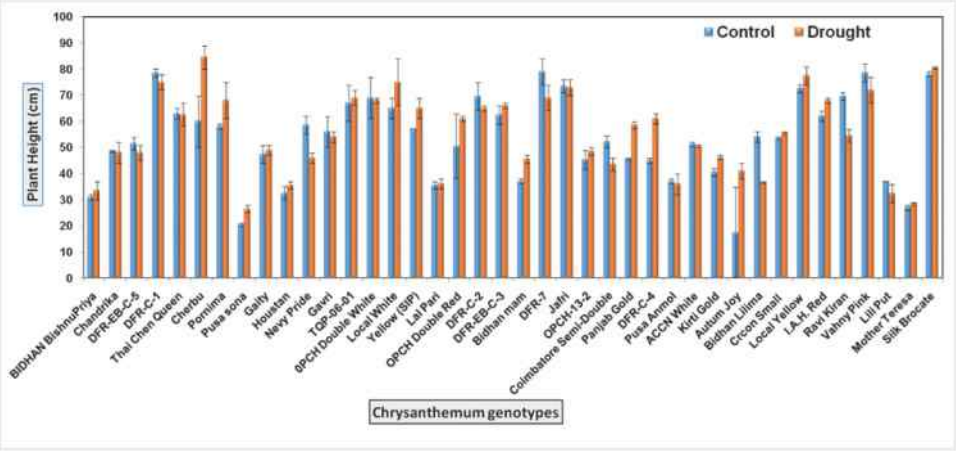


Fig. 1.26: Effect of drought stress on plant height in chrysanthemum genotypes

1.4 Project 04 (ICAR Code No: IXX 14255): Improvement of Rose for Commercial Traits

1.4.1 Germplasm Collection

A total of 212 genotypes of rose under different category are maintained at ICAR-DFR Research Farm (Table 1.26). The germplasm comprises of eight wild species *Rosa brunonnii, Rosa bournoniana, Rosa canina, Rosa damascena, Rosa indica, Rosa multiflora, Rosa moschata* and *Rosa sericea*. *Rosa indica, Rosa multiflora*, Rose Nishikant are being used as a rootstock.

Table. 1.26 Rose germplasm collected and maintained at ICAR-DFR, Pune

Sr no	Name	Sr no	Name	Sr no	Name	Sr no	Name	Sr no	Name	Sr no	Name
1.	Abhisarika	37.	Blue Moon	72.	Etoile de Hollande	107.	Just Joey	142.	Negerette	177.	Rio Samba
2.	Abhishek	38.	Bonnenuit	73.	Ferry Porsche	108.	Kakinada	143.	Neptune	178.	Rock Star
3.	Avalanche	39.	Bora Bora	74.	.Figaro	109.	Karen Blixen	144.	Night Time 5	179.	*Rosa brunonnii*
4.	Ahalya	40.	Bordo	75.	Firelight	110.	Karl Harbest	145.	Noblese	180.	*Rosa canina*
5.	Akebono	41.	Botero	76.	First Prize	111.	Karl Herbst	146.	Northern Light	181.	Rosa Cheii
6.	Alliance	42.	Branddenburg Gate	77.	Flirticious	112.	Khushali	147.	Oklahoma	182.	*Rosa damascena*
7.	Almondeen	43.	Bronze star	78.	Folklore	113.	Kiss of Fire	148.	Orange Babe	183.	*Rosa indica*
8.	Altesse	44.	Bugatti	79.	Fragrant Dream	114.	Local Accession 2	149.	Paradise	184.	*Rosa multiflora*
9.	American Heritage	45.	Camara	80.	Fragrant Mauve	115.	Local Accession 3	150.	Peach Avelanche	185.	*Rosa moschata*
10.	Amtestista	46.	Cardinal	81.	Fragrant Plum	116.	Local Accession 4	151.	Pink Montezuma	186.	Rose Nishikant
11.	Andrea Stelzer	47.	Carmosine	82.	Freedom	117.	Lady X	152.	Pink Panther	187.	*Rosa webbiana*
12.	Apricot Spice	48.	Carvetty	83.	Friendship	118.	Lalima	153.	Pink Promise	188.	Rose Sherbet
13.	Arjun	49.	Catalonia	84.	Garak	119.	Little Buckaroo	154.	Pink Rajat	189.	Roter Stren
14.	Arka Ivory	50.	Charisma	85.	George Burn	120.	Local Accession 1	155.	Preference	190.	Rough Royale
15.	Arka Kinnari	51.	Charles Mallerin	86.	Gladiator	121.	Loree	156.	Preyasi	191.	Royal Canadian
16.	Arka Parimala	52.	Charleston	87.	Gold Medal	122.	Love	157.	Prince Clause	192.	Ruby Pink
17.	Arka Pride	53.	Christian Dior	88.	Gold Strike	123.	Madam Delbard	158.	Princess de Manaco	193.	Sadabahar
18.	Arka Savi	54.	53.Coffee Home	89.	Gonda	124.	Madam Violet	159.	Pusa Abhishek	194.	Scarlet Night
19.	Arka Sharmilly	55.	Command Performance	90.	Granada	125.	Mahadani	160.	Pusa Alpana	195.	Scented Night
20.	Arka Sinchana	56.	Cryzia	91.	Grand Opera	126.	Manasi	161.	Pusa Arun	196.	Sensation
21.	Arka Sukanya	57.	Dean De Pointer	92.	Helmut Scmidt	127.	Marcipols	162.	Pusa Bahadur	197.	Sentaeur Royal
22.	Arka Swadesh	58.	Derek Nimmo	93.	High Esteem	128.	Marianne Tudor	163.	Pusa Gaurav	198.	Sentimental
23.	Arunima	59.	Diamond Jubilee	94.	Himangni (Hemangni)	129.	Mattgod	164.	Pusa Mahak	199.	Shriniwasa
24.	Autumn	60.	Double Delight	95.	Hot Pewter	130.	Mirandy	165.	Pusa Manhar	200.	Skyline
25.	Avemaria	61.	Dr. Bhartram	96.	Iceberg	131.	Miss Elizabeth	166.	Pusa Muskan	201.	Local Accession 5 (Solapur)
26.	Azuresea	62.	Dr. Gold Berge	97.	Ico Delight	132.	Monsterima	167.	Pusa Shatabdi	202.	Soma
27.	Babylone	63.	Dr. GSR	98.	Inge Horstman	133.	Montezuma	168.	Pusa Sonora	203.	Sophia

Table. 1.26 Rose germplasm collected and maintained at ICAR-DFR, Pune

Sr no	Name	Sr no	Name	Sr no	Name	Sr no	Name	Sr no	Name	Sr no	Name
27.	Babylone	63.	Dr. GSR	98.	Inge Horstman	133.	Montezuma	168.	Pusa Sonora	203.	Sophia
28.	Bahurupi	64.	Dream Time	99.	Jadis	134.	Montreal	169.	Queen Elizabeth	204.	Strawberry
29.	Barbarabush	65.	Dnyandev	100.	Jaleshwari	135.	Moon Stone	170.	Radhanath	205.	Strawbery Ice
30.	Barklore	66.	Duke Of Windsor	101.	Jantar Mantar	136.	Mr. Lincoln	171.	Radharani	206.	Sugandha
31.	Barrone e de Rothschild	67.	Eaparic De Milland	102.	Jass	137.	Mrinalini	172.	Radharani	207.	Summer Fragarance
32.	Bedami	68.	Echo	103.	Jawani	138.	Narangi	173.	Raktagandha	208.	Summer snow
33.	Beverly	69.	Eduard	104.	Jogan	139.	Natal blex	174.	Raktima	209.	Sunfire
34.	Bewitched	70.	Eiffel tower	105.	John F Kenndy	140.	Neela	175.	Remember	210.	Super Star
35.	Big Chief	71.	Elvis	106.	Jumiliya	141.	Neelambri	176.	Revival	211.	Survi
36.	Sweet India	72.	Sweet Surrender	107.	Sweetness	142.	Taj Mahal	177.	Tiffany	212.	Swami Ranganathnanda

1.4.2 Germplasm evaluation for loose flower production

Thirty rose (*Rosa* × *hybrida* L.) genotypes were evaluated for important economical traits under open field conditions and data is presented in Table. 1.27. The taller plants were recorded in genotype Rose Sherbet (156.8 cm), followed by Edward (154.8 cm), Folklore (147.3 cm), Acc. No-3 (132.2 cm), Juleshwari (120.0 cm), Queen Elizabeth (117.6 cm) Kakinada (116.3 cm), Acc No 5 (116.1 cm) and Pusa Alpana (114.7 cm). Similarly wide spread plants and good branching were observed in genotypes Rose Sherbet (218.3 cm and 19.89), Acc No 3 (219.9 cm and 22.44), Kakinada (211.1cm and 11.44) and Edward (251.0 cm and 25.00).

For loose flower production the fragrance and number of petals per flower are important trait. The fragrant genotypes have more acceptance in the market however the petals shattering is a major problem with most of fragrant genotypes. Therefore, efforts were made to identify the genotypes having fragrance and petal shattering. Genotypes like Acc. No-3 (70.78) and Kakinada (73.00) were found with more number of petals per flower. The genotype Rose Sherbet and Pusa Alpana have fragrance and less petals shattering. The genotype Acc. No-3 and Kakinada, Rose Sherbet, Pusa Alpana, Acc. No-5 and Edward were found with extended duration of flowering.

The genotypes Rose Sherbet, Pusa Alpana, Acc. No-3, Acc. No-5 and Kakinada were found to be suitable for loose flower production. The perpetual flowering was also observed in these genotypes which is most desired trait for commercial cultivation.

Table. 1.27 Evaluation of rose genotypes for loose flower production

Sr no	Variety Name	Plant Height (cm)	Plant Spread (cm)	No of Branches	Bud Length (cm)	Bud Diameter (cm)	Flower Diameter (cm)	Flower stalk Length (cm)	Flower Stalk Dia (cm)	No of petals per flower
1.	Arka Sharmeeli	105.4	186.1	6.89	2.15	1.70	7.99	4.87	0.85	35.22
2.	Pusa Alpana	114.7	161.9	8.11	2.27	1.44	7.47	5.00	0.76	40.44
3.	Rose Sherbet	156.8	218.3	19.89	2.00	1.18	7.24	4.40	0.22	43.33
4.	Ice Berg	88.7	209.0	5.89	1.97	0.94	6.21	4.50	0.33	30.56
5.	Loree	110.7	169.0	7.44	1.99	1.09	5.49	3.81	0.20	54.44
6.	Acc No 3	132.2	219.9	22.44	1.80	1.63	7.28	4.75	0.77	70.78

Sr no	Variety Name	Plant Height (cm)	Plant Spread (cm)	No of Branches	Bud Length (cm)	Bud Diameter (cm)	Flower Diameter (cm)	Flower stalk Length (cm)	Flower Stalk Dia (cm)	No of petals per flower
7.	Kakinada	116.3	211.1	11.44	1.54	1.13	6.29	3.27	0.23	73.00
8.	Acc No 4	90.0	154.3	7.11	1.58	1.03	4.92	5.04	0.20	27.22
9.	Acc No 5	116.1	202.1	10.56	2.27	1.27	6.93	3.84	0.22	47.78
10.	Edward	154.8	251.0	25.00	1.88	1.13	6.30	2.93	0.26	41.44
11.	Bonne nuit	98.5	201.0	8.67	2.43	1.36	9.39	7.60	0.32	22.67
12.	Manasi	103.6	242.3	6.11	2.04	1.10	6.62	3.57	0.33	19.44
13.	Arunima	80.0	171.4	6.33	1.64	1.02	5.24	3.81	0.20	68.89
14.	Hemangini	74.4	168.8	5.56	1.98	1.16	5.97	3.78	0.23	50.67
15.	Ahilya	86.3	256.6	7.33	1.43	0.82	5.53	3.81	0.20	17.00
16.	Pusa Abhishek	77.5	130.7	5.22	2.62	1.29	7.79	5.78	0.31	22.67
17.	Ferry Porsche	108.4	147.3	4.22	2.36	1.33	8.37	6.88	0.38	52.00
18.	Kiss of Fire	89.8	147.3	4.22	2.36	1.33	8.37	6.88	0.38	52.00
19.	Superstar	78.0	124.0	3.33	2.14	1.20	7.60	3.60	0.38	24.78
20.	Abhisarika	82.3	124.0	3.33	2.14	1.20	7.60	3.60	0.38	24.78
21.	Pusa Muskan	91.2	173.4	7.78	2.74	1.46	6.61	5.49	0.28	21.78
22.	Sweet India	97.6	182.3	4.56	2.76	1.39	8.68	7.10	0.40	43.78
23.	Elvis	81.9	118.1	4.22	1.74	1.37	7.46	5.03	0.40	34.67
24.	Sadabahar	75.1	162.4	7.22	1.97	1.06	7.31	4.19	0.20	27.67
25.	Juleshwari	120.0	145.8	5.11	1.68	1.17	6.18	6.19	0.37	62.78
26.	Queen Elizabeth	117.6	133.9	4.00	5.09	1.32	8.80	8.84	0.34	38.44
27.	Rough Royal	84.4	150.0	6.89	2.36	1.42	8.48	6.26	0.36	55.78
28.	Stealthy Kiss	55.3	87.8	6.11	2.26	1.19	8.14	8.33	0.36	33.89
29.	Folklore	147.3	233.9	9.44	2.56	1.83	9.01	9.24	0.78	29.39
30.	Raktima	80.4	142.7	7.78	2.62	1.89	9.49	9.67	0.78	28.78
	SE(m)	5.02	9.23	0.58	0.44	0.03	0.17	0.28	0.02	2.23
	CD (P)=0.05	14.20	26.13	1.63	1.23	0.09	0.48	0.78	0.05	6.32

1.4.3 Evaluation of rose genotypes for value addition

Based on the flower characteristics like flower colour, number of petals and perpetual flowering ten genotypes (Local Accession-1, Local Accession-3, Local Accession-4, Edward, Rose Sherbet, Neptune, Night Time, Royal Canadian, Pusa Bahadur and Christian Dior) were identified and evaluated for value addition purpose. The biochemical parameters like Anthocyanin (mg/l), total Flavonoids (mg/g), total Phenols (mg GAE/g), antioxidant activity (%), protein (mg/g),TSS (°Brix), moisture (%) and ash(%) was estimated. Based on the estimation of biochemical parameters genotype Rose Sherbet were found to be with higher anthocyanin content (68.29 mg/l) and antioxidant activity (66.53 %) and also found rich in total phenols (33.97 mg GAE/g) content. Genotype Local Accession-4 were found to be rich in total flavonoids content (8.65 mg/g). Royal Canadian genotype found with maximum content of protein (2.99 mg/g) and TSS (10.48°Brix) (Table 1.28).

Table. 1.28 Evaluation of biochemical parameters of rose genotypes

Treatment (Varieties)	Anthocyanin (mg/l)	Total Flavonoids (mg/g)	Total Phenols (mg GAE/g)	Antioxidant Activity (%)	Protein (mg/g)	TSS (°Brix)	Moisture (%)	Ash (%)
Local Accession-1	60.67	6.14	31.24	66.49	2.20	9.42	81.51	3.62
Local Accession-3	28.29	5.97	27.23	66.21	1.86	9.35	83.04	3.62
Local Accession-4	41.82	8.65	23.58	65.18	1.83	8.97	82.54	4.01
Edward	12.22	3.42	21.75	65.53	1.66	9.53	82.67	4.25
Rose Sherbet	68.29	4.33	33.97	66.53	1.82	9.20	81.14	3.43
Neptune	51.79	3.90	31.51	66.06	2.43	9.52	82.93	2.92
Night Time	65.68	4.96	31.69	66.54	2.39	9.35	83.17	4.13
Royal Canadian	39.51	3.31	39.66	67.38	2.99	10.48	80.95	3.58
Pusa Bahadur	53.22	5.62	26.29	65.76	1.88	10.35	80.52	2.89
Christian Dior	52.55	3.50	28.07	65.81	1.78	9.43	81.18	4.06
SE(m)	0.58	0.03	0.55	0.11	0.03	0.22	0.30	0.06
CD at 5%	1.73	0.09	1.63	0.32	0.11	0.66	0.90	0.17

1.4.4 Hybridization

The parents were identified based on the seed setting behavior and used for hybridization. In 2023 extensive crossing was carried out among selected parents and presented in Table. 1.29. The hybrid seeds harvested from previous season were germinated and seedlings are being raised. The hybrid seeds of current season were harvested and kept for stratification treatment.

Table. 1.29 Crossing among selected parents in rose

Sr. No.	Female x Male	Sr. No.	Female x Male
1.	Christian Dior × Pusa Bahadur	17.	Royal Canadian × Summer fragrance
2.	Rose Sherbet × Christian Dior	18.	Pusa Arun × Cardinal
3.	Rose Sherbet × Pusa Bahadur	19.	Christian Dior × Jantar Mantar
4.	Rose Sherbet × Pusa Arun	20.	Gold Strike × Christian Dior
5.	Gold Strike × Raktima	21.	Gold Strike × Bonne Nuit
6.	Raktima × Christian Dior	22.	Gold Strike × Oklahoma
7.	Rose Sharbet × Bonne Nuit	23.	Double Delight × Raktima
8.	Rose Sherbet × Oklahoma	24.	Double Delight × Oklahoma
9.	Raktima× Bonne Nuit	25.	Pusa Muskan × Night Time
10.	Raktima × Bonne Nuit	26.	Night Time × Royal Canadian
11.	Oklahoma× Bonne Nuit	27.	Neptune × Pusa Muskan
12.	Christian Dior × Oklahoma	28.	Summer Fragrance × Arka Parimala
13.	Pusa Bahadur × Rose Sherbet	29.	Summer Fragrance × Black Lady
14.	Christian Dior × Blue moon	30.	Summer Fragrance × Bonne Nuit
15.	Christian Dior × Bonne nuit	31.	Christian Dior × Oklahoma
16.	Christian Dior × Edward	32.	Christian Dior × Night Time

1.5 Project 5 : Improvement of marigold for commercial trait

1.5.1 Germplasm collection, maintenance, and evaluation

Two African marigold genotypes, namely DFR M Acc-1 and DFR M Acc-2, were collected from Hajo village, Assam, and added to the existing marigold germplasm collection. In 2023, a total of 27 genotypes, which included 23 African and 4 French marigold genotypes, were evaluated for 10 morphological and yield traits. The data recorded on all 10 traits studied were presented in Table 1.30 for African marigold genotypes and Table 1.31 for French marigold genotypes. Maximum plant height of 85.80 cm was observed in Serocole, and a minimum plant height of 44.70 cm was observed in KAU M-46. The largest plant spread north-south of 78.10 cm was found in DFR HM-1, while the smallest plant spread north-south of 39.80 cm was observed in KAU M-1. The highest and lowest plant spread east-west of 77.90 and 40.50 cm were reported in DFR M-2 and KAU M-1, respectively.

KAU M-46 had the earliest flower bud initiation after transplantation, taking only 45.30 days. On the other hand, the longest days for flower bud initiation were noticed in BRMG-113, which took 60.20 days. Similarly the time taken for flower bud initiation, KAU M-46 also exhibited the earliest flowering, reaching a fifty percent flowering time in 52.60 days after transplantation. Genotype KAU M-2 took the longest time, 72.60 days, to reach fifty percent flowering after transplantation. The number of primary branches per plant was higher in DFR HM-1 (7.10) and lower in KAU M-46 (3.10). Arka Shubha had the highest number of secondary branches, which was 19.10. On the other hand, DFR M-12 had the lowest number of secondary branches, which was 7.90.

The Serocole produced the highest number of flowers per plant with 75.10, while the AAU M-4 produced the lowest number with 50.90. The Raipur AM Local had the largest flower diameter, measuring 6.90 cm and the smallest flower diameter was observed in KAU M-46, which measured 3.80 cm. The highest flower yield per plant was 450.50 g reported in the Serocole, and the lowest was 260.10 g in the AAU M-4. Flower yield and the number of flowers per plant are important traits to consider when selecting genotypes for breeding programs and varietal identification in marigold. More flowers per plant were reported in genotypes Serocole (75.10), followed by DFR HM-1 (71.90), KAU M-2 (71.70), and DFR M-2 (70.10). The highest flower yield per plant was in Serocole (450.50 g), followed by DFR HM-1 (445.90 g), Arka Abhi (440.20 g), and DFR M-2 (435.90 g). Uniform flower type (petaloid flower type) was observed in five hybrid marigold genotypes, namely Arka Abhi, Arka Vibha, Arka Bhanu, Arka Shubha, and DFR HM-1.

1.5.2 Identification of male sterile lines

1.5.2.1 Inbred lines (Single flower type) – Homozygous inbred lines viz., DFR OPP-1 (Fig. 1.27), DFR OPP-2, DFR OPP-3, DFR OPP-4 and DFR OPP-5 were developed by repeated selfing of single flower type plants derived from gyno monoecious parents, and all five inbred lines have orange-coloured flowers. These inbreds lines can be used as a pollen parent in the development of F1 hybrids.

1.5.2.2 Apetalous male sterile line (DFROAPMs-1) – Apetalous line DFROAPMs-1 (Orange colour) with capitulum composed of degenerated petals and stamens (Fig. 1.28) was identified and characterized in marigold. This male sterile line upon crossing with maintainer line produces both fertile and sterile progenies in the ratio of 1:1, so we classified that male sterility in this line is controlled by nuclear genes i.e. gene male sterility in recessive gene condition. This type of genetic male sterility was already reported by many researchers in marigold.

1.5.2.3 Petalous male sterile line (DFROPMs-1)- Similar to apetalous male sterility, one more unique type of male sterility, i.e., petaloid sterile line, was identified and selected from the genotype Serocole. The capitulum of DFROPMs-1 is composed of only ray florets and propagated through vegetative means. This type of petalous male sterile line can be used for the development of F1 hybrids.

1.5.2.4 Development of F1 Hybrid (DFR HM-1)

DFR MH-1 is an F1 hybrid (Fig. 1.29) developed by using DFROPMs-1 as a seed parent and DFR OPP-1 as a pollen parent. This unique F1 hybrid produces only petalous flowers with significantly more flower yield (445.90 g) per plant.

Fig 1.27 DFR OPP-1 (Inbred line with single flower type)

Fig. 1.28 DFROAPMs-1 (Apetalous male sterile line with degenerated stamens and petals)

Fig. 1.29 DFROPMs-1 (Petalous male sterile line)

Table 1.30. African marigold (*Tagetes erecta*) evaluated for morphological and yield traits

Sl. No.	Genotypes	PH (cm)	PS (N-S) cm	PS (E-W) cm	DFB	DFF	NPB	NSB	NFP	FD	FY
1	Arka Abhi	84.50	55.20	56.20	49.50	59.50	8.10	15.10	67.90	5.50	440.20
2	Arka Bhanu	82.60	47.80	52.60	48.50	61.20	4.90	14.60	65.50	5.20	410.30
3	Arka Vibha	70.60	52.10	55.70	50.20	59.30	3.80	18.90	61.90	5.30	399.70
4	Arka Shubha	71.20	47.20	49.80	46.90	54.60	3.70	19.10	70.20	5.00	390.90
5	KAU M-1	46.90	39.80	40.50	46.90	54.50	3.30	9.20	64.90	4.50	369.60
6	KAU M-2	53.10	45.20	49.80	62.50	73.60	3.90	10.30	71.70	5.10	404.30
7	KAU M-46	44.70	47.80	49.60	45.30	52.60	3.10	8.70	56.60	3.80	310.60
8	AAU M-4	70.10	51.20	52.30	53.10	61.50	4.60	14.20	50.90	4.70	260.10
9	Pusa Narangi Gainda	85.10	61.20	66.80	52.90	62.50	5.10	16.10	57.90	4.90	390.50
10	Pusa Basanti Gainda	80.20	54.50	49.80	54.60	64.30	4.90	17.20	54.60	5.00	360.90
11	Pusa Bahar	64.50	44.50	47.60	56.40	63.90	4.70	13.60	61.80	4.50	378.90
12	Punjab Gainda No.1	72.30	41.50	50.20	45.90	54.60	5.40	15.10	63.20	5.30	402.60
13	Serocole	85.80	80.50	84.50	50.20	58.90	8.10	16.90	75.10	4.70	450.50
14	Raipur AM local	83.80	57.80	62.90	53.60	60.10	5.90	9.80	63.20	6.90	391.50
15	DFR M-12	46.60	48.90	54.80	47.30	57.50	3.80	7.90	56.60	4.10	341.20
16	DFR M-26	48.90	50.10	51.60	51.60	58.70	3.30	8.30	58.80	4.20	330.20
17	BM-4	53.80	43.50	42.50	49.80	59.80	4.80	13.50	54.20	5.10	350.60
18	BM-5	57.60	50.20	47.90	54.90	62.10	4.30	14.90	57.90	5.70	415.50
19	BRMG-113	54.33	54.60	57.90	60.20	72.60	5.60	14.20	58.90	6.10	384.20
20	DFR M Acc-1	68.90	50.20	53.60	59.80	71.20	4.90	12.80	60.20	5.20	360.50
21	DFR M Acc-2	70.20	53.10	53.70	55.90	72.60	4.70	11.90	54.30	6.10	345.90
22	DFR M-2	78.90	76.80	77.90	51.30	59.50	6.80	17.10	70.10	4.80	435.90
23	DFR HM-1	84.50	78.10	76.30	54.60	62.40	7.10	14.20	71.90	5.20	445.90
	Mean	67.79	53.56	55.85	52.26	61.63	4.99	13.63	62.10	5.08	378.39
	SD	14.26	11.09	11.03	4.69	5.93	1.42	3.31	6.63	0.69	44.60
	SE	2.98	2.32	2.30	0.98	1.24	0.30	0.69	1.38	0.14	9.31

Table 1.31. French marigold (*Tagetes patula*) evaluated for morphological and yield traits

Sl. No.	Genotypes	PH (cm)	PS(N-S) cm	PS (E-W) cm	DFB	DFF	NPB	NSB	NFP	FD	FY
1	Pusa Deep	48.20	48.90	49.80	45.00	51.00	8.90	17.80	152.60	4.00	450.60
2	CGFM-1	40.20	41.60	44.90	50.00	61.00	6.30	18.20	98.90	3.20	310.50
3	CGFM-2	48.90	44.90	49.80	49.00	57.00	6.10	18.90	150.60	3.50	420.60
4.	FR-R-5-1	52.60	51.20	52.30	47.00	54.00	5.80	16.90	90.30	4.40	410.20
	Mean	47.48	46.65	49.20	47.75	55.75	6.78	17.95	123.10	3.78	397.98
	SD	4.52	3.69	2.68	1.92	3.70	1.24	0.72	28.67	0.46	52.64
	SE	2.26	1.84	1.34	0.96	1.85	0.62	0.36	14.34	0.23	26.32

PH-Plant Height (cm), PS (N-S) -Plant Spread North South (cm), PS(E-W) -Plant Spread East West South (cm), DFB- Days to flower bud initiation after transplantation, DFF- Days to fifty percent flowering after transplantation, NPB-Number of Primary Branches, NSB-Number of Secondary Branches, NFP- Number of Flowers per Plant, FD- Diameter of Flower (cm), FY-Loose Flower Yield(g/plant)

1.6 Project 6 : Improvement of Aster for Commercial Traits

1.6.1Germplasm maintenance and Evaluation

17 Aster (*Callistephus chinensis*) genotypes that included 13 varieties and 4 newly identified genotypes viz., DFR AA No.1, DFR AA No.11, DFR AA No.14, and DFR AA No.17 were evaluated for 10 different morphological and yield traits. Details of data recorded for various traits studied in all 17 genotypes were presented in Table 1.32. The tallest plant with a height of 75.17 cm was recorded in Phule Ganesh Purple and a minimum plant height of 35.58 cm was noticed in Arka Archana. Maximum and minimum flower diameter of 7.05 cm and 2.95 cm was recorded in genotypes Phule Ganesh White and Arka Nirali. Longest stalk length of 32.87 cm was observed in Phule Ganesh Purple and shortest stalk length i.e. 16.70 cm. DFR AA No.1 was the earliest to flower, taking 64 days after transplantation, while Arka Kamini took the maximum time to flower, with 103 days after transplantation. Highest number of flowers per plant (75.83) was observed in the genotype DFR AA No.17, while lowest was in Arka Shubhi (44.67). The Phule Ganesh White plant had the highest weight of 10 flowers (36.50 g), while the Arka Nirali plant had the lowest weight of 10 flowers (16.58 g). Number of flowers/plant and 10 flowers weight are important traits to be considered for varietal selection and in breeding programs of aster, higher 10 flower weight were reported in the genotypes Phule Ganesh White (36.50 g), followed by DFR AA No.1 (36.38 g), CAAc 1 (35.95 g), Phule Ganesh Pink (34.70 g) and DFR AA No.14 (34.50 g). The genotype DFR AA No.14 had more number of flowers/plants (75.83) followed by CAAc-1 (69.83), Arka Nirali (67.17) and DFR AA No.1 (65.83). The unique characteristics of the new genotypes identified, namely DFR AA No.1, DFR AA No.11, DFR AA No.14, and DFR AA No.17, are listed below.

1.6.2 Unique traits of new aster genotypes identified

Fig. 1.30 DFR AA No.1

1.6.2.1 DFR AA No.1

- Flowers are semi-double flower type and pink-coloured flowers (RHS Red Purple 72 C)
- Flower diameter of 6.1 cm
- 65.83 flowers per plant and average weight of 10 flowers is 36.38 g.
- It is the earliest to flower, taking 64 days after transplanting for fifty percent flowering.
- Flowers are suitable for garland and floral decoration (Fig. 1.30).

Fig. 1.31 DFR AA No.11

1.6.2.2. DFR AA No.11

- Flowers are Semi-double type and pink-colored (Red Purple 73 A)
- Flower Diameter is 5.82 cm
- 58.17 flowers per plant, and the weight of 10 flowers is 32.47 g.
- Flowers are suitable for garland and floral decoration (Fig. 1.31).

Fig. 1.32 DFR AA No.14

1.6.2.3. DFR AA No.14

- Flowers are semi-double type and pink colored (Red Purple 64 B)
- Average flower diameter of 5.50 cm
- 75.83 flowers per plant, and the average weight of 10 flowers is 34.50 g.
- The stalk length is 21.29 cm.
- Flowers are suitable for garland, flower arrangement and floral decoration (Fig. 1.32).

Fig. 1.33 DFR AA No17

1.6.2.4. DFR AA No.17

- Flowers are semi-double type and pink colored (RHS Red Purple 68 A) with short pseudo-ray florets.
- Flower diameter is 3.11 cm.
- 27.5 flowers per plant, and the average weight of 10 flowers is 26.6 g.
- The stalk length measures 26.53 cm.
- Flowers are suitable for cut flowers, bouquet flower arrangements and floral decoration (Fig. 1.33).

Table 1.32 Evaluation of aster genotypes for morphological and yield traits

Variety	Plant type	Branch Density	Ray floret colour	Flower head type	Plant Height (cm)	Flower head diameter (cm)	Stalk Length	Days to Flowering (D.A.T.)	No. of Flowers/ plant	Wt. of 10 Flowers (gm)
Phule Ganesh Pink	Spreading	Sparse	Red Purple 72 A	Semi-double	62.32	6.42	22.21	74	64.50	34.70
Phule Ganesh White	Semi-erect	Dense	White NN 155 D	Semi-double	70.34	7.05	30.67	82	61.83	36.50
Phule Ganesh Purple	Semi-erect	Dense	Purple Voilet 82 A	Semi-double	75.17	6.27	32.87	85	59.67	32.75
Phule Ganesh Violet	Spreading	Sparse	Voilet 83 A	Semi-double	65.46	6.20	31.25	84	51.83	30.25

Variety	Plant type	Branch Density	Ray floret colour	Flower head type	Plant Height (cm)	Flower head diameter (cm)	Stalk Length	Days to Flowering (D.A.T.)	No. of Flowers/ plant	Wt. of 10 Flowers (gm)
Arka Advika	Semi-erect	Medium	White Group 155 A	Pseudo ray florets	54.54	3.17	28.10	81	49.17	27.15
Arka Kamini	Erect	Dense	Red Purple 74 A	Semi-double	55.14	4.83	18.98	103	57.67	22.00
Arka Nirali	Semi-erect	Medium	Purple N 79 B	Pseudo ray florets	57.93	2.95	18.13	84	67.17	16.58
Arka Shubhi	Erect	Dense	Red Purple 65 A	Semi-double	52.57	4.62	17.78	93	44.67	23.38
Arka Aadya	Spreading	Sparse	Red Purple 63 B	Semi-double	47.28	5.28	19.32	81	46.83	24.15
Arka Archana	Spreading	Medium	White N 155 D	Semi-double	35.58	4.82	16.70	78	56.00	27.40
Arka Poornima	Semi-erect	Medium	White N 155 D	Powederpuff	65.42	5.40	21.32	85	53.67	36.73
Arka Shashank	Semi-erect	Medium	White N 155 D	Powederpuff	54.85	3.87	19.27	76	45.17	28.03
CAAc 1	Semi-erect	Medium	Red Purple 61 C	Semi-double	58.58	6.94	25.35	68	69.83	35.95
DFR AA No. 1	Semi-erect	Medium	Red Purple 72 C	Semi-double	70.81	5.90	26.49	64	65.83	36.38
DFR AA No. 11	Semi-erect	Medium	Red Purple 73 A	Semi-double	64.39	5.82	18.07	91	58.17	32.47
DFR AA No. 14	Semi-erect	Medium	Red Purple 64 B	Semi-double	69.32	5.50	21.29	96	75.83	34.50
DFR AA No. 17	Semi-erect	Medium	Red Purple 68 A	Pseudo ray florets	61.85	3.15	26.53	87	55.67	28.93
Mean					60.09	5.19	23.20	83	57.85	29.87
SD					9.77	1.30	5.27	9.7	8.92	5.92
SE					2.37	0.31	1.28	2.4	2.17	1.44

1.7 Project 07: ICAR Project IXX 18391: Improvement of Crossandra for Commercial Traits

1.7.1 Evaluation of varieties for loose flower production

Five varieties viz., Local Orange-1, Local Yellow -1, Soundarya, Arka Shravya and Arka Chenna were evaluated for loose flower production. Highest flower yield was recorded in Soundarya followed by Arka Shravya.

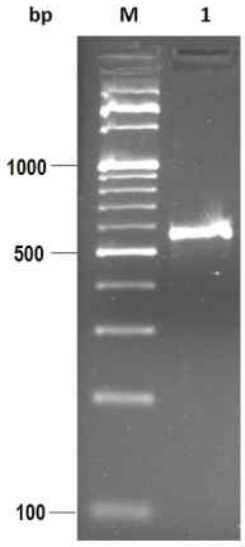
Variety	Loose Flower Yield (g/plant)
Local Orange -1	17.98
Local Yellow -1	10.85
Soundarya	46.44
Arka Shravya	36.53
Arka Chenna	17.58
CD (0.05)	2.70

1.7.2 Mutation Breeding

The seed of cv. Local Orange was irradiated with five doses of gamma rays (10kR, 15 kR, 20 kR, 25 kR and 30 kR). The seeds irradiated with 15 kR and 30 kR gamma rays did not germinate. The seedlings from remaining treatments were transplanted for evaluation.

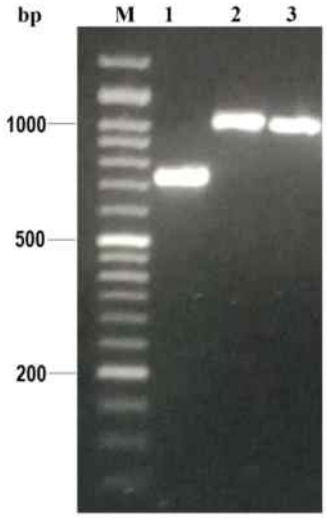
1.7.3 Molecular identification of Fusarium sp. causing wilt in crossandra using multi-locus sequence typing

The species of *Fusarium* causing wilt in crossandra was identified at molecular level through multi locus sequence typing i.e. sequencing of i) internal transcribed spacer (ITS), ii) translation elongation factor 1-alpha (Tef-1α) and iii) RNA polymerase II second largest subunit (RPB2). All the three genes were amplified in PCR and sequenced using the respective gene specific primers described by O' Donnell *et al*. (2010) (Fig. 1.34; Table 1.33). The nucleotide sequences of the genes (Fig. 35) were analyzed individually, compared in *Fusarium*-ID, *Fusarium*- MLST database and NCBI database and identified the species as *F. falciforme* (syn. *Neocosmospora falciformis*) (Fig. 36). To our knowledge this is the first report of *F. falciforme* causing wilt in crossandra.



Lane M: 100 bp DNA Ladder;
Lane 1: *F. falciforme* ITS

Fig. 1.34 PCR amplification of Internal Transcribed Spacer (ITS) regions of the rDNA of *F. falciforme* using ITS1 and ITS4 primers



Lane M: 50 bp DNA Ladder; Lane 1: TEF-1α;
Lane 2: RPB2 Fragment 1; Lane 3: RPB2 Fragment 2

Fig. 1.35 PCR amplification of *F. falciforme* genes translation elongation factor 1-alpha (Tef-1α) using EF1 and ef2 primers and RNA polymerase II second largest subunit (RPB2) using 5f2, 7cr and, 7cf and 11ar primers

Table 1.33: PCR primers used for amplification and sequencing of genes of F. falciforme

Locus	Size (bp)	Primers (5'-3')
ITS Internal Transcribed Spacer regions	~550	**ITS1-** TCCGTAGGTGAACCTGCGG **ITS4-**TCCTCCGCTTATTGATATGC
TEF-1α (Translation elongation factor 1α)	~750	**EF1-** ATGGGTAAGGARGACAAGAC **EF2-** GGARGTACCAGTSATCATG
RPB2 (RNA polymerase II second largest subunit)	~1750	**5f2-** GGGGWGAYCAGAAGAAGGC **7cr-** CCCATRGCTTGYTTRCCCAT **7cf-** ATGGGYAARCAAGCYATGGG **11ar-** GCRTGGATCTTRTCRTCSACC

Fig. 1.36a. Nucleotide sequence of Internal Transcribed Spacer (ITS) regions of the ribosomal DNA of *F. falciforme*

TCTTGGTCAATTTAGAGGAAGTAAAAGTCGTAACAAGGTCTCCGTTGGTGAACCAGCGGAGGGATCATTACC
GAGTTATACAACTCATCAACCCTGTGAACATACCTATAACGTTGCCTCGGCGGGAACAGACGGCCCCGTAACA
CGGGCCGCCCCCGCCAGAGGACCCCCTAACTCTGTTTCTATAATGTTTCTTCTGAGTAAACAAGCAAATAAAT
TAAAACTTTCAACAACGGATCTCTTGGCTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTG
AATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGTATTCTGGCGGGCATGCCT
GTTCGAGCGTCATTACAACCCTCAGGCCCCCGGGCCTGGCGTTGGGGATCGGCGGAAGCCCCCTGCGGGCAC
AACGCCGTCCCCCAAATACAGTGGCGGTCCCGCCGCAGCTTCCATTGCGTAGTAGCTAACACCTCGCAACTG
GAGAGCGGCGCGGCCACGCCGTAAAACACCCAACTTCTGAATGTTGACCTCGAATCAGGTAGGAATACCCGC
TGAACTTAAGCATATCAATAAGGCCGGAGGAA

Fig. 1.36b. Nucleotide sequence of translation elongation factor 1-alpha (Tef-1α) gene of *F. falciforme*

TTCACCTCAAGGTGGTGGTCATCGGCCAGGTGGATTCTGGCAAGTCGACCACCGTAAGTCAAACCCTCATCG
CGATCTGCTTATCTCGGGTCGTGGAACCCCGCCTGGCATCTCGGGCGGGGTATTCATCAGTCACTTCATGCTG
ACAATCATCTACAGACCGGTCACTTGATCTACCAGTGCGGTGGTATCGACAAGCGAACCATCGAGAAGTTCG
AGAAGGTTGGGGACATCTCCCCCGATCGCGCCTTGCTATTCCACAACGAATTCCCTCCCTCGCGATACGCTCT
GCGCCCGCTTCTCCCGAGTCCCAAAATTTTTGCGGTCCGACCGTAATTTTTTTGGTGGGGCATTTACCCCGCC
ACTCGGGCGAAGTTGGAAAAAGCCCTGATCCCTGCACACAAAAACACCAAACCCTCTTGGCGCCCATCATCA
CGTGGTTCACAACAAACCCTAACCGGTCCAACAATAGGAAGCCGCTGAGCTCGGTAAGGGTTCCTTCAAGTA
CGCCTGGGTCCTTGACAAGCTCAAGGCCGAACGTGAGCGTGGTATCACCATCGACATTGCCCTCTGGAAGTT
CCAAACTCCCCGCTACTATGTCACCGTCATTGGTATGTTGCTGTCACCTCTGTCACACATGTCTCACCACTAAC
AATCAACAGACGCCCCCGGCCACCGTGAATTCATCAAG

Fig. 1.36c. RNA polymerase II second largest subunit (RPB2) gene of *F. falciforme*

TCAGAGAAGGCTGCAAGCTCCACTGCTGGTGTCTCTCAGGTGTTGAACAGATACACCTTTGCATCCACTCTTT
CACATTTGCGACGAACCAACACCCCTATTGGACGAGATGGAAAGCTCGCCAAGCCCCGTCAGCTACACAACA
CCCATTGGGGTCTGGTCTGTCCAGCCGAGACGCCTGAGGGTCAGGCCTGTGGTCTGGTCAAGAACTTGTCCC
TGATGTGCTACGTCAGTGTCGGCTCTCCCTCCGAACCTCTGATTGAGTTCATGATCAACCGAGGTATGGAAGT
CGTGGAAGAGTACGAGCCCCTGAGATACCCGCATGCTACCAAGATCTTTGTCAATGGTGTCTGGTGCGGTGTT
CACTCAGACCCCAAGCATCTCGTCAGCCAGGTTCTGGACACACGACGAAAGTCGTACCTGCAGTATGAGGTG
TCACTTGTTCGTGACATTCGAGATCGAGAGTTCAAGGTCTTCTCCGACGCTGGCCGAGTCATGAGGCCGGTCT
TTACGGTCCAGCAGGAGGATGACCACGAGTCTGGTATTGCCAAGGGAGCTTTGGTTCTGACCAAGGACCTTG
TCAACAAGCTTGCTAAGGAGCAGGCGGAGCCACCAGAGGACCCATCAATGAAGATTGGATGGGAGGGTCTG
ATCCGAGCCGGAACCATTGAGTACCTCGATGCTGAGGAAGAGGAGACGGCTATGATTTGCATGACTCCTGAG
GACCTTGATCTCTATCGCATGCAAAAGGCTGGTTACGTCGTAGATGACGATAACACGGACGACCCCAACAGG
AGATTGAAGACCAAGACGAACCCCACAACTCACATGTACACTCATTGTGAGATTCACCCCAGTATGATTCTTG
GCATTTGTGCCAGTATCATCCCCTTCCCCGATCACAACCAGGTATGTGCCCATGATTCAACGTGATGCCAGCGC
GGCTAACAATATGTAGTCACCCCGTAACACCTACCAATCTGCCATGGGCAAAAGCAAGCCATGGGCTTCTTCC
TGACAAAATACTCTCGCCGTATGGATACCATGGCCAACATTTCTTTACTACCCGCAAAAACCTCTGGCGACAA
CACGATCCATGGAGTTCCTCAAGTTCCGTGAACTGCCAGCCGGTCAGAACGCCATCGTCGCTATCGCTTGCTA
CTCTGGTTACAACCAAGAAGATTCCGTCATTATGAACCAGAGTAGTATCGATCGAGGCCTGTTCCGCAGTCTG
TTCTTCAGATCCTACTCTGACCAGGAGAAGAAGGTCGGTCTGAACTACACGGAAGTATTCGAGAAGCCCTTC
CAGCAGTCGACGCTTCGTATGAAGCACGGTACCTACGACAAGCTGGACGAGGATGGTATCGTGGCCCCCGGT
GTGCGAGTGTCAGGTGAAGATATCATCATCGGCAAGACTGCGCCGATTGATCAAGAGAACCAGGATCTGGGT
ACCAGGACAACGGTGCATCAGCGTCGTGATATCTCCACGCCGCTGCGAAGTACCGAGAATGGTATCGTCGATT
CGGTCATTGTGACGGTCAATGCCGACAACGTCAAGTACGTCAAGGTCCGTGTGAGGACGACCAAGATTCCTC
AGATTGGTGACAAGTTCGCCTCTCGTCACGGACAGAAGGGTACCATTGGTGTCACCTACCGACAGGAGGATA
TGCCCTTTACCAGGGAGGGTGTGACACCAGACATTATCATTAACCCCCACGCCATTCCGTCGCGAATGACAAT
TGCACATTTGATTGAATGCCTCCTCAGTAAGGTGTCAACGCTCGAAGGCATGGAGGGTGATGCCACACCTTTC
ACCGATGTCACTGTCGACTCCGTTTCGGAGCTGCTCCGGAAGCACGGCTACCAGTCTCGAGGTTTCGAGATC
ATGTACAACGGCCATACTGGACGCAAGCTTCGAGCGCAGGTGTTCTTTGGACCTACCTACTACCAGC

1.8 Project 08 (ICAR Code No: IXX18373): Studies on enhancement of seed vigour indices and their associated mechanisms in ornamental crops

1.8.1 Evaluation of rose

Rose is the world's most popular flower due to its long history, symbolism, colour, fragrance and sheer elegance of form. The genus *Rosa* consists of about 200 species and thousands of cultivars in which more than 150 species have been recorded. Also, only 11 out of 200 *Rosa* species have contributed to the origin of modern cultivars. Breeding programs in *Rosa* has been hindered due to poor seed germination. Dormancy in rose achenes is mainly attributed due to inhibitors in pericarp and testa, physiological barriers in the embryo and hard pericarp. To enhance the seed germination various techniques were employed. To break the physical dormancy acid and sand paper scarification have been employed.

Various traditional methods were employed to alleviate seed dormancy, with acid treatment being one of the commonly utilized strategies. Sulfuric acid, in particular, was applied to seeds to soften their hard coating, creating small fissures that enhance imbibition of water and seed germination. Despite the positive effects on seed germination, sulfuric acid treatment has certain bottlenecks. Its corrosive nature poses a significant disadvantage as it can adversely impacts seed viability. Furthermore, when sulfuric acid is introduced into the soil, it initiates acidification, leading to detrimental effects on soil nutrient availability. This soil acidification ultimately results into reduced agricultural productivity. Therefore, there is a requirement of a feasible seed treatment strategy that has a similar effect of acid without any constraints for the seeds as well as the environment.

Recently, Deep Eutectic Solvents (DES) emerged as a promising alternative for acid that has been applied to the processing of lignocellulosic materials for removal of lignin and hydrolysis of cellulose. DESs are eutectic mixtures of Lewis or Bronsted acids and bases (hydrogen bond donor (HBD) and hydrogen bond acceptor (HBA) which constitute diverse anionic and cationic species that exerts bond breakage mechanism as like ionic liquids. The formation of hydrogen bonds between HBD and HBA induces charge delocalization, lowering the melting point of DES. The resulting acid-base catalysis facilitates the breakage of ether linkages in lignin phenyl propane units during the delignification process by DES.

In the present study, DES potential has been assessed for the delignification of rose seed pericarp (Fig. 1.37).

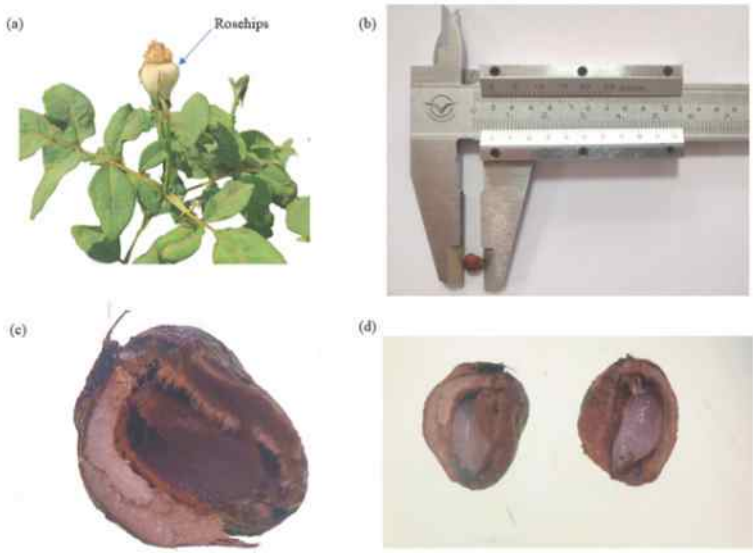


Fig. 1.37. Schematic diagram of rose seed pericarp characterization

a) Rose hips of var. Rose Sherbet,
b) measurement of rose seeds diameter,
c) pericarp d) embryo with pericarp

1.8.2 Effect of DES on delignification of the pericarp of var. Rose Sherbet seeds

As illustrated from Table 1.34, it becomes evident that the raw rose sherbet seed possesses a high lignin percentage of 63 % (w/w), significantly surpassing the expected range of 4.4 to 6 % (w/w) for germinating seeds.

Table 1.34: Lignin and delignification percentage of raw and DES treated seeds of Rose Sherbet

Treatment	Duration (min)	Lignin % (w/w)	Delignification %(w/w)
Raw seed	280	63.0 ± 0.10	_
DES (ChCl: Formic acid)	30	71.3 ± 0.11	15
DES (ChCl: Oxalic acid)	30	52.7 ±0.15	15
DES (ChCl: Formic acid)	280	37.2 ± 0.07	40
DES (ChCl: Oxalic acid)	280	6.2 ±0.09	90
Sulphuric acid treatment	30	15.0 ± 0.11	75

1.8.3 Pericarp thickness analysis before and after DES based seed treatment

SEM analysis was conducted to assess changes in pericarp thickness before and after DES based seed treatment (Fig. 1.38). The pericarp thickness of rose achenes (*Rosa hybrida*) was initially reported as 1.4 ± 0.4 mm. Results from SEM analysis indicates that the pericarp thickness of Rose Sherbet seeds prior to DES treatment measures 1220 ± 106 µm, corresponding to the 63% (w/w) lignin content in the pericarp. Notably, DES treatment with ChCl: oxalic acid for 5 h results in the maximum fold reduction (61%) in pericarp thickness.

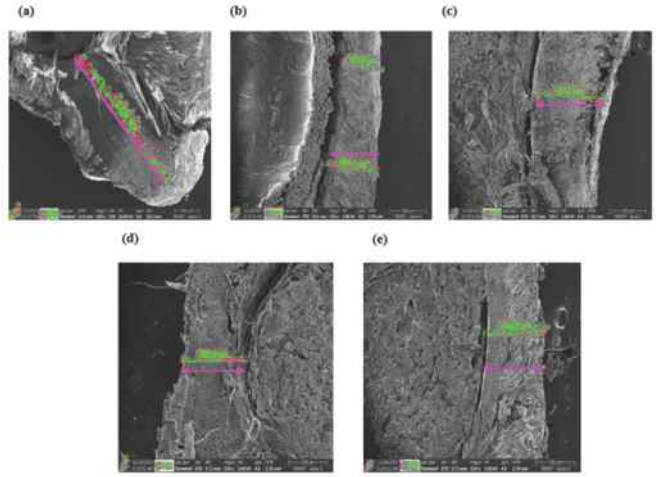


Fig. 1.38. SEM analysis of rose seed pericarp before and after DES treatment

a) Rose Sherbet pericarp before DES treatment (control),

b-e) pericarp thickness reduction after DES treatment

As depicted in Table-1.35, after undergoing two distinct DES treatments (ChCl: Formic acid and ChCl: Oxalic acid), it was observed that for DES (ChCl: Oxalic acid) treatment for 5 hours, the lignin content of rose sherbet seeds post-treatment was 6.2 % (w/w), which is close to the expected range for lignin content in germinating seeds (Abati et al. 2021).

Table 1.35: Thickness of pericarp and fold reduction percentage in thickness of raw and DES treated seeds

Treatment	Duration (min)	Thickness of pericarp (µm)	Fold reduction (%)
Raw seed	280	1220.00 ± 106.00	_
Sulphuric acid treatment	30	403.75 ± 118.72	66.00
DES (ChCl: Oxalic acid)	30	1030.00 ± 21.34	15.00
DES (ChCl: Formic acid)	30	1130.00 ± 67.42	7.37
DES (ChCl: Oxalic acid)	280	472.50 ± 21.42	61.00
DES (ChCl: Formic acid)	280	780.00 ± 109.21	36.06

In conclusion, the study addresses the decrease in the germination potential of Rosa Sherbet seeds, caused from the development of a thick, lignified pericarp during storage. This hinders the necessary water imbibition crucial for successful germination. The use of two types of Deep Eutectic Solvents (DES) —choline chloride and oxalic acid, and choline chloride and formic acid — aimed at reducing pericarp thickness and, consequently, improving the germination of rose sherbet seeds. Current research demonstrates that DES (ChCl: Oxalic acid) achieves maximum delignification, highlighting the effectiveness of DES treatment in overcoming the lignification barrier. The recent need for environmentally sustainable seed treatment strategies, poses DES as a promising solution for facilitating delignification and enhancing the seed's imbibition ability. The eco-benign nature of DES treatments, characterized by milder conditions, biodegradability, and cost-effectiveness, suggests a potential shift towards the use of DES in future seed treatments for seed germination.

1.8.4 Improvement of aster for commercial traits

Aster [*Callistephus chinensis* (L.) Nees.] is a member of family Asteraceae, is one of the important commercial flower crops in the floriculture industry. It is an important seed propagated annual flower crop mainly used for loose and cut flower production in Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, West Bengal, etc. The demand for quality seeds of this crop is continuous, as the crop is not season specific and can be grown throughout the year. Nevertheless, the non-availability of quality seeds is one of the major problems in cultivation of aster crop. Aster seeds are known to lose viability rapidly under ambient storage conditions and hence leading to poor germination in the field. Seeds are remarkably complex and effective mechanism to remain viable or to ensure their long survival until next growing season. The present study was conducted to delineate the longevity of aster seeds (Phule Ganesh Pink) under ambient storage conditions.

(A) (B) (C)

Fig. 1.39. Seed longevity studies in China aster
A)Germination in fresh lot of aster, B) Reduction in germination after 4 months,
C) Loss of viability after 8 months in aster seeds

In this study, it was observed that after 6 months of observation, the germination percentage of aster has significantly reduced to 60 percent (Fig. 3). Further, the germination has reduced significantly (10 percent) after 10 months.

1.8.5 Standardization of seed testing protocols in floriculture crops

Seed viability of floriculture crops has been assessed by the tetrazolium (2,3,5-tryphenyl tetrazolium chloride, TTC) test. The working principle of the test lies on reduction of the colourless and water soluble 2,3,5-triphenyl-2H-tetrazolium chloride (TTC) to an insoluble red compound (formazan). This reduction occurs as a consequence of hydrogen ions donated to the TTC upon dehydrogenase activity in metabolically active tissues, such as the seed embryo. Consequently, seed viability is usually determined using a topographical method (visual observation) to characterize the pattern and intensity of formazan staining pattern and the intensity of coloration for individual seed embryos (Fig. 1.40).

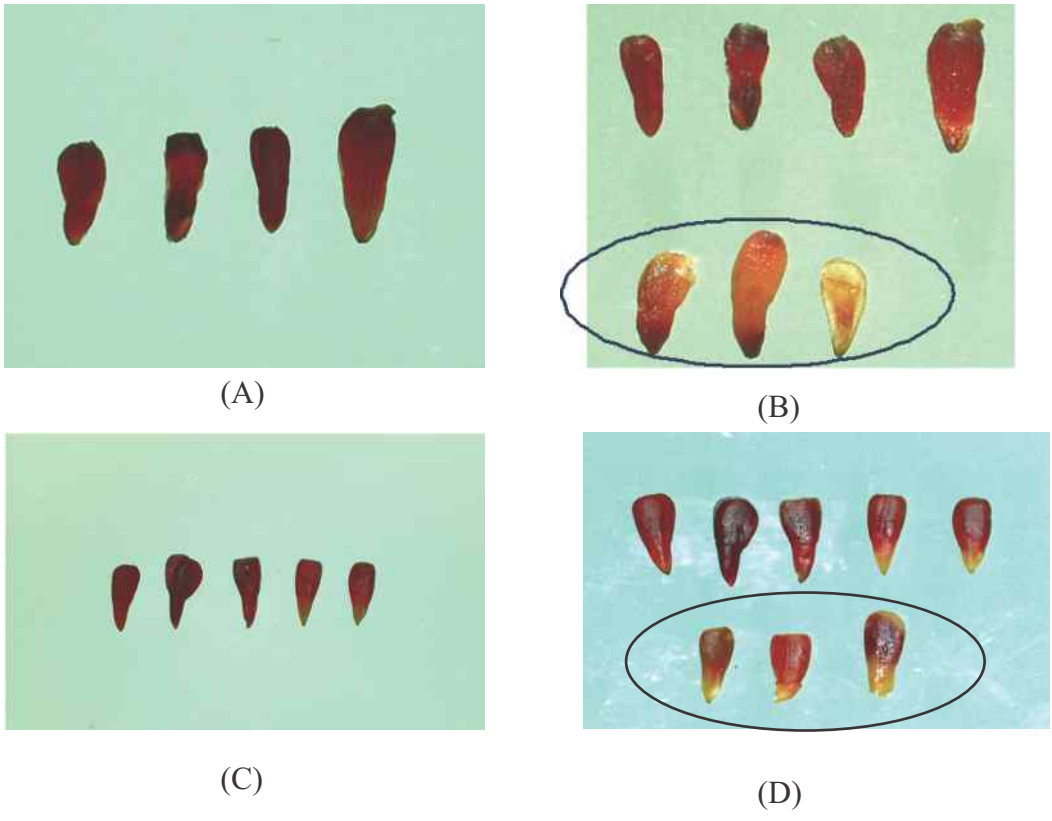


Fig. 1.40. Seed viability tests

A) Seed viability tests in chrysanthemum, B) Permitted non-viable tissues: 1/3 of the radicle tip; 1/3 of distal end of cotyledons; ½ if superficial, C) Seed viability tests in aster, D) Permitted non-viable tissues: 1/3 of the radicle tip; 1/3 of distal end of cotyledons; ½ if superficial

1.9 Project 9 (ICAR Project Code IXX 14258): Development of Unique DNA Fingerprints of Flower Crops

1.9.1 SRAP fingerprinting of Gladiolus accessions

SRAP fingerprinting of 30 gladiolus accessions was carried out (Fig. 1.41). The cluster analysis revealed two main clusters: Cluster-I and Cluster-II. Cluster-I, comprising ten genotypes, was further divided into subclusters, Cluster-I-a and Cluster-I-b, with approximately 41.80% similarity. Notably, Cluster-I-a showed a maximum genetic similarity of 70.00% between cultivars C.P.G and Subhangani, while Cluster-I-b displayed a maximum genetic similarity of 66.67% between cultivars Arka Darshan and Arka Naveen. Similarly, Cluster-II was segregated into two sub-clusters, Cluster-II-a and Cluster-II-b, with around 45.60% similarity. Within these subclusters, cultivars Arka Amar and Sweta in Cluster-II- demonstrated maximum genetic similarity of 70.37%, whereas Cluster-II-b showcased a maximum genetic similarity of 75.86% between cultivars Pusa Suhagin and Pusa Srijana. Furthermore, six gladiolus genotypes-Urmi, Arka Shobha, Bindiya, Gulal, Arka Ayush, and Arka Kesar were identified as outliers (Fig. 1.42), suggesting their potential suitability as parents for desired traits in gladiolus breeding programs.

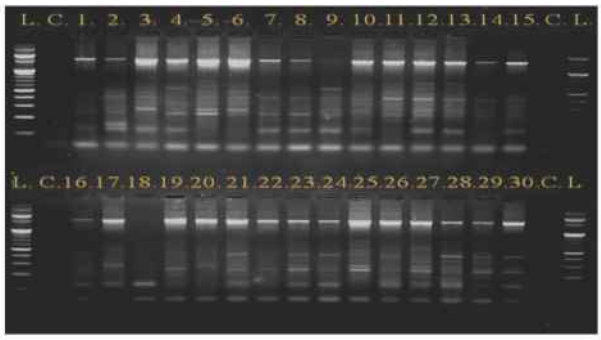


Fig. 1.41 PCR amplification using SRAP Primer Me5Em4 in gladiolus

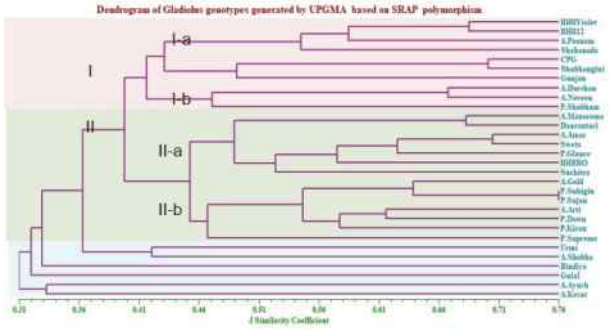


Fig. 1.42 Relationship among dendrogram of gladiolus genotypes

1.9.2 Fingerprinting of Chrysanthemum genotypes using ISSR markers

ISSR fingerprinting was performed on ten Chrysanthemum genotypes (Fig. 1.43). Further analysis revealed that similarity coefficient ranged from 0.79 to 0.55. Bidhan Shweta emerged as an outlier, distinguished by a similarity coefficient of 0.55. The remaining genotypes formed one major cluster I, which was subsequently subdivided into sub-clusters. Within major cluster I, Charlie and Akitha formed distinct sub-clusters, exhibiting almost 0.7 similarity coefficient. Notably, Bidhan Rajat and Coimbatore Semi double demonstrated high similarity, with a coefficient of 0.73 (Fig. 1.44).

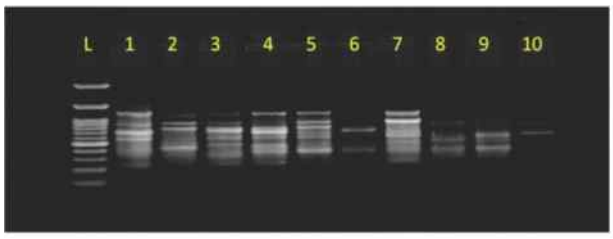


Fig. 1.43 PCR amplification of ten genotypes of chrysanthemum using primer UBC 810

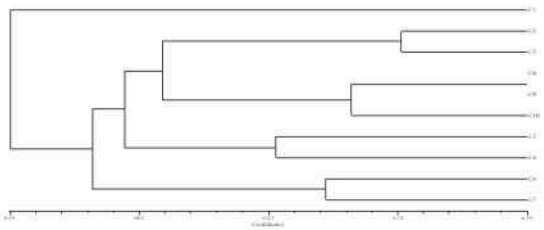


Fig. 1.44 Relationship among 10 genotypes of chrysanthemum

1.9.3 SRAP fingerprinting of Heliconia accessions

SRAP fingerprinting was utilized to analyse diversity of 29 Heliconia accessions (Fig. 1.45). The cluster analysis revealed the presence of two primary clusters with approximately 68% similarity. Within these clusters, distinct sub-groupings emerged: Petra Quitz and *H. Rostrata* parrot beak exhibited high similarity within one sub-cluster, while Tropics, Kathy, and Lady Di showcased notable similarity in another. Notably, Lobster claw and Rowling displayed considerable similarity. However, *Latis pathis*, Temptress, and Red Christmas were identified as outliers. Additionally, H-25, *H. metallica*, and Golden torch formed a distinct sub-cluster, contrasting with the remaining genotypes, which comprised a major sub-cluster (Fig. 1.46).

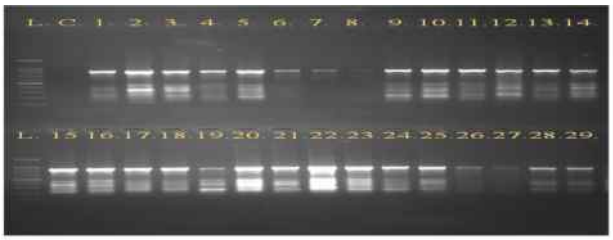


Fig. 1.45 PCR amplification of heliconia accessions using SRAP primer (Me7Em2)

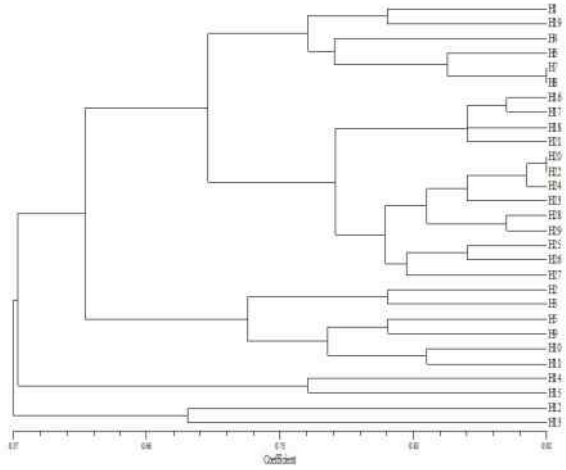


Fig. 1.46 Relationship among 29 accessions of heliconia

1.9.4 SCoT Fingerprinting of Rose accessions

SCoT fingerprinting was conducted on 18 rose accessions, and subsequent analysis is underway.

In summary in this project, SRAP, ISSR, and SCoT markers were utilized to assess the genetic diversity of gladiolus (66), tuberose (13), chrysanthemum (10), heliconia (29), and rose (18) genotypes (Table 1.36). A total of 25, 14, 11, and 9 polymorphic markers were identified for gladiolus, tuberose, chrysanthemum, and heliconia, respectively, which hold significance for their respective breeding programs. Additionally, the efforts are underway to develop variety-specific SCAR markers which will aid in accurate varietal identification.

Table 1.36: Summary of fingerprinting work

Crop	Number of Varieties	Marker system used	Total number of Markers used	Polymorphic markers identified
Gladiolus	10+30+26	SRAP and ISSR	80	25
Tuberose	13	SRAP	80	14
Heliconia	29	SRAP and ISSR	30	11
Chrysanthemum	10	ISSR	20	9
Rose	17	SCoT	Yet to complete	--

1.10 Project 10: Trait-specific Improvement of Ornamental Crops through Genetic Engineering and Genome Editing

1.10.1 Comparative assessment of antioxidant potential of marigold cultivars using different extraction methods

The comparative antioxidant potential of 21 marigold cultivars was assessed utilizing various extraction methods. Sonication, microwave, and conventional techniques were explored for different parameters to extract carotenoids, total phenols, and antioxidant capacity from petals of 21 marigold varieties. Sonication demonstrated superior extraction efficiency, yielding higher amounts of carotenoids and total phenols, along with exhibiting greater antioxidant potentials (Fig. 1.47) compared to both microwave and conventional extraction methods.

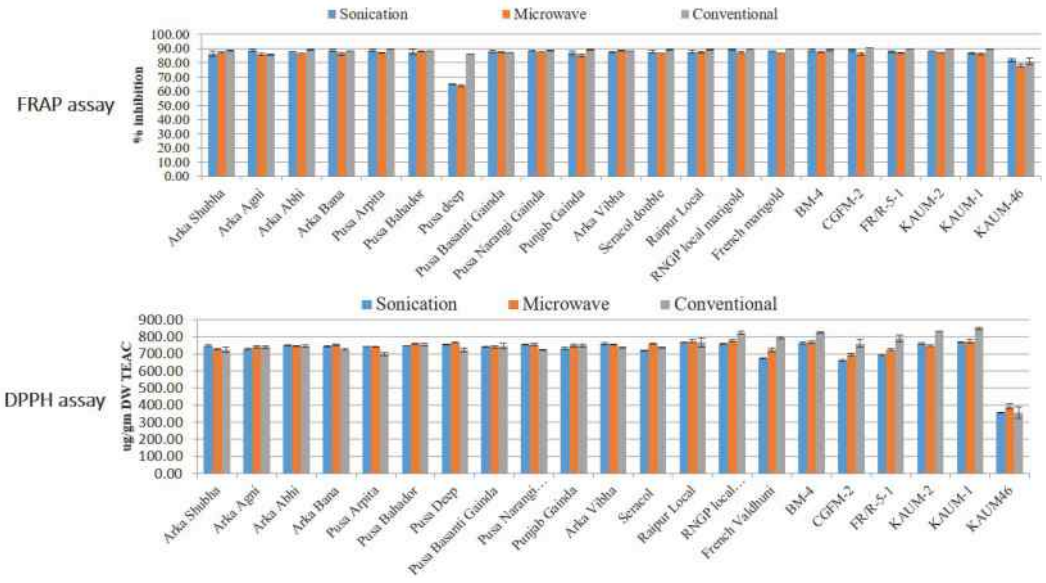


Fig. 1.47. Antioxidant Potential Assay of 21 marigold cultivars using different extraction methods

1.10.2 Comparative transcriptome and VOCs analysis of scented and non-scented rose and tuberose cultivars

A comparative analysis of transcriptome and volatile organic compounds (VOCs) was performed on scented (Double Delight) and non-scented (Pusa Bahadur) rose cultivars, primarily focusing on terpenoid biosynthesis pathways. KEGG annotation revealed 103 unigenes associated with "terpenoid backbone biosynthesis. Comparative VOC analysis identified 58 important compounds in the bud and open flower stages of Double Delight and Pusa Bahadur rose varieties, including monoterpene and sesquiterpene hydrocarbons, esters, fatty acids, alcohols, aldehydes, and alkane hydrocarbons. Terpenoids, notably monoterpene and sesquiterpene hydrocarbons, were the predominant VOCs. Variability in volatile emission was observed between the two varieties and stages. Sesquiterpene presence was highest in the buds of Double Delight, scarce in the buds of Pusa Bahadur, and absent in the opened flower stage of both the varieties (Fig. 1.48a, b). A comparative analysis of volatile compound composition and gene expression in highly scented (Prajwal) and non-scented (Calcutta Double) tuberose cultivars at bud and flower stage has been conducted (Fig. 1.49a,b).

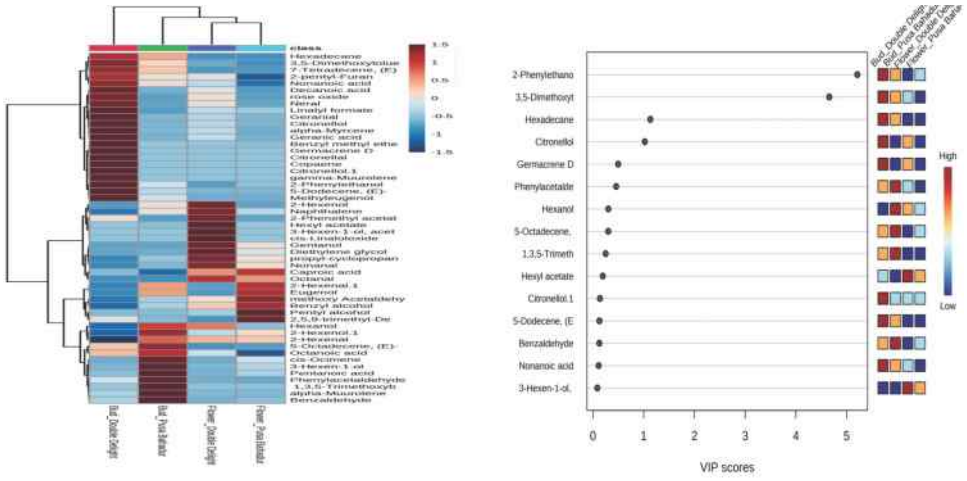


Fig. 1.48 a Heat map of 58 volatile organic compounds (VOCs) of scented and non-scented rose at bud and flower stage

Fig. 1.48 b PLS-DA analysis of VIP score plots of the VOCs

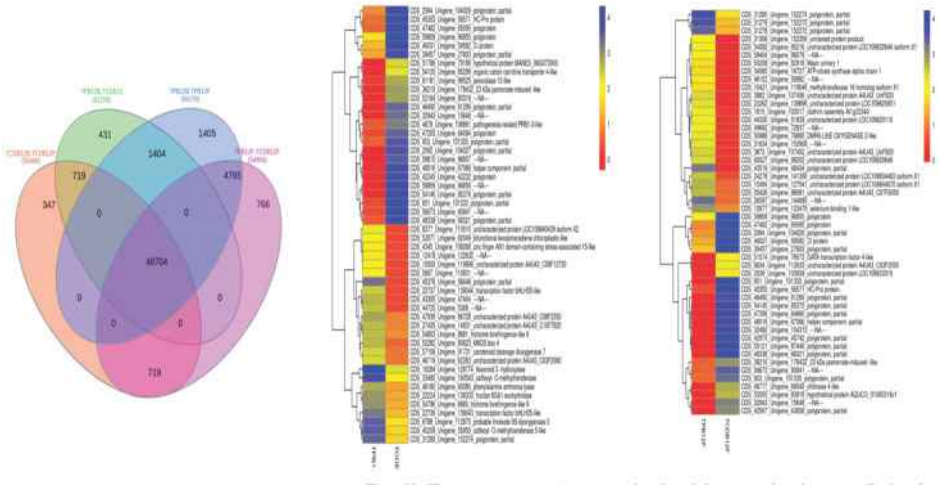


Fig. 1.49 a Veen diagram comprising DEGs in all 4 combinations

Fig. 1.49 b Heatmap representing up-regulated genes at bud and flower stage (Prajwal vs Calcutta Double)

1.10.3 Genetically modified lutein-rich marigold development

Overexpression vector carrying flower-specific promoter and carotenoid enhancing TF has been constructed (Fig. 1.50), confirmed by sequencing and development of transgenic marigold is in progress. Constructed the CRISPR Cas-9 genome editing vector for lutein enrichment by knocking the pathway gene. Putative 50 genome edited PCR positive marigold plants for lutein enhancement has been achieved and further confirmation of editing is in progress.

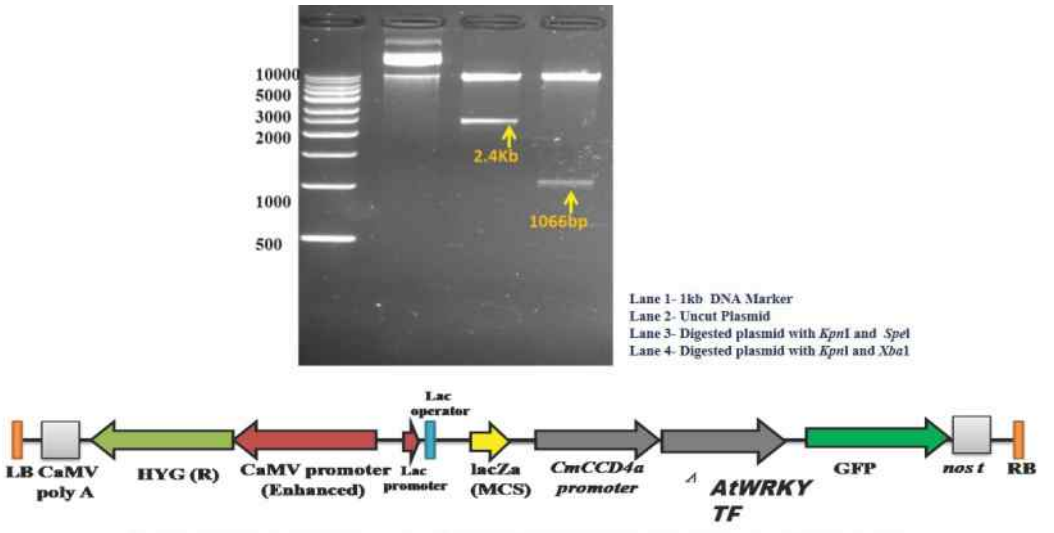


Fig 1.50 .Flower specific over expression of AtWRKY TF for lutein enhancement in marigold

1.10.4 Pre-Project works

1.10.4.1 Pollen morphology studies of Indigenous of chrysanthemum varieties (Asteraceae) by SEM

A palynological investigation of 134 Chrysanthemum cultivars was conducted using scanning electron microscopy. Pollen grains exhibited similarities in shape, size, aperture characteristics, polarization, and symmetry but differed in exine ornamentation pattern, spine density, and quantitative measurements. Certain pollen traits proved to be taxonomically valuable for distinguishing Chrysanthemum cultivars (Fig. 1.51). Comparative analysis with other Asteraceae members via the PalDat database underscored the reliability of pollen morphology for classification. Similar palynological investigation are being carried out for rose (100), gladiolus (78) and tuberose (13) germplasm available at ICAR-DFR and Ganesh Khind, Pune.

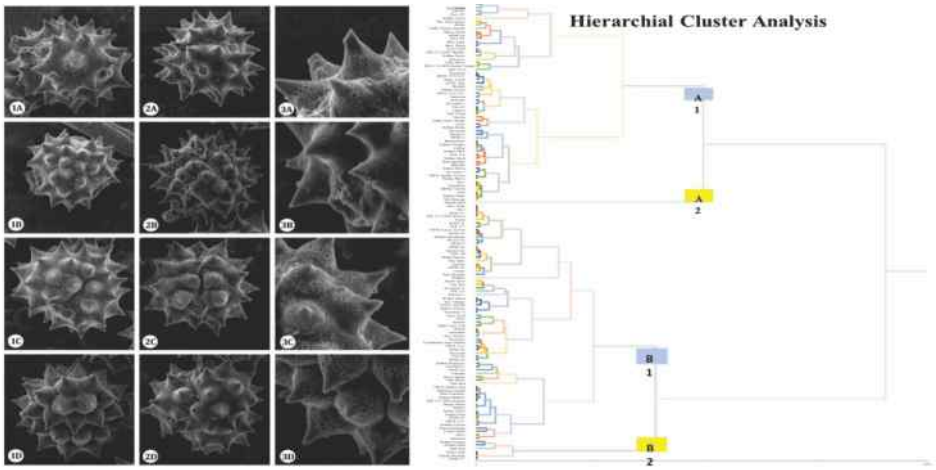


Fig. 1.51. Pollen morphology studies of indigenous chrysanthemum varieties

1.10.4.2 Comparison and optimization of nuclear isolation buffers for plant DNA flow cytometry of flower crops

DNA flow cytometry necessitates the preparation of intact nuclei suspensions, followed by staining with a DNA-specific fluorochrome for analysis. Various lysis buffers were developed to maintain nuclear integrity, protect DNA, and enable accurate staining. Among six common buffers tested (Galbraith's, LB01, GPB, Tris.$MgCl_2$, Tris.MgCl2.PVP, MB01), MB01 proved most suitable for chrysanthemum, *M. Champaka*, rose, marigold, and jasmine. Tris-PVP was optimal for rose and marigold, while Tris.MgCl2 was ideal for jasmine alone. None of the buffers were suitable for *Heliconia* species. The optimized buffer will be utilized for DNA flow cytometry analysis of all flower crop germplasm available at ICAR-DFR germplasm repository.

1.10.4.3 Genome-wide identification and characterisation of important family genes from ornamental crops

In silico identification and characterization of SWEET, Aquaporins (AQPs), CONSTANS (CO) from ornamental crops and their expression analysis was carried out in Rose (*Rosa chinensis*), Spider plant (*Tarenaya hassleriana)*, *Kalanchoe (Kalanchoe fedtschenkoi) and Monkey flower (Mimulus guttatus).* Further these genes can be utilized to improve the important traits of ornamental crop plants (Fig. 1.52).

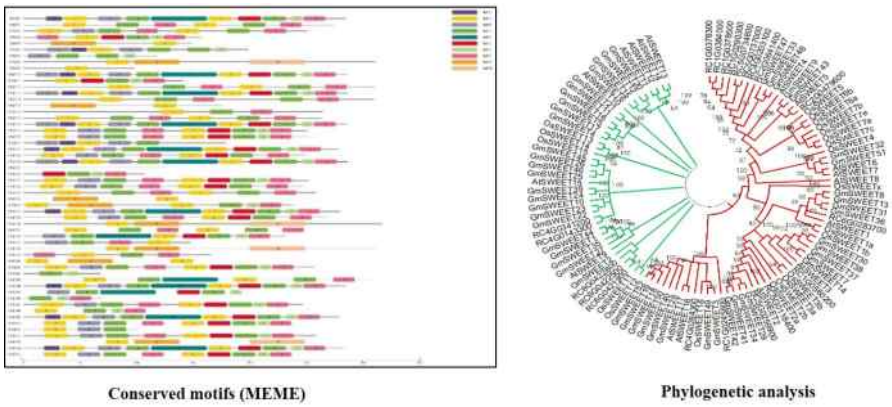


Fig. 1.52. In solico identification and characterization of SWEET. Aquaporins (AQPs), CONSTANS (CO) from ornamental crops

1.11 Project 11: Collection, Characterization, Evaluation, Conservation and Sustainable Utilization of Tropical Orchids

For characterization, evaluation, conservation and utilisation of native species and hybrids of tropical orchids, we have collected 11 species of native tropical orchids, 15 Dendrobium hybrids and 11 Vanda hybrids and maintained them in a net house at ICAR-Directorate of Floricultural Research, Regional Station, Vemagiri, Andhra Pradesh. The indigenous tropical orchid species were collected from Kerala and Karnataka. These include (i) *Cymbidium aloifolium*, (ii) *Coelogyne* spp. (2), (iii) *Cottonia peduncularis*, (iv) *Dendrobium herbaceum*, (v) *Dendrobium kingianum*, (vi) *Dendrobium ovatum*, (vii) *Pholidota imbricata*, (vii) *Luisia zylanica*, and (ix) *Rhyncostylus retusa*. The Vanda hybrids include (i) *V.* Yano Blue, (ii) *V.* Pachara Delight, (iii) *V.* Siriporn Pink, (iv) *V.* Suchai Gold Spot, (v) *V.* Nopporn Golden Hill, (vi) *V.* Dino Dream, (vii) *V.* Nopporn White Diamond (viii) *V.* Pakchong Blue, (ix) *V.* Pure Wax Blue, (x) *V.* Marissa Little Doll and (xi) Papilionanda Paksorn Fragrance. Dendrobium hybrids collected include (i) *Den.* Udon Red (ii) *Den.* Singapore White (iii) *Den.* Aiyara (iv) *Den.* Sonia Red (v) *Den.* Sonia White (vi) *Den.* Burana Jade (vii) *Den.* Shavin White (viii) *Den.* Burana White (ix) *Den.* Burana Charm (x) *Den.* Caezar Warawan (xi) *Den.* Mini Ya Ya (xii) *Den.* Ersakul (xiii) *Den.* Emma White (xiv) *Den.* Liberty White (xv) and *Den.* Thongchai Gold. These species/hybrids will be evaluated and used for genetic enhancement and the development of new cultivars.

2. Crop Production

2.1 Project 1 (ICAR Project Code IXX 18591): Study on Determination of Air Purification Capacity in Ornamental Plants

2.1 Evaluation

A pot experiment was conducted with five different indoor plant species along with five varieties in each indoor plant species during 2023 at ICAR-DFR, Pune under an inter-institutional project, "Study on Determination of the Air Purification Capacity in Ornamental Plants". The objective was to study the oxygen releasing efficiency and leaf anatomical variations of different varieties in five indoor plants species. The results obtained from the experiment are mentioned below.

2.1.1 Aglaonema

Five different varieties of Aglaonema were selected, namely- i) Aglaonema Maria, ii) Aglaonema Commutatum, iii) Aglaonema Silver Queen, iv) Aglaonema Tigress, and v) Aglaonema Pink Dalmatin.

2.1.1.1 Chlorophyll content

In *Aglaonema*, the total chlorophyll content was observed higher in *Aglaonema commutatum* (2.593 mg/g fresh weight of leaf), whereas Aglaonema Pink Dalmatian contained lower chlorophyll content (1.733 mg/g fresh weight of leaf). Further, carotenoids were observed higher in Aglaonema Pink Dalmatian (5.561 mg/g fresh weight of leaf) whereas Aglaonema Pink Dalmatian estimated lower carotenoids content (3.366 mg/g fresh weight of leaf) (Fig. 2.1).

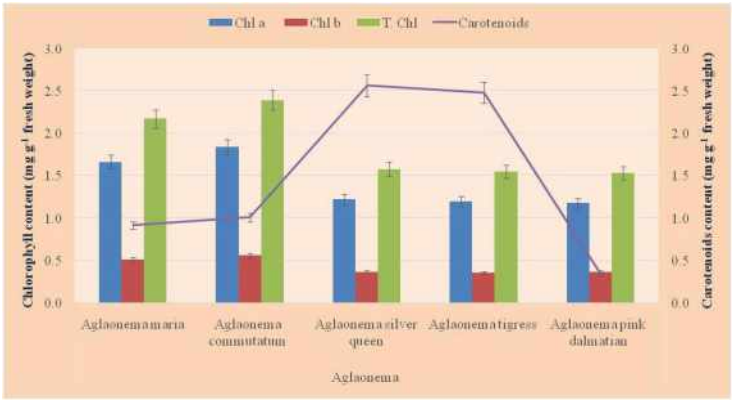


Fig. 2.1. Chlorophyll a, b and total chlorophyll content and total carotenoids content in five varieties of Aglaonema

2.1.1.2 Secondary metabolites

The data obtained on secondary metabolites clearly indicated significant variation in total phenols and total flavonoids among various varieties under each indoor plant species. In Aglaonema indoor plant species Aglaonema Pink Dalmatian was found higher total phenols (112 µg/mL), whereas Aglaonema Pink Dalmatian was found lower (76 µg/mL) (Fig. 2.2). Further, another secondary metabolite, total flavonoids was recorded higher in case of Aglaonema Maria (114 µg/mL), whereas Aglaonema Silver Queen was found lower total flavonoids (36 µg/mL).

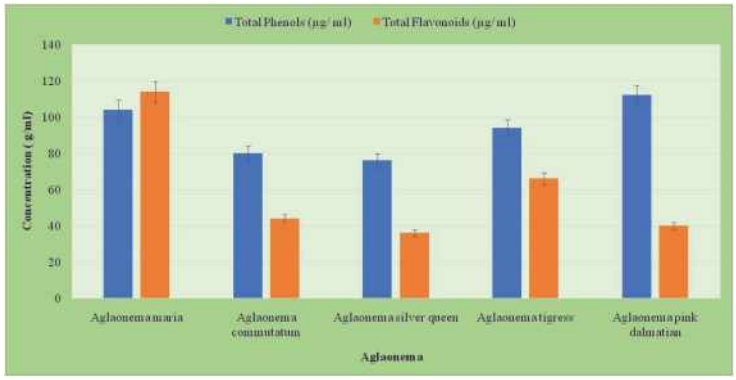


Fig. 2.2. Total phenols and total flavonoids content in the leaves of five varieties of Aglaonema

2.1.1.3 Oxygen liberation and Relative humidity within the leaf

In Aglaonema, the total oxygen liberation by leaf was observed higher in Aglaonema Maria (21.50%), whereas Aglaonema Silver Queen oxygen liberation by leaf was lower (21.44%) (Fig. 2.3).

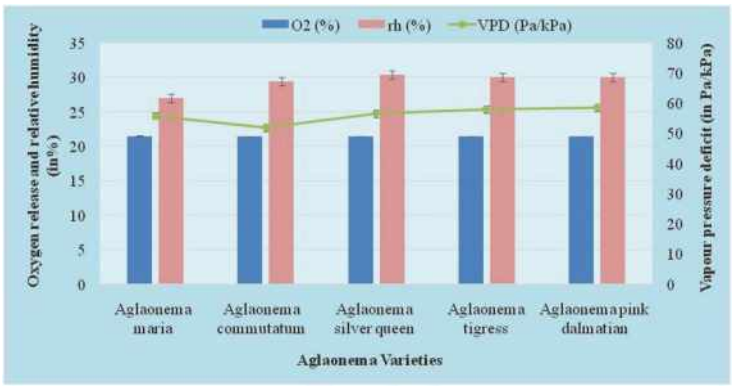
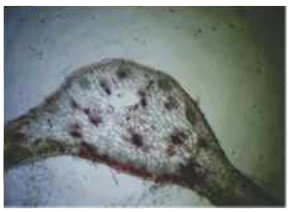


Fig. 2.3. Oxygen releasing efficiency and relative humidity (%)in the leaves of five varieties of Aglaonema

2.1.1.4 Histochemical variations

In *Aglaonema*, there were enormous anatomical changes observed in top, middle and bottom leaf sample in all the varieties. The variety Aglaonema Maria shown higher number of vascular bundle among all the five varieties followed by Aglaonema silver queen whereas least number of vascular bundle was observed in Aglaonema Pink Dalmatian. The arrangement of vascular bundle was observed in scattered manner as shown in Fig. 2.4.

Variety	Top Leaf Sample	Middle Leaf Sample	Bottom Leaf Sample
Aglaonema Maria			
Aglaonema Commutatum			

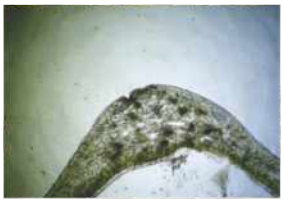
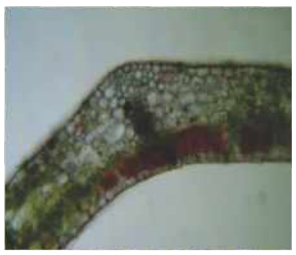
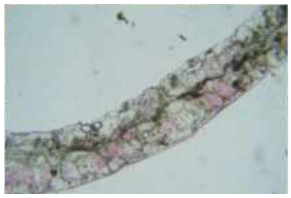
Variety	Top Leaf Sample	Middle Leaf Sample	Bottom Leaf Sample
Aglaonema Silver Queen			
Aglaonema Tigress			
Aglaonema Pink Dalmatin			

Fig. 2.4. Anatomical variations in different varieties of Aglaonema.

2.1.2 Dracaena

Five different varieties of Dracaena were selected, namely- i) Dracaena Mahatma, ii) Dracaena Song of Jamaica, iii) Dracaena Song of India, iv) Dracaena Green, and v) Dracaena Massangeana.

2.1.2.1 Chlorophyll content

In *Dracaena*, the total chlorophyll content was observed to be higher in Dracaena Massangeana (1.816 mg/g fresh weight of leaf), whereas Dracaena Song of India of the lower chlorophyll content (1.594 mg/g fresh weight of leaf). Further, carotenoids were observed higher in Dracaena Massageana (4.247 mg/g fresh weight of leaf) whereas Dracaena song of Jamaica estimated lower carotenoid content (3.022 mg/g fresh weight of leaf) (Fig. 2.5).

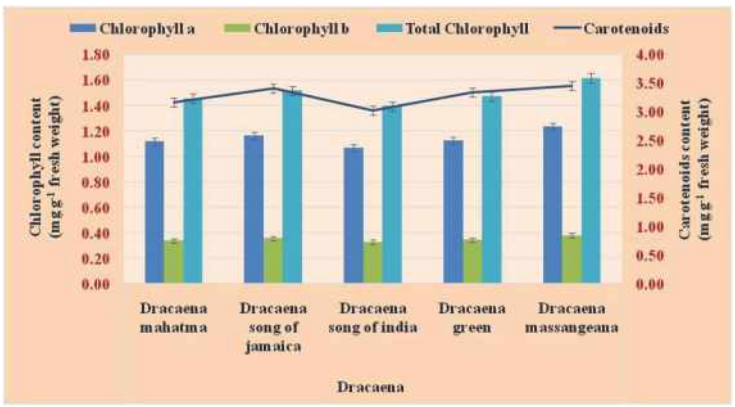


Fig. 2.5. Chlorophyll a, b and total chlorophyll content and total carotenoids content in five varieties of Dracaena

2.1.2.2 Secondary metabolites

The data obtained on secondary metabolites clearly indicated significant variations in total phenols and flavonoids among different varieties. In Dracaena, Dracaena Mahatma contained higher total phenols (67 µg/mL), whereas Dracaena Massangeana had lower total phenols (57 µg/mL) (Fig. 2.6). Further, total flavonoids was recorded higher in case of Dracaena Mahatma (120 µg/mL), whereas Dracaena Song of Jamaica contained lower total flavonoids (57 µg/mL).

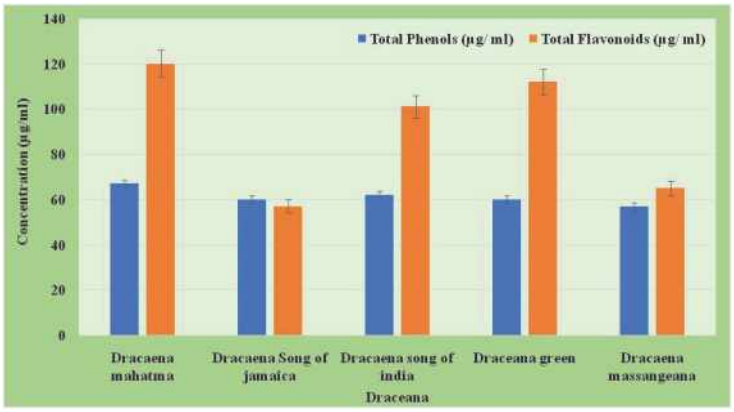


Fig. 2.6. Total phenols and total flavonoids content in leaves of five varieties of Dracaena

2.1.2.3 Oxygen liberation and relative humidity in leaf

In Dracaena, the total oxygen liberation by leaf content was observed higher in Dracaena Massangeana (21.49%), whereas Dracaena Green was found lower oxygen liberation by leaf (21.36%) (Fig. 2.7).

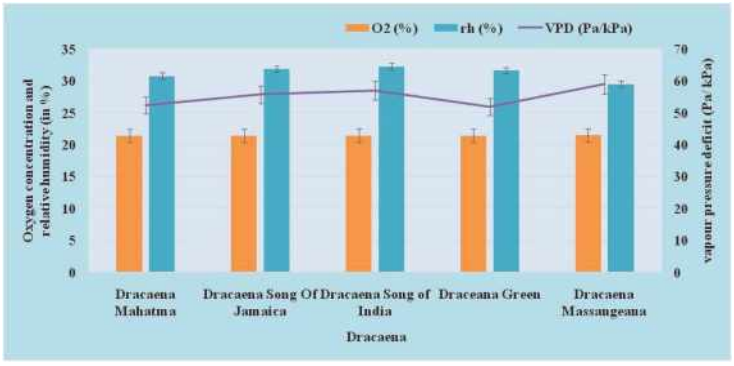


Fig. 2.7. Oxygen releasing efficiency and relative humidity (%) in leaves of five varieties of Dracaena

2.1.2.4 Histochemical variations

In Dracaena, there were enormous anatomical changes observed in top, middle and bottom leaves. Higher number of vascular bundle was recorded in Dracaena Massangeana among all the five varieties followed by Dracaena Mahatma, whereas least number of vascular bundle was observed in Song of Jamaica. The arrangement of vascular bundle was observed in scattered manner. Large number of vascular bundle found on the edges of leaf and few in the middle as shown in Fig. 2.8.

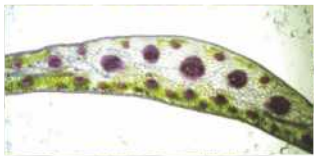
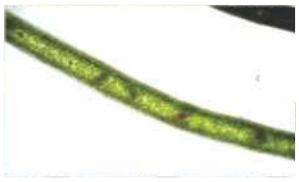
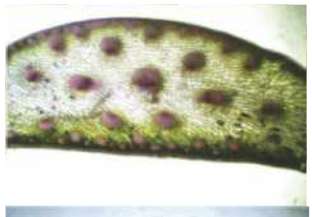
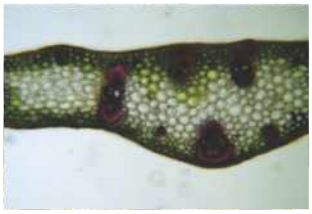
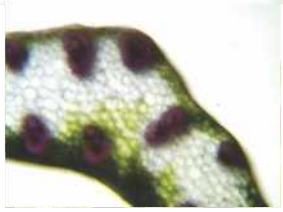
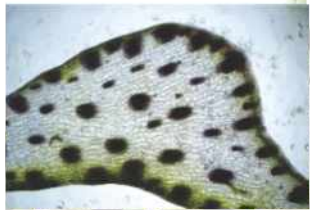
Variety	Top Leaf Sample	Middle Leaf Sample	Bottom Leaf Sample
Dracaena Mahatma			
Dracaena Song of Jamaica			
Dracaena Song of India			
Draceana Green			
Dracaena Massangeana			

Fig. 2.8. Anatomical variations of five different varieties in Dracaena plants.

2.1.3 Indoor palms

Five different varieties of palms were selected, namely- i) Areca Palm, ii) Foxtail Palm, iii) Bamboo Palm, iv) Sago Palm, and v) Table Palm.

2.1.3.1 Chlorophyll content

In Palms, the total chlorophyll content was observed to be higher in Bamboo Palm (2.447 mg/g fresh weight of leaf), whereas Sago Palm contained lower chlorophyll content (1.651mg/g fresh weight of leaf) (Fig. 2.9). Further, carotenoids were observed to be higher in Table Palm (5.403 mg/g fresh weight of leaf) whereas Sago Palm contained lower carotenoids content (4.350mg/g fresh weight of leaf).

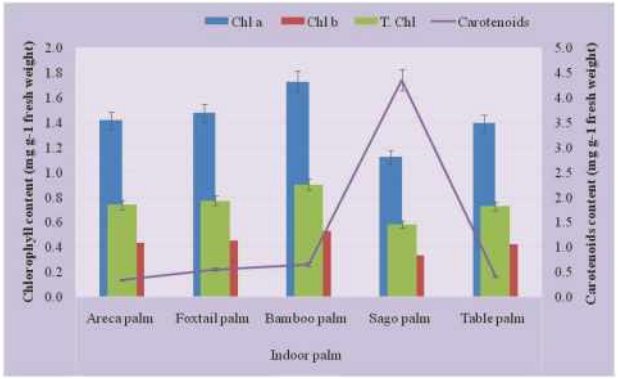


Fig. 2.9. Chlorophyll a, b and total chlorophyll content and total carotenoids content in five varieties of Palms

2.1.3.2 Secondary metabolites

The data obtained on secondary metabolites work clearly indicated that significant variations in total phenols and flavonoids were noticed among different varieties. In Sago palm contained higher total phenols (104 µg/mL), whereas Table palm had lower total phenols (66 µg/mL) (Fig. 2.10). Total flavonoids was recorded higher in case of Sago palm (104 µg/mL), whereas Table palm had lower total flavonoids (50 µg/mL).

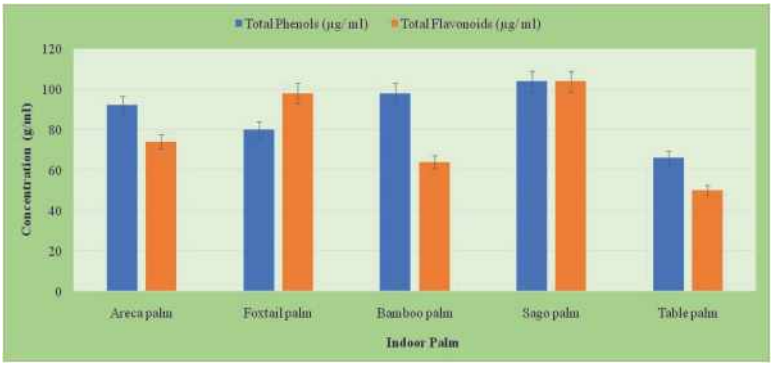


Fig. 2.10. Total phenols and total flavonoids content in leaves of five varieties of palms

2.1.3.3 Oxygen liberation and relative humidity in leaf

In indoor palms, the total oxygen liberation by leaf content was observed higher in areca palm (21.19%), whereas table palm was found lower oxygen liberation by leaf (21.17%) (Fig. 2.11).

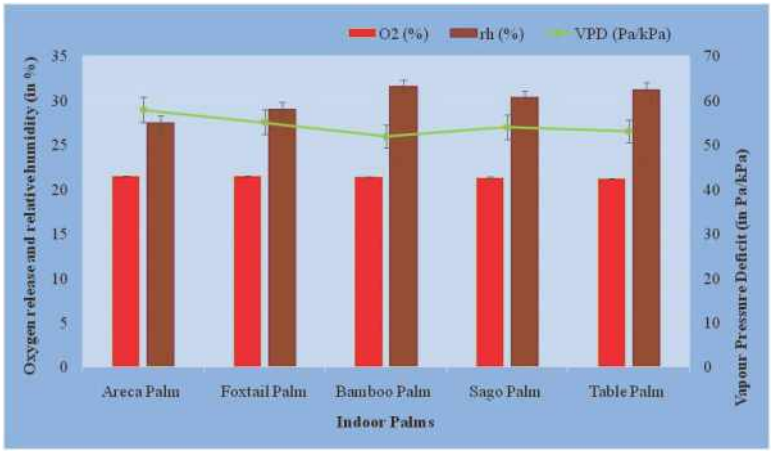


Fig. 2.11. Oxygen releasing efficiency and relative humidity in the leaves of five varieties of palms

2.1.3.4 Histochemical variations

Striking anatomical changes were observed in top, middle and bottom leaf sample in all the varieties. In variety Bamboo Palm higher number of vascular bundles were observed among all the five palm varieties followed by Sago Palm where least number of vascular bundles were observed in Table Palm. The arrangement of vascular bundle was observed in elliptical manner as shown in Fig. 2.12.

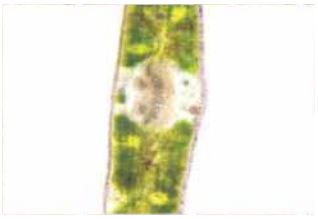
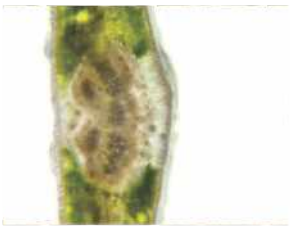
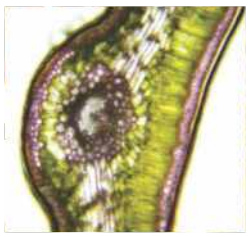
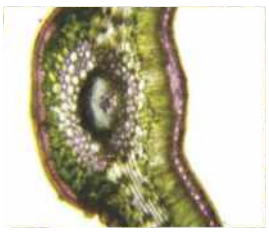
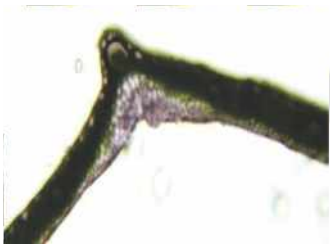
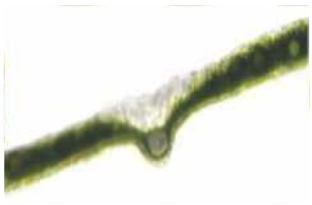
Variety	Top Leaf Sample	Middle Leaf Sample	Bottom Leaf Sample
Areca Palm			
Foxtail Palm			
Bamboo Palm			
Sago Palm			
Table Palm			

Fig. 2.12. Anatomical variations in five different varieties of palms.

2.1.4 Snake Plant

Five different varieties of snake plants were selected, namely- i) *Sensevaria laurentii*, ii) Futura supera, iii) Moonshine, iv) Hanhi, and v) Bacularis

2.1.4.1 Chlorophyll content

In snake plant, the total chlorophyll content was observed higher in Hanhi (2.119 mg/g fresh weight of leaf) (Fig. 2.13), whereas Moonshine contained lower chlorophyll content (1.493 mg/g fresh weight of leaf). Further, carotenoids were observed to be higher in Hanhi (1.831 mg/g fresh weight of leaf) whereas *S. laurentii* contained lower carotenoids content (0.520 mg/g fresh weight of leaf).

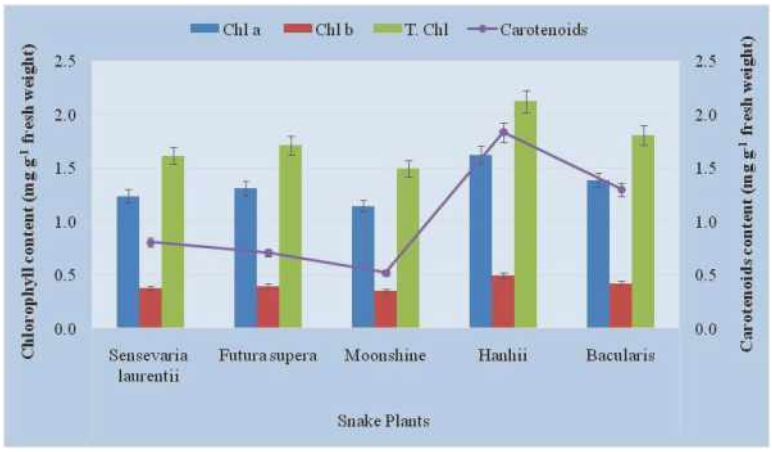


Fig. 2.13. Chlorophyll a, b and total chlorophyll content and total carotenoids content in five varieties of snake plants

2.1.4.2 Secondary metabolites

The data obtained on secondary metabolites clearly indicated significant variation in total phenols and total flavonoids content among different varieties. In Bacularis, higher total phenols (65 µg/mL) were recorded, whereas Futura Supera contained lower (43 µg/mL) content of total phenols. Further, total flavonoid content was higher in case of *Sansevieria laurentii* (107 µg/mL), whereas in Futura Supera contained lower total flavonoids (62 µg/mL) (Fig. 2.14).

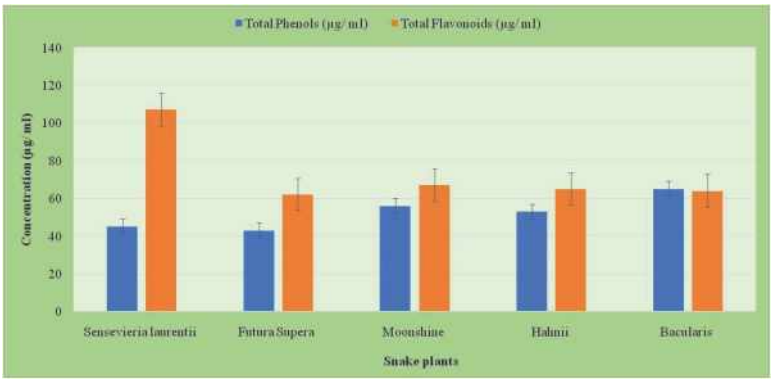


Fig. 2.14. Total phenols and total flavonoids content in the leaves of five varieties of snake plant

2.1.4.3 Oxygen liberation and relative humidity in leaf

In Snake plant, the total oxygen liberation by leaf was observed higher in *Sansevieria laurentii* (20.92%), whereas Bacularis was found lower oxygen liberation by leaf (20.83%) (Fig. 2.15).

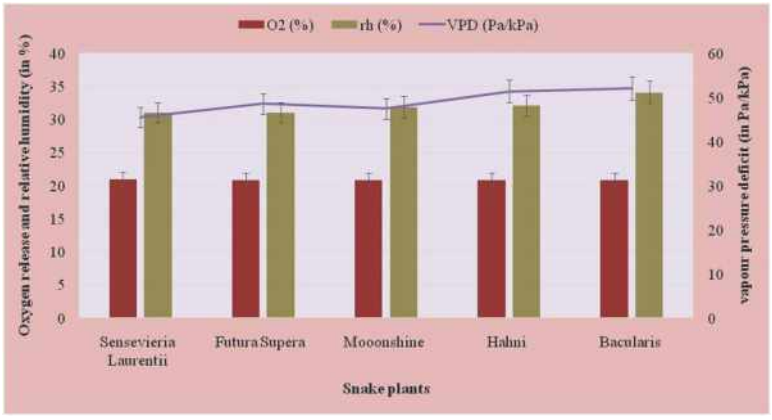


Fig. 2.15. Oxygen releasing efficiency and relative humidity (%) in leaves of five varieties of snake plants

2.1.4.4 Histochemical variations

In Snake Plant, there were distinct anatomical changes observed in top, middle and bottom leaf sample. The variety *Sansevieria laurentii* had higher number of vascular bundles among all the five varieties followed by Moonshine and Futura supera, whereas least number of vascular bundles were observed in Bacularis. The arrangement of vascular bundles were found to be scattered as shown in Fig. 2.16.

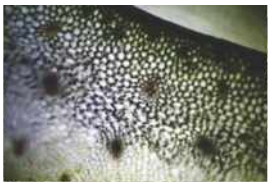
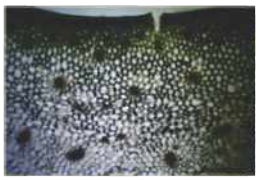
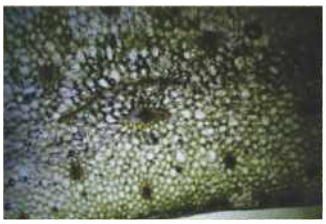
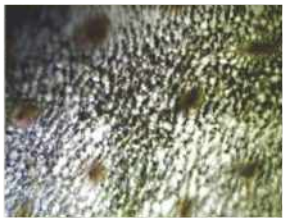
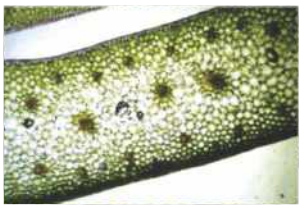
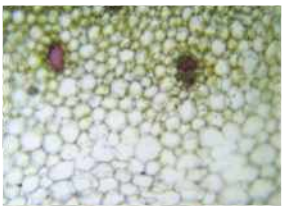
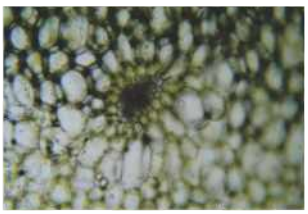
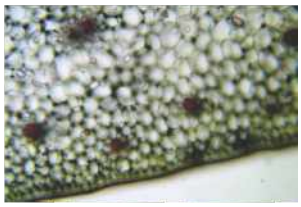
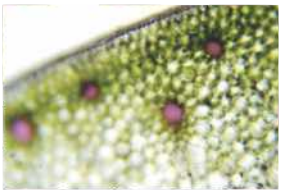
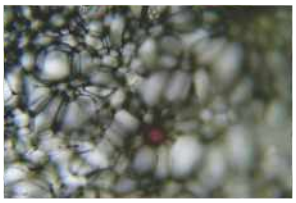
Variety	Top Leaf Sample	Middle Leaf Sample	Bottom Leaf Sample
Sensevieria laurentii			
Futura Supera			
Moonshine			
Hahnii			
Bacularis			

Fig. 2.16. Anatomical variations in five different varieties of snake plants

2.1.5 Chlorophytum

Five different varieties of Chlorophytum were selected, namely- i) Chlorophytum Hawaiian, ii) Chlorophytum Green, iii) *Chlorophytum comosum*, iv) *Chlorophytum laxum*, and v) *Chlorophytum pendananus*

2.1.5.1 Chlorophyll content

In *Chlorophytum*, total chlorophyll content was observed to be higher in *Chlorophytum* Green (2.21 mg/g fresh weight of leaf), whereas Chlorophytum Hawaiian contained lower chlorophyll content (1.635 mg/g fresh weight of leaf). Further, carotenoids were observed to be higher in *Chlorophytum Hawaiian* (4.528 mg/g fresh weight of leaf) whereas *Chlorophytum laxum* contained lower carotenoid content (3.196 mg/g fresh weight of leaf) (Fig. 2.17).

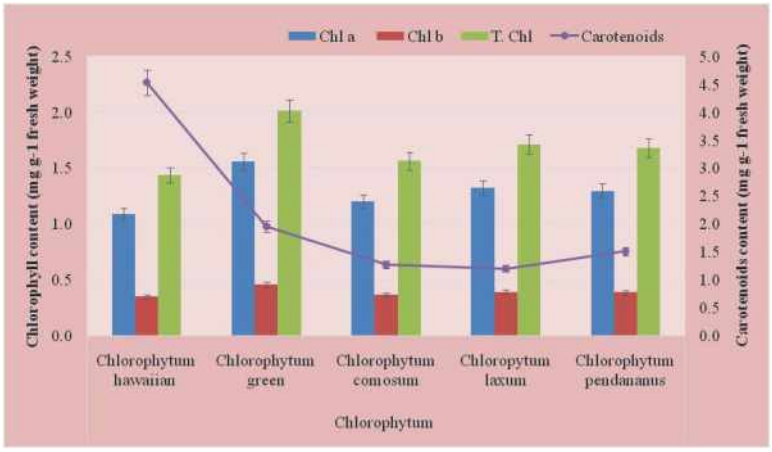


Fig. 2.17. Chlorophyll a, b and total chlorophyll content and total carotenoids content in five varieties of *Chlorophytum*

2.1.5.2 Secondary metabolites

The data obtained on secondary metabolites clearly indicated that significant variations in total phenols and flavonoids content was observed among various varieties. In *Chlorophytum pendananus* higher total phenols (100 µg/mL) were recorded, whereas *Chlorophytum hawaiian* contained lower levels (62 µg/mL) of total phenols (Fig. 2.18). Total flavonoids contained higher in case of *Chlorophytum Hawaiian* (64 µg/mL), whereas *Chlorophytum pendananus* contained lower total flavonoidss (30 µg/mL).

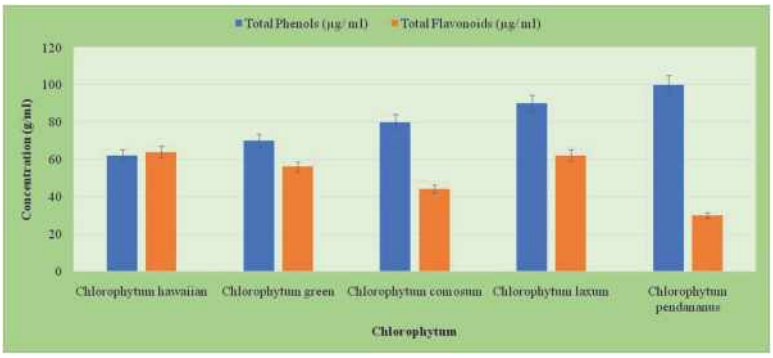


Fig. 2.18. Total phenols and total flavonoids content in the leaves of five varieties of *Chlorophytum*

2.1.5.3 Oxygen liberation and relative humidity in the leaf

In *Chlorophytum,* the total oxygen liberation by leaf was observed to be higher in *Chlorophytum comosum* (21.47%), whereas Chlorophytum Hawaiian had lower oxygen liberation (21.31%) (Fig. 2.19).

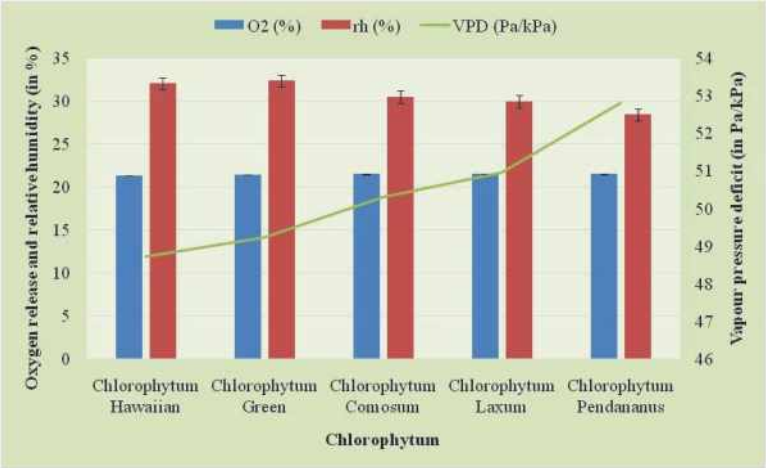
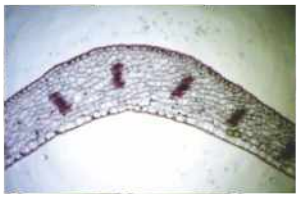
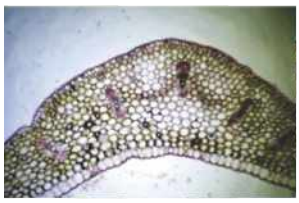
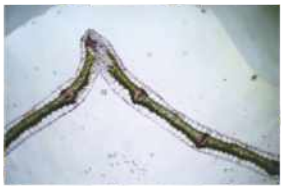
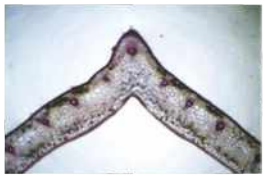


Fig. 2.19. Oxygen releasing efficiency and relative humidity (%) in leaves of five varieties of *Chlorophytum*

2.1.5.4 Histochemical variations

In *Chlorophytum*, significant anatomical variations were observed in top, middle and bottom leaf sample. Chlorophytum Green contained higher number of vascular bundles among all the five varieties followed by *Chlorophytum comosum* whereas least number of vascular bundles were observed in *Chlorophytum pendananus*. The arrangement of vascular bundle was observed in center of the leaf in linear manner as shown in Fig. 2.20.

Variety	Top Leaf Sample	Middle Leaf Sample	Bottom Leaf Sample
Chlorophytum Hawaiian			
Chlorophytum Green			
Chlorophytum comosum			
Chlorophytum laxum			
Chlorophytum pendananus			

3. Crop Protection

3.1 Exploration and Utilization of Predatory Mites and Bugs for the Management of Thrips and Mites on Commercial Flower Crops

3.1.1 Anthocorid bugs recorded on floricultural crops

Bugs belonging to the family anthocoridae are polyphagous insect predators. Anthocorid bugs are ideal biocontrol agents, due to their high searching efficiency and feeding rate, short duration of development, density dependent response to the pest population and synchronization of predator and prey population. *Orius* spp. was the common anthocorid bug species recorded on floricultural crops. The *Orius* spp. was found to be feeding on the sucking pests (Table 3.1)

Table 3.1: List of Anthocorid bugs recorded on floricultural crops

Sl. No.	Host plant	Bug species
1	*Cosmos sulphurous*	*Orius* spp.
2	Chrysanthemum	*Orius* spp.
3	*Hibiscus rosasinensis*	*Orius* spp.
4	*Polianthes tubrosa*	*Orius* spp.
5	*Rosa* spp.	*Orius* spp.
6	*Ficus benjamina*	*Blaptostethus pallescens*

3.1.2 Predatory potential of predatory mite, *Neoseiulus longispinosus* on two spotted spider mite, *Tetranychus urticae*

The functional response of predator describes the interaction between number of prey consumed at various prey densities and prey stages. The predatory potential of *N. longispinosus* was found to be increasing with increase in number of prey densities (Table 3.2, 3.3).

Table 3.2: Feeding potential of *Neoseiulus longispinosus* on red spider mite

Prey density	Mean consumption in 24 hours		
	Egg	Nymph	Adult
5	2.40 (1.82)	2.40 (1.83)	2.00 (1.71)
10	5.00 (2.43)	3.40 (2.08)	2.60 (1.88)
15	6.40 (2.70)	5.20 (2.48)	3.20 (2.04)
20	7.20 (2.85)	6.20 (2.65)	4.00 (2.21)
25	7.80 (2.95)	7.00 (2.80)	4.40 (2.28)
30	8.20 (3.03)	7.20 (2.84)	5.00 (2.40)
CD @ 0.01%	0.31	0.39	0.47

Table 3.3: Functional response of *Neoseiulus longispinosus* to different prey stage of *Tetranychus urticae*

Prey density	Mean consumption in 24 hours		
	Egg	Nymph	Adult
5	0.80 (1.33)	0.43 (1.19)	0.10 (1.05)
10	1.50 (1.57)	0.77 (1.32)	0.33 (1.15)
15	2.25 (1.80)	1.03 (1.42)	0.63 (1.27)
20	2.43 (1.85)	1.27 (1.50)	0.97 (1.40)
25	2.48 (1.86)	1.60 (1.61)	1.20 (1.48)
30	2.51 (1.87)	1.73 (1.65)	1.27 (1.50)
CD @ 0.01%	0.13	0.09	0.07

3.2 Eco-friendly Pest Management in Commercial Loose Flower Crops

3.2.1 Identification of resistance sources of Chrysanthemum against *Spodoptera litura*

A total of 151 chrysanthemum genotypes were screened; out of which 02 genotypes (Bidhan Rupanjali and Bidhan Agnisikha) were found to be potential resistant sources against *S. litura.* Whereas no resistance source (s) of chrysanthemum were not observed against aphids, *Aphis gossypii* & *Macrosiphoniella sunburni.*

3.2.2 Natural enemy complex of tuberose mealybug, *Dysmicoccus neobrevipes*

Natural enemy complex of tuberose mealybug, *D. neobrevipes* was studied under field conditions. Entomopathogenic fungus, *Cladosporium cladoproides* (Fig. 3.1) and rove beetle (unidentified species of staphylinidae) (Fig 3.2) were found to be the major natural enemies of *D. neobrevipes* under field conditions. Entomopathogenic fungus, *C. cladoproides* was characterized at morphological level and further confirmed at molecular level.

Fig. 3.1 *Cladosporium cladoproides* infected mealybug cadaver

Fig. 3.2. Staphylinid beetle feeding on mealybug nymphs

3.2.3 Screening of tuberose genotypes for resistance against mealybug, *Dysmicoccus neobrevipes*

Among 22 tuberose varieties screened, 02 tuberose varieties *viz*., Arka Prajwal and Pune local double were found to be highly susceptible varieties and they act as a reservoir for mealybug, *D. neobrevipes* (Fig. 3.3). Five varieties *viz*., Hyderabad Single; GKTC- 4; Bidhan Ujjwal; Calcutta Double; Sringar were observed to be moderately susceptible. Two-year field studies in choice and no-choice conditions revealed that Bidhan Snigdha, Swarna Rekha and Phule Rajat were found to be resistant to subterranean mealybug, *D. neobrevipes* (Fig. 3.4). Resistance factor (s) in these genotypes are being identified.

Fig. 3.3 Screening of tuberose genotypes against mealybugs under field conditions (3.3A) and mealybug (*D. neobrevipes*) infestation on tuberose variety 'Prajwal' (3.3B)

Fig. 3.4 Mealybug (D. neobrevipes) resistance sources of tuberose

3.2.4 Screening of tuberose genotypes for resistance against bud borer, *Helicoverpa armigera*

Different tuberose genotypes were screened to identify the resistance source against bud borer, *H. armigera*. Bud borer infestation was recorded upto 16.63% in tuberose genotypes, except genotype Pune local single, which was found to be free from bud borers throughout the season (Fig. 3.5)

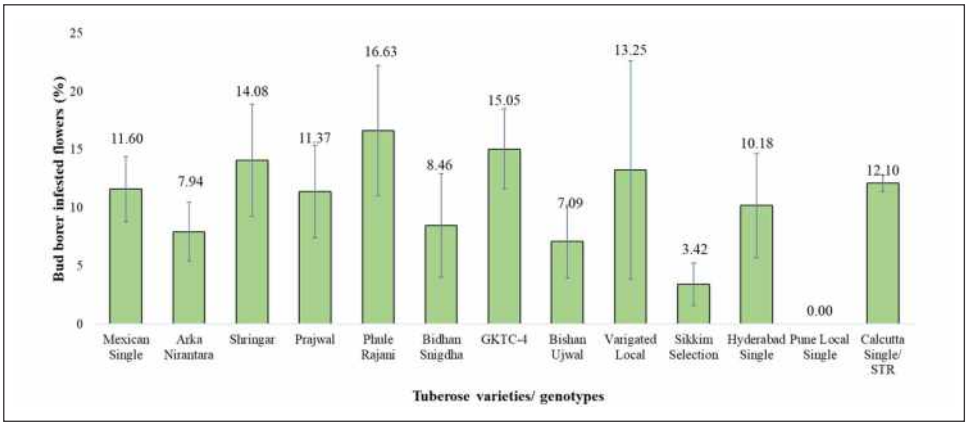


Fig. 3.5 Bud borer infestation (%) in different tuberose genotypes under field conditions

3.2.5 Morphological and molecular characterization of blossom midge *Contarinia maculipennis* infesting tuberose flower buds

The blossom midge specimens collected from various locations in India have been confirmed to be the species *'C. maculipennis* Felt'. This identification was based on characteristics such as the arrangement of spiracles on the maggot's eighth abdominal segment and the relative lengths of antennal flagellomeres in females and males (Fig. 3.6). These findings align with descriptions provided in previous scientific literature. Importantly, this study marks the first documented instance of infestation of tuberose buds by the blossom midge *C. maculipennis* worldwide. The specimens were also characterized at molecular level. The representative mtCOI sequence for *C. maculipennis* has been deposited in the NCBI database under accession number 'OQ781199'.

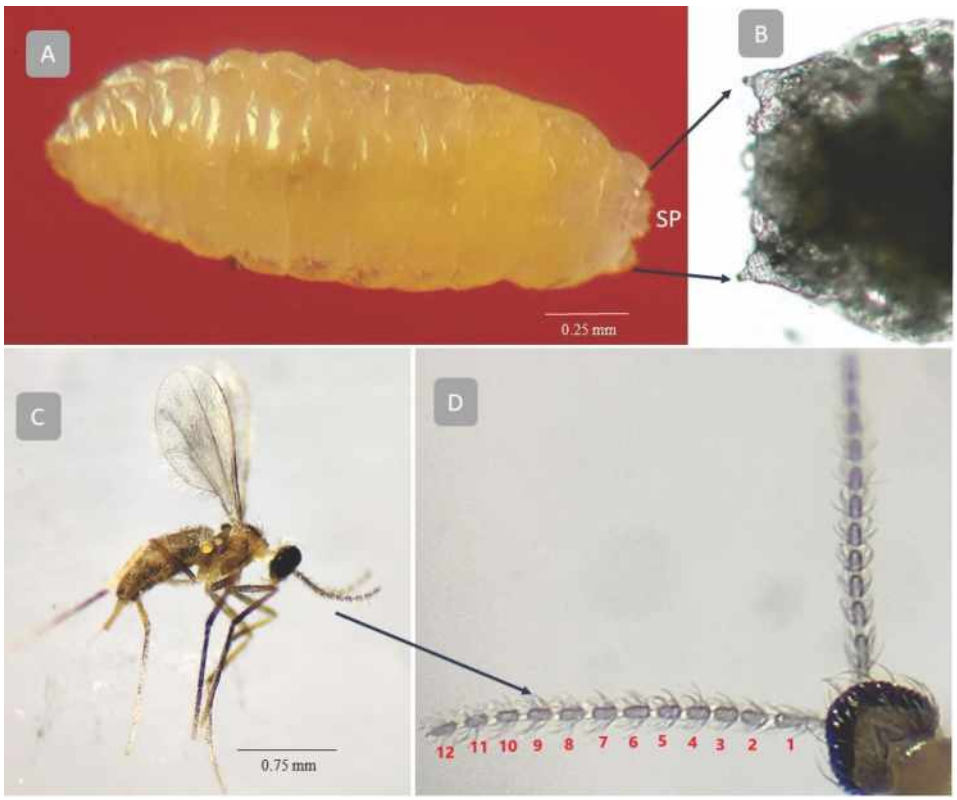


Fig 3.6 Diagnostic characters of *C. maculipennis*. The spiracles of the maggot's eighth abdominal segment at the end of the posteriorly directed lobes (Figure 3.6A & B); First antennal flagellomere of female is 1.87 times as long as the second (Figure 3.6C & D). (Published as: Firake et al. 2024. Blossom midge *Contarinia maculipennis* Felt infesting tuberose (*Agave amica*) flowers in India. *Current Science*. 126(2): 263-270.)

3.2.6. Evaluation of IPM module (s) against blossom midge infesting tuberose at Pune

The IPM module was developed based on the eco-biology of the target pest and its interactions with the new host, 'Tuberose.' The module was evaluated under field conditions for two seasons at two locations: Pune (Maharashtra) and Vemagiri, Kadiyam (Andhra Pradesh). At Pune farm, the adoption of IPM I (without chemical pesticides) proved highly effective against blossom midges. In IPM I plots, midge incidence decreased from 37.88% to 10.13% during the first season (2022-23) and from 25.79% to 8.62% during the second season trial (2023-24) (refer to Table 3.4). Additionally, the marketable yield of tuberose was significantly higher in IPM I plots, yielding 12.61 tonnes/ha during 2022-23 and 12.40 tonnes/ha during 2023-24. The Incremental Benefit Cost Ratio (IBCR) was recorded at 2.59 to 2.84 during the two seasons (Table 3.4).

At Vemagiri (Andhra Pradesh) farm also, the implementation of IPM I demonstrated high effectiveness against blossom midges. In IPM I plots, midge incidence decreased from 31.29% to 9.63% during the first season (2022-23) and from 25.79% to 8.62% during the second season trial (2023-24) (refer to Table 3.5). Additionally, the marketable yield of tuberose showed a significant increase in IPM I plots, reaching 12.46 tonnes/ha during 2022-23 and 13.24 tonnes/ha during 2023-24. The Incremental Benefit Cost Ratio (IBCR) was recorded between 2.35 and 2.56 over the two seasons, highlighting the economic advantages of this approach (Table 3.5).

Table 3.4 Evaluation of IPM module (s) against blossom midge infesting tuberose at Pune

Treatments	Mean bud damage (%) at harvesting		Yield (tonnes/ha)		Incremental Benefit Cost Ratio (IBCR)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
IPM module I (Proposed module)	10.13	8.62	12.61	12.40	2.84	2.59
IPM module II (Comparison purpose)	9.92	7.83	12.91	12.86	2.92	2.75
Farmer's practice (Comparison purpose)	33.50	24.83	5.22	5.96	0.11	1.05
Untreated Control (Check)	37.88	25.79	4.71	5.03	-	-
SEM (±)	1.22	0.65	0.45	0.31	-	-
df (error)	21.00	21.00	21.0	21.0	-	-
CD at 5%	3.60	1.90	1.33	0.92	-	-

Note: Components of different management modules

IPM module I: Accurate & timely diagnosis + Regular harvesting & destruction of infested buds + Avoiding flood irrigation + Frequent racking up/harrowing the soil between tuberose at 20-25 day's interval + sticky traps @ 100/ha + Spray NSKE 5% @ 5 ml/litre water for three times at 20 day's interval during flowering. Discourage use of chemical pesticides

IPM module II: Components similar to IPM module I except here the botanical NSKE 5 is replaced with chemical pesticide 'Lambda-cyhalothrin 5 %EC @ 0.75 ml/litre water at 20 days intervals during flowering

Farmer's practice: (based on survey conducted in different tuberose growing areas): Three sprays each of mix formulation of Thiamethoxam 12.6 % + Lambda-cyhalothrin 9.5 % ZC @ 0.5 ml/litre and Profenofos 40 % + Cypermethrin 04 % EC @ 2ml/litre at 10 days interval starting from bud initiation stage

Table 3.5 Evaluation of IPM module (s) against blossom midge infesting tuberose at Vemagiri, Kadiyam (Andhra Pradesh)

Treatments	Mean bud damage (%) at harvesting		Yield (tonnes/ha)		Incremental Benefit Cost Ratio (IBCR)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
IPM module I (Proposed module)	9.63	8.62	12.46	13.24	2.35	2.56
IPM module II (Comparison purpose)	9.38	7.83	12.59	13.46	2.36	2.60
Farmer's practice (Comparison purpose)	29.75	24.83	6.18	6.59	0.32	0.44
Untreated Control (Check)	31.29	25.79	5.58	5.93	-	-
SEM (±)	0.80	0.65	0.28	0.47	-	-
df (error)	21.00	21.00	21.0	21.0	-	-
CD at 5%	1.13	1.90	0.84	1.38	-	-

Note: Components of different management modules

IPM module I: Accurate & timely diagnosis + Regular harvesting & destruction of infested buds + Avoiding flood irrigation + Frequent racking up/harrowing the soil between tuberose at 20-25 day's interval + sticky traps @ 100/ha + Spray NSKE 5% @ 5 ml/litre water for three times at 20 day's interval during flowering. Discourage use of chemical pesticides

IPM module II: Components similar to IPM module I except here the botanical NSKE 5 is replaced with chemical pesticide 'Lambda-cyhalothrin 5 %EC @ 0.75 ml/litre water at 20 days intervals during flowering

Farmer's practice: (based on survey conducted in different tuberose growing areas): Three sprays each of mix formulation of Thiamethoxam 12.6 % + Lambda-cyhalothrin 9.5 % ZC @ 0.5 ml/litre and Profenofos 40 % + Cypermethrin 04 % EC @ 2ml/litre at 10 days interval starting from bud initiation stage

3.2.7. Studies on bud borer complex of Jasmine: Molecular and Grower-friendly diagnosis and bio-ecology

During the rainy and post-rainy season in 2023, jasmine buds suffered damage from over 8 species of borers, predominantly *Contarinia* sp., *Hendecasis duplifascialis, Palpita vitrealis, Phycita* sp., *Orgyia* sp., *Lobesia* sp., *Olene mendosa,* and *Problepsis* sp., with up to 98.80% of buds affected. Species specific DNA barcodes targeting CO I gene of mitochondrial DNA were developed for the borers. These barcodes will be helpful for rapid and reliable diagnosis of borer species infesting jasmine. Grower-friendly diagnosis system has also been developed to reliably detect borer species based on the symptoms they produce on host plant parts such as size and position of bored hole, excreta size, colour and structure, webbing style *etc*.

3.2.8. Studies on diversity of flower visitors on China aster during 2023

Studies were conducted to know different insect species visiting aster flowers. More than 72 species of insects were found visiting aster flowers during day time. Among them, Lepidoptera and Hymenoptera were the dominant orders followed by Diptera and Coleoptera. The activity of flower visitors was significantly higher during 10.00AM to 2.00PM (Fig. 3.7).

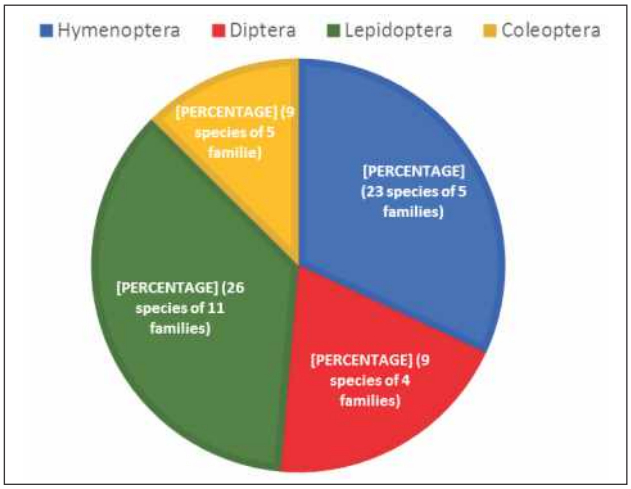


Fig. 3.7 Diversity of flower visitors on China aster

3.2.9. Effect of bee pollination on yield and physiological parameters of aster seeds

Field trial was repeated to determine the role of bee pollination in enhancing quality and quantity of aster seeds. Red dwarf bee, *Apis florea* was found to be the dominant pollinator species on aster flowers followed by Indian bee *A. cerana*. Results of the field trial conducted during 2023 revealed that bee pollination play a significant role in enhancing quality and quantity of seed yield under field conditions. Seed yield was found to be increased by 2.3 times in bee pollinated plots compared to bee pollination excluded plots and test weight from 1.72g to 2.3g. Also, it has increased germination (%) of seeds from 30.25% to 91% in aster variety Phule Ganesh Pink.

3.2.10. Foraging ecology of pollinators on different aster genotypes of ICAR DFR, Pune

China aster crop attract large number of flower visitors including pollinator. Foraging bahavior of two honey bee species *viz*., *A. cerana* and *A. florea* were recorded on aster genotypes. Four aster genotypes *viz*., DFR-Ento-11, DFR-Ento-12, DFR-Ento-13 and DFR-Ento-09 found to have significantly higher abundance (bees/sqm/3min) and foraging speed (in seconds) of bees; whereas significantly less foraging rate (flowers/min) compared to other genotypes (Table 3.6). Different floral traits of four bee-friendly aster genotypes have been shown in Fig. 3.8.

Table 3.6 Foraging behaviour of pollinators on bee-friendly aster genotypes:

Foraging Parameters	DFR-Ento-11	DFR-Ento-12	DFR-Ento-13	DFR-Ento-09
Bee species studied	*A. cerana, A. florea*	*A. cerana A. florea*	*A. cerana A. florea*	*A. cerana A. florea*
Relative abundance of bees (bees/sqm/3min)	45.14	31.99	24.72	33.73
Foraging rate of bees (flowers/min)	3.31	3.03	3.54	3.01
Foraging speed of bees (seconds)	21.97	22.91	20.42	23.42

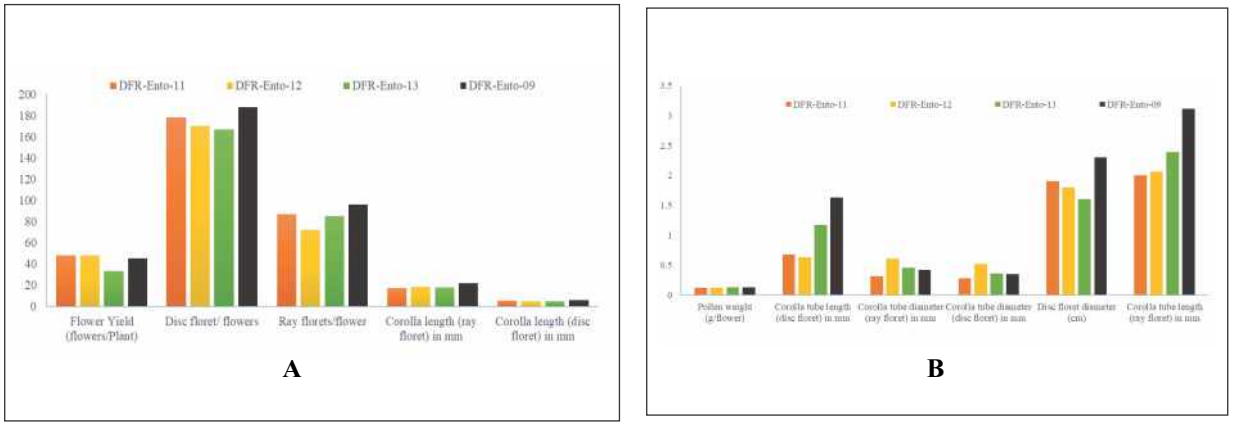


Fig 3.8 Floral traits of four bee-friendly aster genotypes (3.8A&B)

3.2.11. Studies on floral traits of chrysanthemum in relation to foraging ecology of pollinators

Different floral traits were studied in selected 20 chrysanthemum genotypes based on previous experiments. Different genotypes found to have significant variations in visual appearance as depicted in Fig 3.9 (UV & natural light images). Also, significant variations were found in different floral traits of chrysanthemum genotypes *viz*., flower colour (RHS chart); level of attractiveness to bees, flower diameter (cm), disk floret diameter (cm), disk florets/flower, ray floret/ flower and pollen weight (g/flower) (See Table 3.7). We further studied correlation of floral traits of chrysanthemum with foraging parameters of honey bees. Disk floret diameter (cm) and number of disc florets/flower were found to have significant positive correlation with abundance and foraging speed of bees; whereas ray florets per flower recorded significant negative correlation with abundance of bees (Table 3.8)

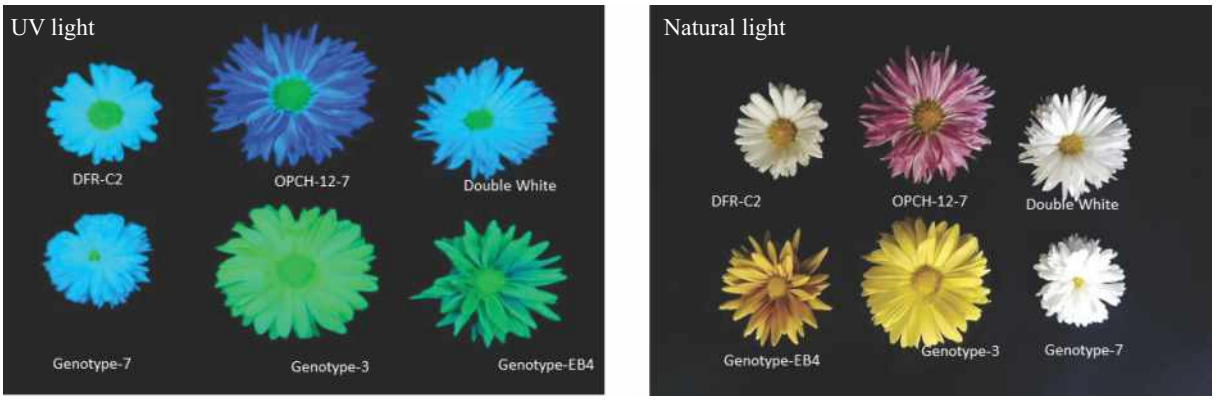


Fig. 3.9 UV and natural light flower images of selected chrysanthemum genotypes.

Table 3.7 Floral characters of different chrysanthemum genotypes in relation to foraging ecology of bees

Varieties	Flower colour (RHS chart)	Level of attractiveness to bees	Flower Diameter (cm)	Disk Floret Diameter (cm)	Disk Florets/ Flower	Ray Floret/ Flower	Pollen weight (g/flower)
DFR C-2	White Group -NN-155-B	Very High	4.10	1.37	174.00	70.67	5.84
OPCH D. White	White group -NN-155-C	Very High	4.37	1.30	157.00	41.33	9.88
OPCH 12-7	Purple Red -NN-74-A	Very High	4.10	1.03	150.00	65.67	8.66
Pusa Sweth	White Group NN155 –A0	High	5.67	1.30	165.00	94.00	13.86
Pusa Chitraksha	Red Purple Group 70-A	High	4.30	1.23	119.00	63.75	10.48
PAU 147-11	Red Purple Group -60A	High	5.13	1.30	158.00	99.00	9.57
DFR C-3	Yellow Group-7-C	Medium	6.13	1.47	143.85	54.33	10.97
DFR C-7	White Group -NN-155-D	Medium	4.70	1.17	224.00	36.67	9.59
OPCH 13-3	White Group -NN-155-A	Medium	4.50	0.70	72.33	192.00	11.26
PUSA Aditya	Yellow Group 6-A	Less	4.43	1.37	108.67	32.33	9.03
PUSA Kesari	Greyed Orange 163-A	Less	4.23	0.80	56.33	168.00	9.20
OPCH 13-2	White Group -NN-155-A	Less	3.83	0.97	175.00	73.00	9.70
OPCH-Yellow	Yellow Group -3-A	Less	3.23	0.67	64.67	160.33	10.72
DFR C-4	Yellow Group-5-A	No	4.37	0.87	87.33	131.67	11.66
PAU-35	White Group -NN-155A	No	4.63	0.90	132.33	137.33	7.91
Classic Pink	Purple Group -N-78-A	No	4.97	1.33	172.67	48.67	13.08
F value			13.66	11.63	6.03	19.93	4.35
P value			0.00	0.00	0.00	0.00	0.00

Table 3.8 Correlation of different floral characters of chrysanthemum with foraging parameters of the honey bees

Parameters	Total Diameter (cm)	Disk Floret Diameter (cm)	Disk Florets/Flower	Ray Florets/ Flower	Pollen weight (g/flower)	Abundance	Foraging rate	Foraging speed
Total Diameter (cm)	1	.472**	.366**	-.112	.463**	-.016	.033	.110
Disk floret Diameter (cm)		1	.622**	-.791**	.060	.284*	-.108	.249*
Disk florets/flower			1	-.648**	.039	.465**	-.118	.322**
Ray florets/ flower				1	.098	-.345**	.122	-.137
Pollen weight (g/flower)					1	-.205	.121	-.188
Abundance						1	.123	.503**
Foraging rate							1	.179
Foraging speed								1

3.2.12 Identification of bee-friendly genotypes of chrysanthemum

Out of the 20 chrysanthemum genotypes that were chosen for examination regarding bee-friendly traits; three genotypes viz., OPCH 12-7; OPCH Double white and DFR C-2 recorded to have higher abundance (>40 bees/plant/3min) and foraging speed (>20 seconds/ flower) and lower foraging rate (< 6 flowers/ min) compared to other genotypes. Considering the favourable foraging parameters these three genotypes were found to be bee-friendly genotypes. Therefore, different floral traits were studied in these three genotypes of chrysanthemum (Fig 3.10). Number of flowers per plants and corolla length (mm) of ray florets were found to be significantly higher in OPCH-12-7 (Fig. 3.10A & F); whereas pollen weight per flower & ray florets per flower observed to be more in DFR Double white (Fig. 3.10D &E). Disc floret diameter (cm) was recorded to be considerably higher on variety DFR-C2 (Fig. 3.10C).

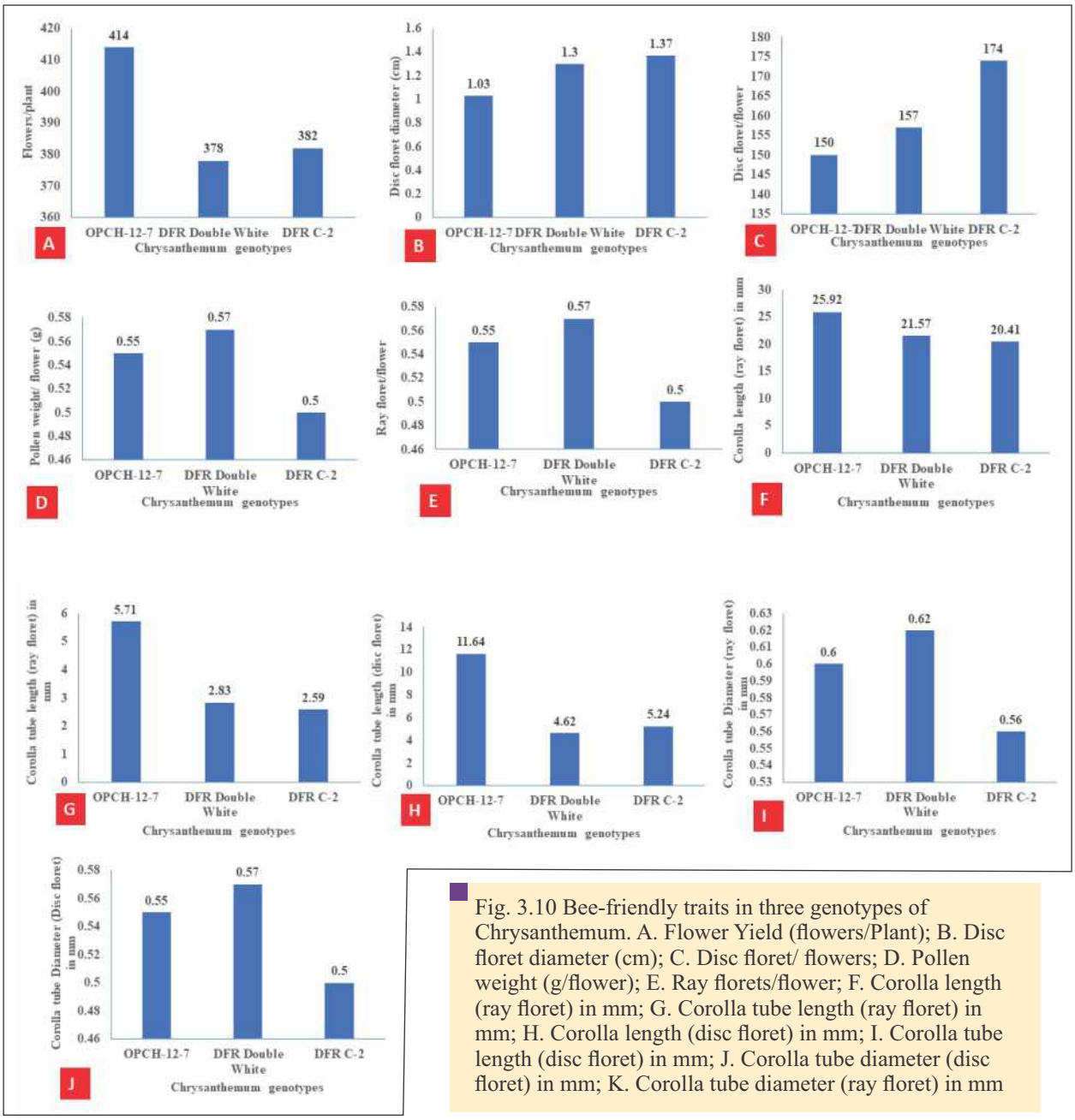


Fig. 3.10 Bee-friendly traits in three genotypes of Chrysanthemum. A. Flower Yield (flowers/Plant); B. Disc floret diameter (cm); C. Disc floret/ flowers; D. Pollen weight (g/flower); E. Ray florets/flower; F. Corolla length (ray floret) in mm; G. Corolla tube length (ray floret) in mm; H. Corolla length (disc floret) in mm; I. Corolla tube length (disc floret) in mm; J. Corolla tube diameter (disc floret) in mm; K. Corolla tube diameter (ray floret) in mm

3.3. Integrated Nematode Management in Flower and Ornamental Nursery Crops

3.3.1 Root-knot nematode problem in flower and ornamental nursery crops

Identified root-knot nematode (RKN) problem in Gomphrena (open-field), Nerium and Bauhinia in Kadiyam nursery areas (Fig. 3.11 A, B&C). RKN affected Gomphrena plants were stunted, and the foliage showed withering with extreme discolouration and yellowing. Very conspicuous and peculiar galls are present on roots. At later stages, the plant were wilted and roots completely rottened. In Bauhinia plants, root-knot infection was observed in nurseries that are present in poly bags (Kadiyapulanka area). Heavily infested with root-knot and severe galling was observed on these roots. In case of Nerium, root-knot nematode infection was observed as patchy appearance in open-field conditions. Infected plants showed stunted growth and yellowing of leaves.

Fig. 3.11A: Root-knot nematode problem in Gomphrena

Fig 3.11B: Root-knot nematode problem in Nerium

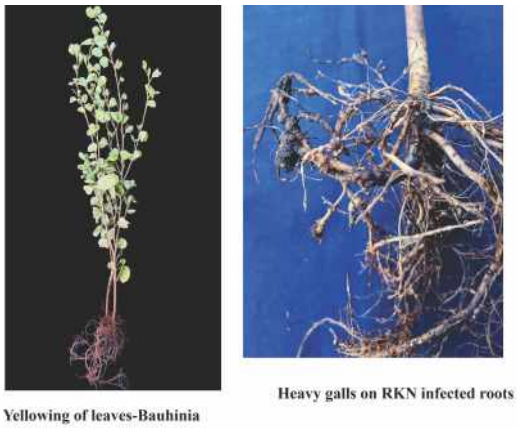


Fig 3.11C: Root-knot nematode problem in Bauhinia

3.3.2 Evaluation of new nematicides under field condition against root-knot nematode in Tuberose

The efficacy of new nematicides, fluopyram 34.48% SC and fluensulfone 2% GR was evaluated with three different concentrations along with carbofuran (recommended dosage) on root-knot nematode in the tuberose field. Local variety, Hyderabad Single (susceptible to root-knot nematode) procured from farmer's fields was used for evaluating nematicides for the root-knot nematode. Out of eight treatments, only two treatments were found effective against root-knot nematode, *viz.*, T6 (Fluopyram 34.48% SC @ 750 ml/ha)

and T_5 (Fluopyram 34.48% SC @ 500 ml/ha) compared to other treatments. When compared to other treatments, the flower yields are significantly higher with the application of Fluopyram 34.48% SC at 750ml per ha (17.88 tonnes/ha) and 500 ml per ha (17.23 tonnes/ha). Nematode population (156-174/250cc soil) and gall index (1.8) were recorded very less in *viz*., T6 (Fluopyram 34.48% SC @ 750 ml/ha) and T_5(Fluopyram 34.48% SC @ 500 ml/ha) compared to other treatments. In untreated control nematode population (523) and gall index (4.9) were recorded higher with less shoot and root growth. Fluopyram higher dose (68, 18.66, 61.66 cm) and medium dose treatments (61, 15.66, 59 cm) exhibited greater parameters, such as plant height, root length, and bulb weight respectively in comparision to the other treatments. There is a significant difference in the spike length of T6 (Fluopyram 34.48% SC @ 750 ml/ha) and T_5(Fluopyram 34.48% SC @ 500 ml/ha) compared to other treatments in which, the spike length is almost similar among treatments. Based on all parameters, it was found that Fluopyram higher two doses were effective followed by Fluopyram 34.48% SC @ 250 ml/ha and Fluensulfone 2% GR @ 3.3 kg a.i./ha (Table 3.9; Fig. 3.12&3.13).

Table 3.9 Effect of different dosages of nematicides in tuberose under field conditions

S No	Treatment	Final nematode population/250 cc soil	Gall index (0-5 scale)	Spike length	Flower yield (Tonnes/ha)	Bulb weight (g)	Plant height (cm)	Root length (cm)
1	T1: Fluensulfone 2% GR@ 1 kga.i./ha	416.7^{d}	3.6^{c}	85.6^{b}	7.56^{c}	30.00^{c}	48.00^{c}	8.30^{ef}
2	T2: Fluensulfone 2% GR@ 2 kga.i./ha	386.7^{c}	3.3^{c}	83.7^{b}	7.47^{c}	34.00^{c}	54.00^{bc}	8.83^{e}
3	T3: Fluensulfone 2% GR@ 3.3 kg a.i./ha	316.7^{b}	3.0^{b}	83.7^{b}	7.87^{c}	46.00^{b}	56.33^{bc}	11.33^{d}
4	T4:Fluopyram 34.48% SC@ 250 ml/ha	308.7^{b}	2.8^{b}	85.9^{b}	9.03^{b}	56.66^{a}	55.33^{bc}	13.33^{c}
5	T5:Fluopyram 34.48% SC@ 500 ml/ha	174.0^{a}	1.8^{a}	94.7^{a}	9.79^{a}	59.00^{a}	61.00^{ab}	15.66^{b}
6	T6:Fluopyram 34.48% SC@ 750 ml/ha	156.7^{a}	1.8^{a}	95.9^{a}	9.81^{a}	61.66^{a}	68.00^{a}	18.66^{a}
7	T7: Carbofuran 3% G @3.3 kg a.i./ ha	410.0^{cd}	3.5^{c}	84.2^{b}	6.73^{d}	4 3.33^{b}	50.00^{c}	12.00^{c}
8	T8: Untreated control	523.3^{e}	4.9^{d}	84.0^{b}	2.73^{2}	18.00^{d}	36.66^{d}	6.66^{f}
	SE	9.69	0.115	2.85	0.17	3.11	2.07	0.80
	CD (P=0.05)	29.67	0.35	8.73	0.55	8.12	8.95	1.34

Note: Planting of nematode-infected bulbs procured from farmers' field

*In a column, any two means having a common letter are not significantly different at the 5% level of DMRT

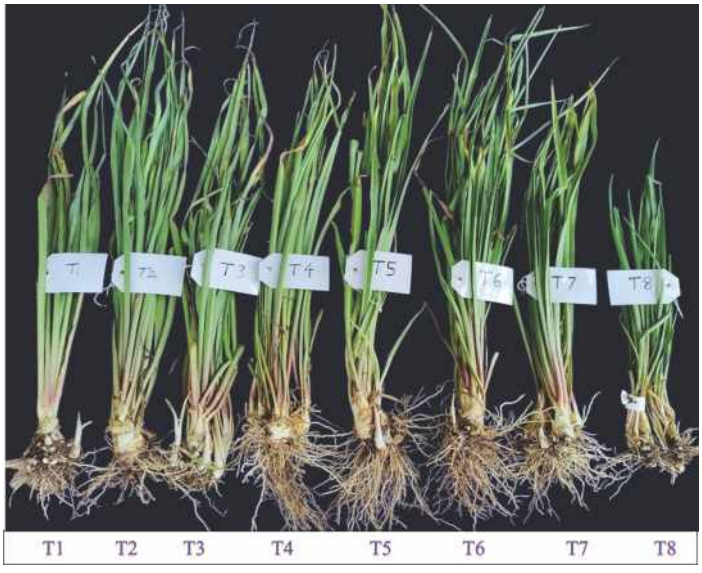


Fig 3.12: Effect of different dosages of nematicide on plant growth parameters (shoot length) in tuberose

Fig 3.13: Effect of different dosages of nematicides on plant growth parameters (root length) in tuberose

3.3.3 Evaluation of Integrated effective nematicide and bioformulations under field condition against root-knot nematode in Tuberose

Evaluated the efficacy of bioformulations (Bio-consortia, *Bacillus pumilus, B. amyloliquifaciens*), and effective nematicide (Fluopyram 34.48% SC) alone and combined effect on root-knot nematode in Tuberose field. Combined dosage of biopesticide and nematicide reduced nematode population effectively compared to the treatments that are given alone. Among all treatments, the flower yields are significantly higher in T6 (13.82 tonnes/ha) and T7 (13.78 tonnes/ha). Growth parameters *i.e.,* shoot length and root length were higher in treatments in T6 (69, 13) and T7 (67, 12.66) compared to other treatments. Nematode population recorded very less in T6 (126) and T7 (117) and higher nematode population recorded in untreated control (411). Based on all parameters, it was found that only two treatments *viz.*, T6 (*Bacillus pumilus* 2.5 kg/ha enriched with FYM + Fluopyram 34.48% SC 250ml/ha) and T7 (*Bacillus amyloliquifaciens* 2.5 kg/ha enriched with FYM + Fluopyram 34.48% SC 250ml/ha) were effective for the management of root-knot nematode in tuberose crop (Table 3.10; Fig. 3.14 & 3.15).

Table 3.10: Evaluation of Integrated effective nematicide and bioformulations under field condition against root-knot nematode in Tuberose

S No	Treatment	Final nematode population/ 250 cc soil	Gall index (0-5 scale)	Flower yield (Tonnes/ha)	Bulb weight (g)	Plant height (cm)	Root length (cm)
1	Bioconsortia (each 2kg enriched in FYM @ 5 t/h)	411.66^{b}	3.50^{b}	2.46^{bc}	60.33^{e}	54.66^{cd}	8.00^{d}
2	*B. pumilus* (5kg enriched in FYM @ 5 t/ha)	388.33^{c}	3.00^{bc}	2.67^{bc}	68.66^{a}	56.00^{cd}	8.33^{cd}
3	*B. amyloliquefasciens* 5kg enriched in FYM @5 t/ha	310.33^{d}	2.83^{cd}	2.53^{bc}	84.33^{c}	58.33^{bc}	9.33^{bcd}
4	Fluopyram 34.48% SC@ 500 ml/ha	285.00^{e}	2.46^{bc}	3.12^{bc}	95.66^{ab}	63.66^{abc}	10.33^{bc}
5	Bioconsortia (each 1 kg enriched in FYM @ 5 t/h) + Fluopyram @ 250 ml/ha	177.00^{f}	2.33^{de}	3.81^{ab}	93.00^{b}	62.33^{abc}	11.33^{ab}

S No	Treatment	Final nematode population/ 250 cc soil	Gall index (0-5 scale)	Flower yield (Tonnes/ha)	Bulb weight (g)	Plant height (cm)	Root length (cm)
T6	*B. pumilus* (2.5kg enriched in FYM @5 t/ha) + Fluopyram @ 250 ml/ha	126.66^{g}	1.66^{f}	4.60^{a}	101. 66^{a}	69.33^{a}	13.00^{a}
T7	*B. amyloliquefasciens* (2.5kg enriched in FYM @5 t/ha) + Fluopyram @ 250 ml/ha	117.66^{g}	1.66^{f}	4.58^{a}	102.6^{a}	67.00^{ab}	12.66^{a}
T8	Untreated control	548.33^{a}	5.00^{a}	2.12^{c}	39.33^{f}	47.33^{d}	7.66^{d}
	SE	6.72	0.75	0.44	2.11	2.07	0.75
	CD (P=0.05)	20.40	0.57	1.34	6.42	9.08	2.28

Note: Planting of nematode-infected bulbs procured from farmers' field
*In a column, any two means having a common letter are not significantly different at the 5% level of DMRT

Fig 3.14: Effect of bioformulations and nematicide on plant growth parameters (shoot length) in tuberose

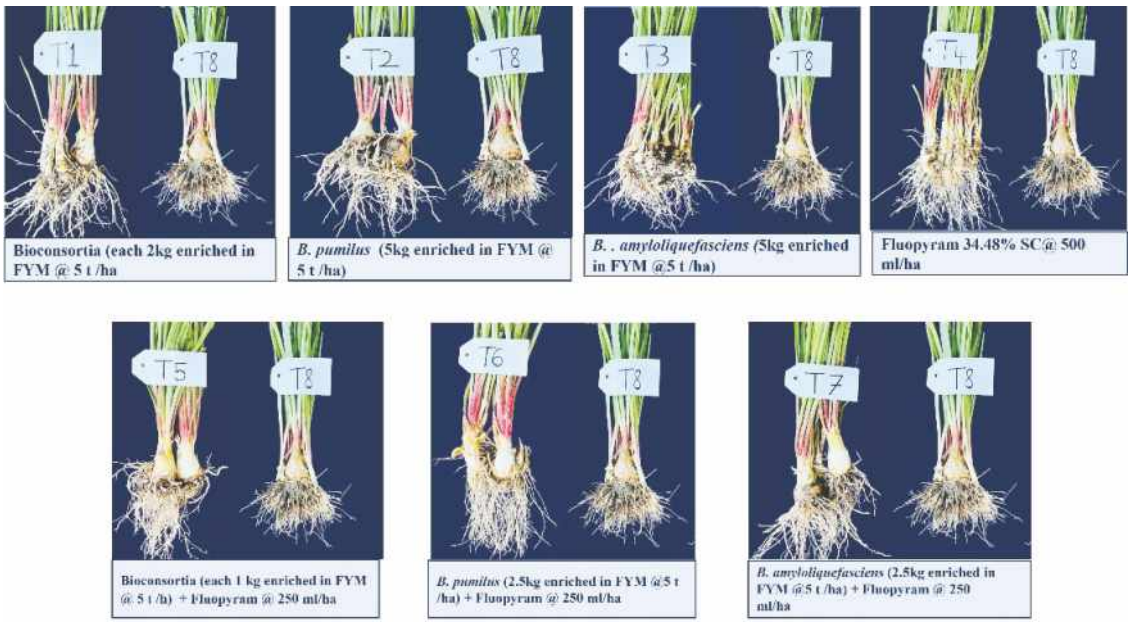


Fig 3.15: Effect of bioformulations and nematicide on plant growth parameters (root length) in tuberose

3.3.4 Characterisation of foliar nematode in chrysanthemum based on morphometric characters

Twenty specimens of females and males were observed under compound microscope and morphometric characters were noted, measured by using imaging software ZEN in Axioscope 5 microscope. Males are smaller in size compared to the females. The morphometric characteristics of females and males are given below

Female: Total length=775.23µ, Maximum body width=24.40µ, Stylet length=13.34 µ, Anterior to vulval length=542.41 µ, Anterior to median bulb=72.95 µ, Tail length=48.37 µ, Tail width=13.92 µ, vulval width=24.01 µ (Fig. 3.16A)

Male: Total length=641.32µ, Maximum body width=20.96µ, Stylet length=10.51 µ, Anterior to median bulb=66.83 µ, Tail length=36.38 µ, Tail width=13.14 µ, Spicule length=19.28 µ (Fig. 3.16B)

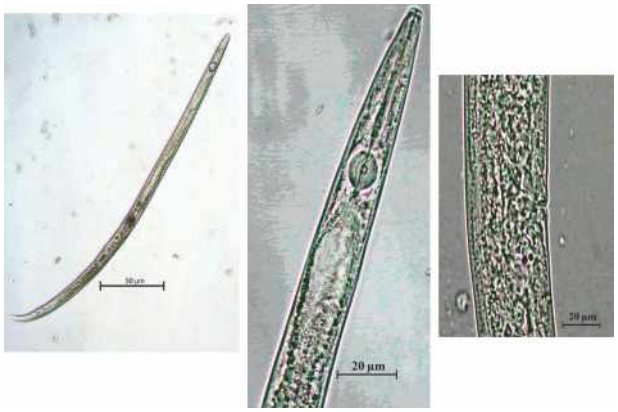


Fig 3.16A: Foliar nematode (female)

Fig 3.16B: Foliar nematode (male)

3.3.5 Screening of tuberose varieties against root-knot nematode

Six tuberose double-type varieties (Swarnarekha, Calcutta double, Phule Rajhat, Hyderabad double, Vaibhav, Suvasini) were evaluated for root-knot nematode resistance. Based on the gall index, six tuberose cultivars were ranked into susceptible and resistant varieties. Only one variety i.e., Suvasini gall index recorded (<1) and it is resistant to root-knot nematode. Remaining varieties *i.e.*, Swarnarekha, Calcutta Double, Phule Rajhat, Hyderabad Double and Vaibhav are highly susceptible to root-knot, infected heavily with root galls recorded gall index (4-5). In highly susceptible varieties the parameters like shoot growth and root growth were very less and are severely stunted compared to other varieties (Table 3.11; Fig. 3.17).

Table 3.11 Screening of Tuberose varieties against root-knot nematode, *Meloidogyne incognita*

S. No	Variety	Gall Index	Plant height Control (cm)	Plant height Nematode infected (cm)	Root length Control (cm)	Root length Nematode infected (cm)
1	Vaibhav	5.00^{a}	14.00^{d}	19.00^{a}	38.66^{d}	32.66^{b}
2	Calcutta Double	5.00^{a}	21.66^{b}	8.00^{c}	46.60^{a}	24.66^{c}
3	Swarna Rekha	4.16^{b}	27.33^{a}	6.83^{c}	40.66^{c}	31.00^{bc}
4	Hyderabad Double	4.16^{b}	16.00^{c}	11.16^{b}	37.66^{d}	33.66^{b}
5	Phule Rajat	4.16^{b}	17.00^{c}	7.50^{c}	42.00^{b}	32.33^{b}
6	Suvasini	0.66^{c}	12.66^{d}	11.30^{b}	47.00^{a}	47.00^{a}
	SE	0.18	0.30	0.36	0.43	2.36
	CD (P=0.05)	0.55	1.62	1.30	1.32	7.27

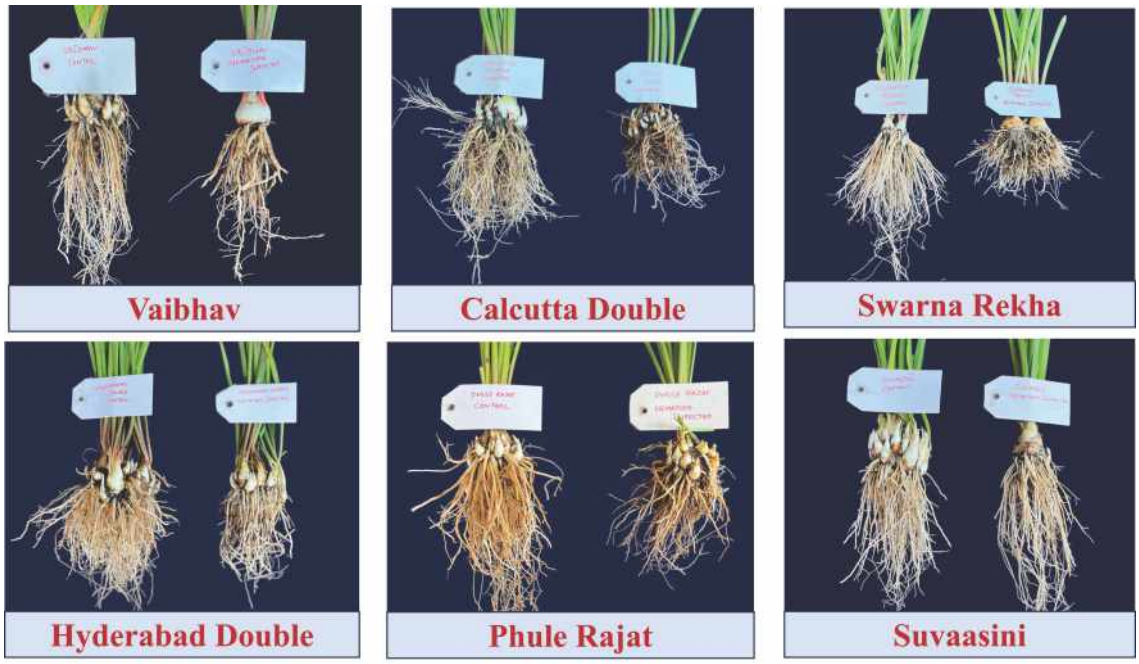


Fig 3.17: Screening of tuberose varieties against root-knot nematode

3.4 Viral and Bacterial Diseases of Flower Crops in India: Diagnostics and Management

3.4.1 Isolation and Identification of Bacteria causing Blight in Anthurium

Bacterial blight of *Anthurium adreanum* is a disease of global significance. The major symptoms of infection consist of necrotic water-soaked spots with a chlorotic halo occurring on the leaves towards the edge. These spots further coalesce and cause necrosis and death of the leaves and spathes. Infection spread to the stems and rhizomes through petioles, causing the death of the plants. These symptoms can be often confused with other biological causes like *Ralstonia* wilt and fungal anthracnose. In order to identify the etiology of the above symptoms in Anthurium, isolation of the pathogen was done on Potato dextrose agar media. Three bacterial colonies were observed from the infected leaves. Pathogenicity test confirmed the yellow mucoid colonies with gram negative short rodes as the causal agent. The bacterium was further identified as *Xanthomonas phaseoli* pv. *dieffenbachiae* based on 16SrRNA sequences (Fig. 3.18A & B).

Fig. 3.18 Anthurium blight (A) *Xanthomonas phaseli* pv. *dieffenbachiae* on PDA (B)

3.4.1.1 Development of a Direct colony PCR method for identification of *Xanthomonas* sp. causing leaf blight in Anthurium

A direct colony PCR protocol for amplification of Xanthomonas sp. without laborious pre-treatment has been developed. Direct colony PCR technique is fast and easy to handle, allowing for DNA amplification directly from bacterial cultures omitting the DNA isolation step. Direct PCR is regularly applied for PCR amplification of bacterial cell cultures, cell lines, and yeast cultures. This reduces the cost and time for molecular detection of bacteria. Its application for detection of Xanthomonas sp. is done for the first time. Toothpicks touched over the single colonies from overnight grown cultures were directly dipped in buffer and was subjected to heat cold lysis. The lysed culture was centrifuged and supernatant was added directly to PCR reaction mix. The amplicons obtained were further sequenced and validated as Xanthomonas phaseoli sp.

3.4.2 Decoding the complete genome of *Candidatus* Phytoplasma asteris causing Phyllody in Marigold for the first time in India

Complete draft genome of *Candidatus phytoplasma asteris* infecting Marigold and causing phyllody symptoms was deciphered through whole metagenome shotgun sequencing. The trimmed reads were processed to assembly using Megahit tool. The whole draft genome of Marigold isolate *Candidatus* phytoplasma asteris is approximately of 669kb in length with a GC content of 28% (Fig. 3.19).

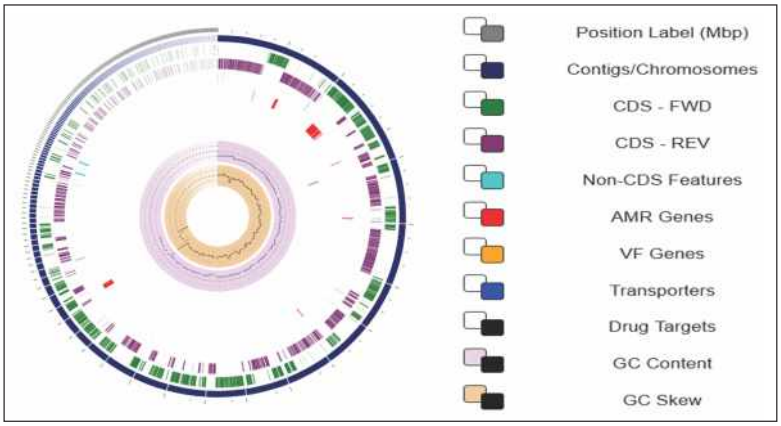


Fig. 3.19 Phytoplasma genome map representing different genes prediction, Coding regions and non-coding regions, Proteins, Antimicrobial resistance, genes, Virulence factors, Transporters, Drug targets and GC content

3.4.3 Profiling of the endophytic microflora of phytoplasma infected Marigold

Early detection of phytoplasma is difficult in flower crops until the most significant symptoms of phyllody appears in plant during flowering stage. To observe association of any facultative endophytes in phytoplasma infected marigold for using them as indirect indicators of phytoplasma infection, isolation and profiling of culturable endophytes from infected and healthy marigold was undertaken. Healthy marigold leaf associated endophytes were most prominently identified as *Bacillus* sp. which is most common genera of endophytes reported, while the Phytoplasma infected marigold leaf associated endophyte genomic characterization pointed to the abundance of enterobacteriales in general and *Pantoea* sp. in specific (Fig. 3.20).

Fig. 3.20 Bacterial colonies from infected marigold leaf extract on nutrient agar media after 24-48 hrs of incubation

3.4.4 UV-C irradiation to enhance the seed health in *Calednula Officinalis*

The effect of UVC irradiation on enhancement of seed viability in Calendula was studied. One year old seeds were exposed to different doses of UV-C irradiation for different durations of exposure: 6 Treatments, 3 replications. Highest percent of germination was observed in 15' UV exposed seeds at 61.66% followed by 60% in 7' exposed seeds compared to 40% in control. The following graph explains it clearly thtat UV-C irradiation enhances the seed viability and seedling vigour in *C.Officinalis* (Fig. 3.21).

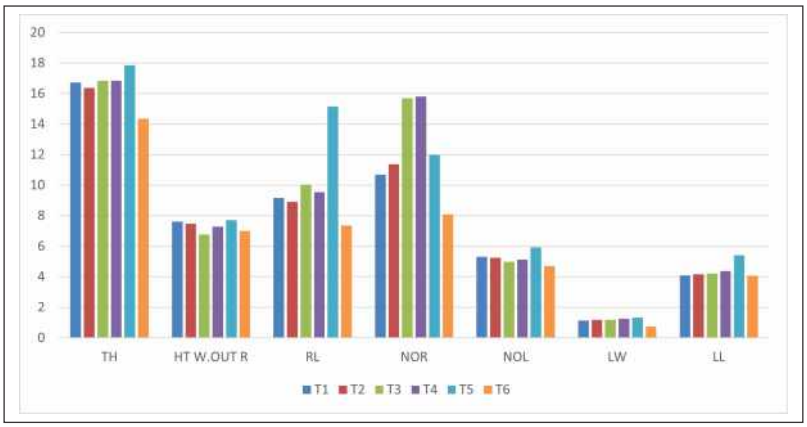


Fig. 3.21 Showing the effect of UV-C irradiation on Calendula seeds. TH-Total Height, HT wout root, Root length, No. of roots, No. of leaves, Leaf width, Leaf length. T1 to T5: Different doses of UV exposure, T6: Control without UV tratment

3.4.5 UV chamber for sterilization of Flowers

A UV chamber with a capacity to treat 1.5kg of flowers (approximately 120 flowers) at a time was set up with UV-C lamp of 32W with coverage of 52.2m^2. The UV sterilization protocol developed for treatment of marigold flowers has been followed for flower sterilization (Fig. 3.22).

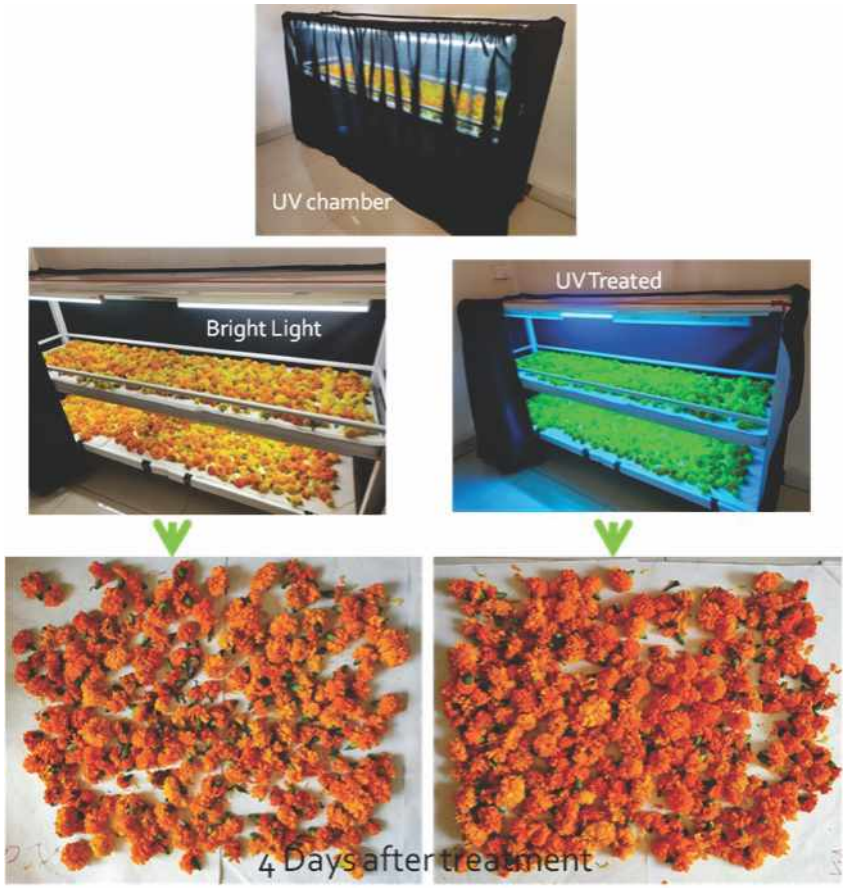


Fig. 3.22 Sterilization of Marigold flowers with UV-C irradiation in UV chamber

3.4.6 Isolation of endophytes from marigold and their evaluation for plant growth promoting activity

Endophytic microflora from both healthy and infected marigold were isolated and characterized. Effect of their external application through seedling dip method was evaluated by planting in sterile media without any application of nutrients externally. Among the eight endopytes evaluated, *Providencia* sp. isolated from phytoplasma infected marigold plants has been found to enhance the vegetative growth and production of flowers in marigold compared to the non treated control plants (Fig. 3.23).

Fig. 3.23 The endophyte Providencia treated plant (T1) in comparison to the control (Untreated)

3.4.7 Tissue culture protocol developed For maintaining Phytoplasma inoculum in marigold Plants

Phytoplasma are difficult to culture pathogens in artificial media, which makes it difficult to evaluate management strategies unlike other culturable bacteria. In order to establish the inoculum *in-vitro*, explants (shoot-tips) from Phytoplasma infected marigold plants were collected and inoculated on a slightly modified MS media for root initiation MS + IBA (1mg/L) + GA_3 (0.5 mg/L). Rooting was observed after 9 days and well grown plantlets were obtained after 20-25days with an efficiency of 33.3%. Presence of phytoplasma was confirmed through PCR (Fig. 3.24).

Fig. 3.24 Shoot tip culture for maintenance of phytoplasma inoculum (Left), Rooted plants (Right)

3.4.8 Development of ecological niche model (Maxent) for current and future distribution of *Impatiens necrotic spot tospovirus* and its vector *Frankliniella occidentalis* under climate change scenario in India

Impatiens necrotic spot tospovirus (INSV), a member of genus orthotospovirus is an emerging and threatening viral pathogen of ornamental and vegetables crops grown in both protected and open cultivation. Like other tospoviruses, INSV also have a wide host range and is transmitted by western flower thrips, *Frankliniella occidentalis*. So far INSV has not been reported from India. *F. occidentalis* notoriously known as "Super Vectors" due to their high rates of reproduction and dispersal, extreme polyphagy, and development of insecticide resistance, has made an entry to the country recently in 2015. INSV also can follow the trails of western flower thrips to India as the pathways of entry of INSV can be through plants for planting, through vectors carried on cut flowers or branches etc. Keeping this backdrop, a prediction model through ecological

niche modelling by applying maximum entropy modelling (Maxent) has been made to plot the scenario of distribution of INSV and *F. occidentalis* in the current climate and projection has been made to visualize the dynamics of both INSV and its vector in the future in the changing climate scenario (Fig. 3.25).

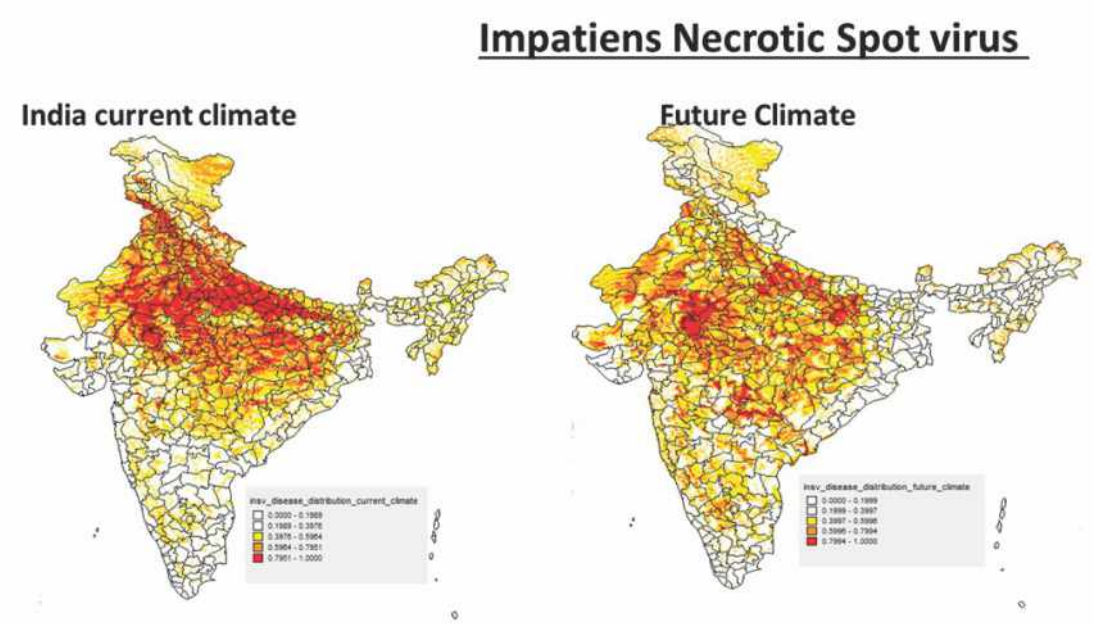


Fig. 3.25 The predictive model for the distribution of INSV in present (2020) and future climatic conditions (2050)

3.4.9Study of seed transmission of cucumber mosaic virus in marigold

The extent of longitudinal transmission of CMV in marigold and effect of seed transmission on seed viability and vigour has been studied. Cucumber mosaic virus infection was confirmed through RT-PCR in marigold plants showing symptoms of chlorosis, mosaic and leaf narrowing**.** From the CMV positive plants matured seeds were collected. One part of the seed lot was used to test the presence of virus through RT-PCR and Seeds from all the varieties tested positive for CMV. The other lot was subjected for seed viability studies and vigour indexing. The CMV infection has been found to reduce the vigour and viability of Marigold seeds. Third lot of 120 seeds of each variety were sown in sterilized soil and maintained under insect free condition. Leaves from the germinated seedlings were pooled and subjected to RT-PCR for the confirmation of virus infection and 33.3percent of the samples tested positive for the presence of CMV. This trend continued up to three generations confirmed through RT-PCR.

3.5 Development of Integrated Disease Management Strategy for Ornamental Nursey Plants and Loose Flower Crops

3.5.1 Characterization and management of Spathiphyllum wilt

3.5.1.1 Molecular identification of Fusarium sp. causing wilt in Spathiphyllum using multi-locus sequencing

The species of *Fusarium* fungi causing wilt in Spathiphyllum was identified by multi locus sequence typing by exploiting four genes *viz.,* i) internal transcribed spacer (ITS), ii) translation elongation factor 1-alpha (Tef-1α), iii) RNA polymerase II largest subunit (RPB1) and iv) RNA polymerase II second largest subunit (RPB2) using the gene specific primers described by O' Donnell et al. (2010) (Table 3.12). The nucleotide sequences of the genes were analyzed individually by comparing in *Fusarium*-ID database, *Fusarium*-

MLST database and NCBI database for species confirmation. Multi-gene analysis revealed that the *Fusarium* isolate, SP-Ff-Kd demonstrated its closest sequence similarities with species of *F. falciforme*. Analysis of the nucleotide sequences of the ITS showed 99.81% similarity with CBS 475.67, RPB1 had 96.51% identity with NRRL-43529 and RPB2 had 98.83% similarity with NRRL-22857 in *Fusarium*-MLST database. The Tef-1α gene showed 99.70% similarity with NRRL-22938 in the *Fusarium*-ID database. All the four gene sequences were submitted in NCBI GenBank and obtained the accession numbers as PP851105, PP858878, PP858879 and PP858880 for ITS (568 bp), Tef-1α (724 bp), RPB1 (1050 bp) and RPB2 (1976 bp) respectively.

The phylogenetic tree was constructed using MEGA-11 by combing the sequences of four genes (ITS, Tef-1α, RPB1 and RPB2) through the maximum parsimony method. Sequences of three closely related isolates of *F. falciforme* including type strain CBS475.67, along with three isolates of *F. solani*, and four other species of *Fusarium* as an out group to understand the genetic relationship between the study isolate and the other isolates of *F. falciforme* and their species complex group. The results showed that the study isolate was shown to have close relationships with other *F. falciforme* isolates than other species as indicated by the phylogenetic analysis. The study isolate was grouped in group I, while other species were clustered in groups II and III (Fig. 3.26). To our knowledge this is the first report of *F. falciforme* causing wilt in Spathiphyllum.

Table 3.12: PCR primers used for amplification and sequencing of genes of *F. falciforme*

Locus	Size (bp)	Primers (5'-3')
ITS Internal Transcribed Spacer regions	~550	ITS1- TCCGTAGGTGAACCTGCGG ITS4-TCCTCCGCTTATTGATATGC
TEF-1α (Translation elongation factor 1α)	~750	EF1- ATGGGTAAGGARGACAAGAC EF2- GGARGTACCAGTSATCATG
RPB1 (RNA polymerase II largest subunit)	~1100	F7- CRACACAGAAGAGTTTGAAGG G2R-GTCATYTGDGTDGCDGGYTCDCC
RPB2 (RNA polymerase II second largest subunit)	~1750	5f2- GGGGWGAYCAGAAGAAGGC 7cr- CCCATRGCTTGYTTRCCCAT 7cf- ATGGGYAARCAAGCYATGGG 11ar- GCRTGGATCTTRTCRTCSACC

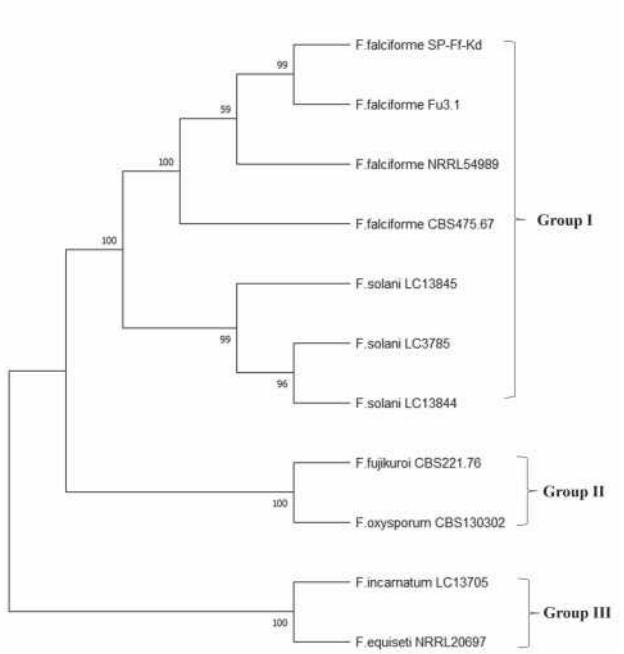


Fig. 3.26 Phylogenetic analysis of *F. falciforme* isolate isolated from Spathiphyllum using combine sequence data of ITS, Tef-1α, RPB1 and RPB2 genes

3.5.1.2 *In planta* evaluation of chemicals against Spathiphyllum wilt

The fungicides carbendazim, tebuconazole and trifloxystrobin+tebuconazole showed greater mycelial growth inhibitory activity against *F. falciforme* under *in vitro* studies were selected for further evaluation of their effectiveness in controlling wilt disease in Spathiphyllum under *in planta* conditions. The fungicides were tested for their prophylactic and curative effect against Spathiphyllum wilt disease. Young plants with 2-3 leaves purchased from nursery were planted in the pots containing sterilized pot mix (mixture of garden land soil and decomposed coir pith). The plants were then transferred and kept in the shade net for one week to acclimate in the sterilized pot mix. For pathogen inoculation, the spore suspension was prepared from 10 days old mycelia of the pathogen grown on PDA. 10 ml of spore suspension ($1x10^6$ conidia/ ml) was soil-drenched to the collar region of each seedling (non-invasively). Then the plants were kept in the incubator at $27 \pm 1^{o}C$, with 12-h light and 80% relative humidity. The fungicides carbendazim, tebuconazole and trifloxystrobin+tebuconazole were prepared with the concentration of @1g/l, 1ml/l and 0.5g/l respectively by suspending in water and applied in the pots separately by drenching with 100 ml of fungicide preparation per pot. The plants were treated with each fungicide separately at the time of planting (prophylactic) and immediately after the appearance of symptoms (curative). The plants were treated with the fungicides three times at 15 day interval in both prophylactic and curative treatments. Plants drenched with and without spore suspension served as inoculated and non-inoculated control respectively. Three replications were maintained for each treatment with three plants each in replication. The effectiveness of the fungicides against Spathiphyllum wilt was assessed 40 days after planting. Results showed that fungicides carbendazim and tebuconazole significantly reduced the incidence of wilt when compared with the untreated control. Among the fungicides under investigation, carbendazim @ 1ml/ l was found to be most effective in controlling wilt which is followed by tebucanazole. The results of the experiment also revealed that curative and prophylactic effect of both the chemicals against the disease was same. This indicates that wilt of Spathiphyllum can be managed with application of either carbendazim or tebuconazole before or even immediately after the appearance of symptoms in the plants (Fig. 3. 27).

Fig. 3.27 In-planta Efficacy Evaluation of Fungicides against Wilt Disease in Spathiphyllum
T1- Carbendazim @1 g/l (Prophylactic); T2- Tebuconazole @1 ml/l (Prophylactic); T3- Trifloxystrobin+tebuconazole @0.5 g/l (Prophylactic); T4- Carbendazim @1 g/l (Curative); T5- Tebuconazole @1 ml/l (Curative); T6- Trifloxystrobin+tebuconazole @0.5 g/l (Curative); T7- Inoculated control; T8- Healthy control

3.5.1.3 Study of host range of *F. falciforme*

The host range of *F. falciforme* was studied using the economically important crops belonging to the family solanaceae namely tobacco, chilli, tomato and brinjal. One-month old seedlings of each crop were transplanted in the pots containing sterilized garden soil and kept in open conditions for one week to acclimate in sterilized garden soil. For pathogen inoculation, the spore suspension was prepared from 10 days old mycelia of the pathogen grown on PDA. 10 ml of spore suspension ($1x10^6$ conidia/ ml) was soil-drenched

to the collar region of each seedling (non-invasively). The plants drenched with sterile distilled water served as control. Then the plants were kept in the incubator at 27 ± 1°C, with 12-h light and 80% relative humidity. Wilting and drying of the inoculated tobacco, chilli, tomato and brinjal plants was observed 7 days after inoculation whereas there were no symptoms appeared in the non-inoculated plants. The pathogenicity was proved by re-isolation of pathogen from the symptomatic plants (Fig. 3.28).

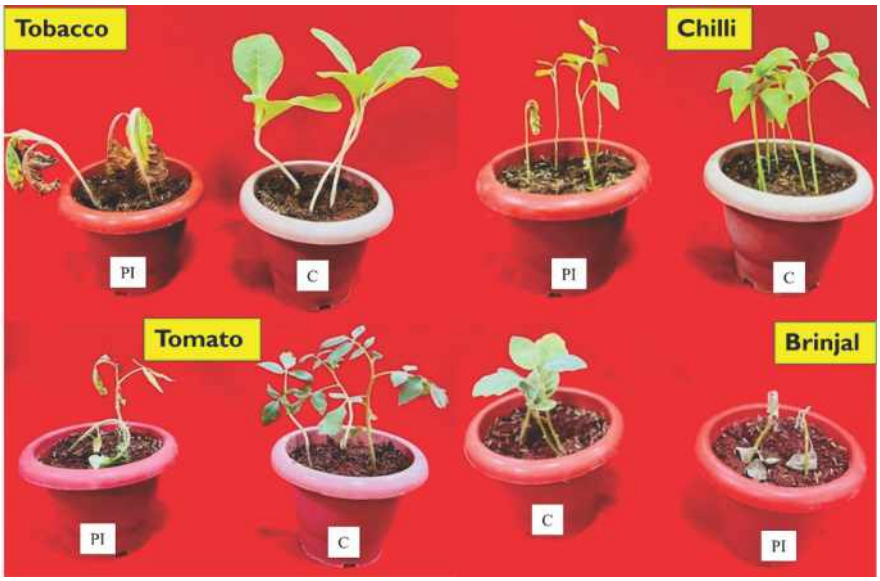


Fig. 3.28 Development of symptoms on the plants artificially inoculated with *F. falciforme* isolated from spathiphyllum. PI-Pathogen inoculated; C-Control

3.6 Investigating the potential of indigenous microbes as biocontrol agents to manage insect and disease problems in flower crops

Biocontrol potential of native antagonists on key soil borne pathogens of flower crops

About eleven native beneficial microbes (fungal-3, bacterial-5, yeast-3) isolated from different niches (details in Table 3.13; Fig. 3.29) studied for biocontrol potential against *Sclerotium rolfsii*, *Fusarium* isolated from gladiolus and chrysanthemum using dual culture technique. The results revealed that two fugal, *Trichoderma* isolates, three bacterial isolates showed more than 50 per cent inhibition against all tested pathogens and selected for further studies (Table 3.14; Fig. 3.30, 3.31 & 3.32).

Table 3.13 List of beneficial microbes studied

Sl. No.	Tentative Isolate code	Identified Genus/organism	Host	Place	Part
1	TDFR	*Trichoderma*	Sclerotium	DFR	Rhizosphere
2	TSK	*Trichoderma*	Sclerotium	Shikrapur	Rhizosphere
3	TMJ	*Trichoderma*	Sclerotium	Manjari	Rhizosphere
4	NSB-G11	Yet to identify	Gladiolus	DFR	Nectar
5	AMJ	Yet to identify	Marigold	Manjari	Rhizosphere
6	BCP	*Bacillus*	Cosmos	Pavananagar	Rhizosphere
7	BMD	*Bacillus*	Marigold	DFR	Rhizosphere
8	PSK	*Pseudomonas*	Marigold	Shikarapur	Rhizosphere
9	NSY-G1-1	Yeast	Gladiolus	DFR	Nectar
10	NSY-G3-1	Yeast	Gladiolus	DFR	Nectar
11	NSY-G3-3	Yeast	Gladiolus	DFR	Nectar

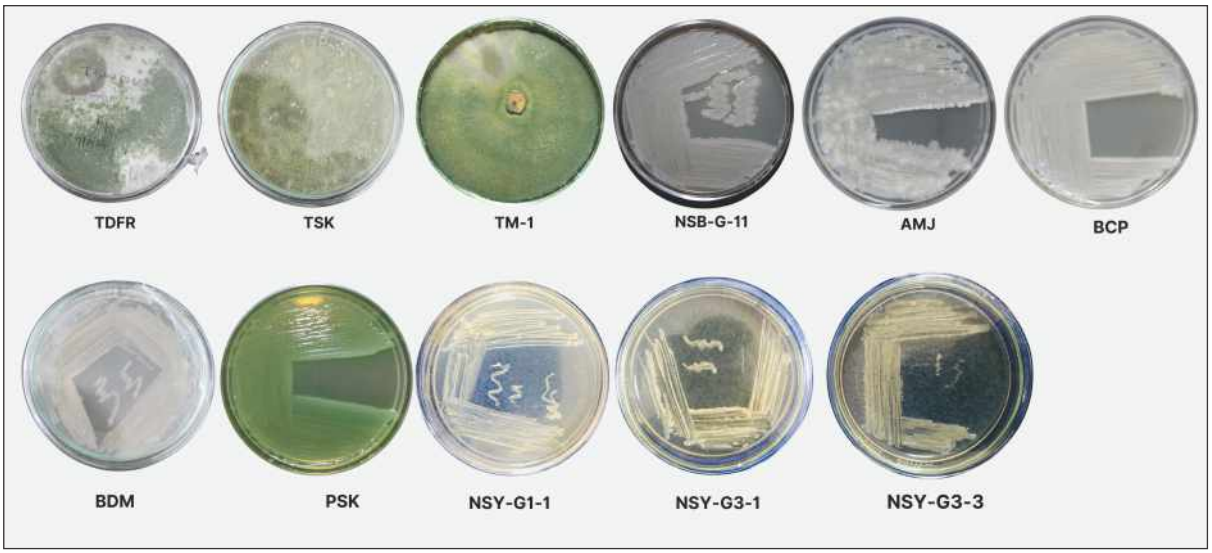


Fig. 3.29 List of beneficial microbes studied for antagonistic ability against major fungal pathogens of flower crops

Table 3.14. Antagonistic potential of beneficial microbes against *Sclerotium rolfsii, Fusarium* isolated from gladiolus and chrysanthemum using dual culture technique

Sl. No.	Isolate	Per cent inhibition		
		Sclerotium rolfsii	*FOG*	*FOC*
1	TDFR	56.29	63.87	63.10
2	TSK	43.14	52.44	47.67
3	TM-1	50.48	65.84	56.52
4	NSB-G-11	61.89	52.25	52.00
5	AMJ	72.96	51.24	57.14
6	BCP	18.51	11.97	7.55
7	BDM	19.92	37.58	33.54
8	PSK	58.81	66.16	53.42
9	NSY-G1-1	41.29	23.63	23.75
10	NSY-G3-1	16.61	29.35	8.05
11	NSY-G3-3	2.22	33.24	20.45
	SEM	1.09	1.0	0.76
	CD@%1	4.38	4.0	3.05
	CV	4.74	3.92	3.45

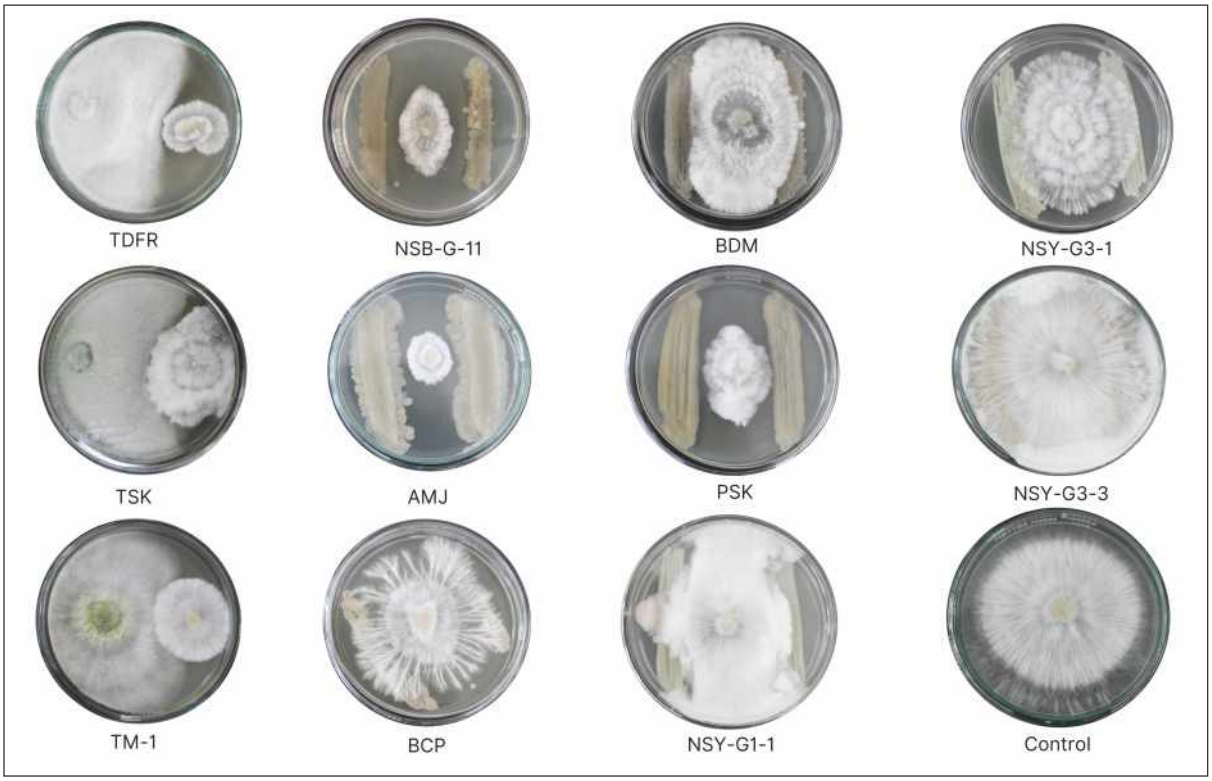


Fig. 3.30: Antagonistic potential of beneficial microbes against *Sclerotium rolfsii*

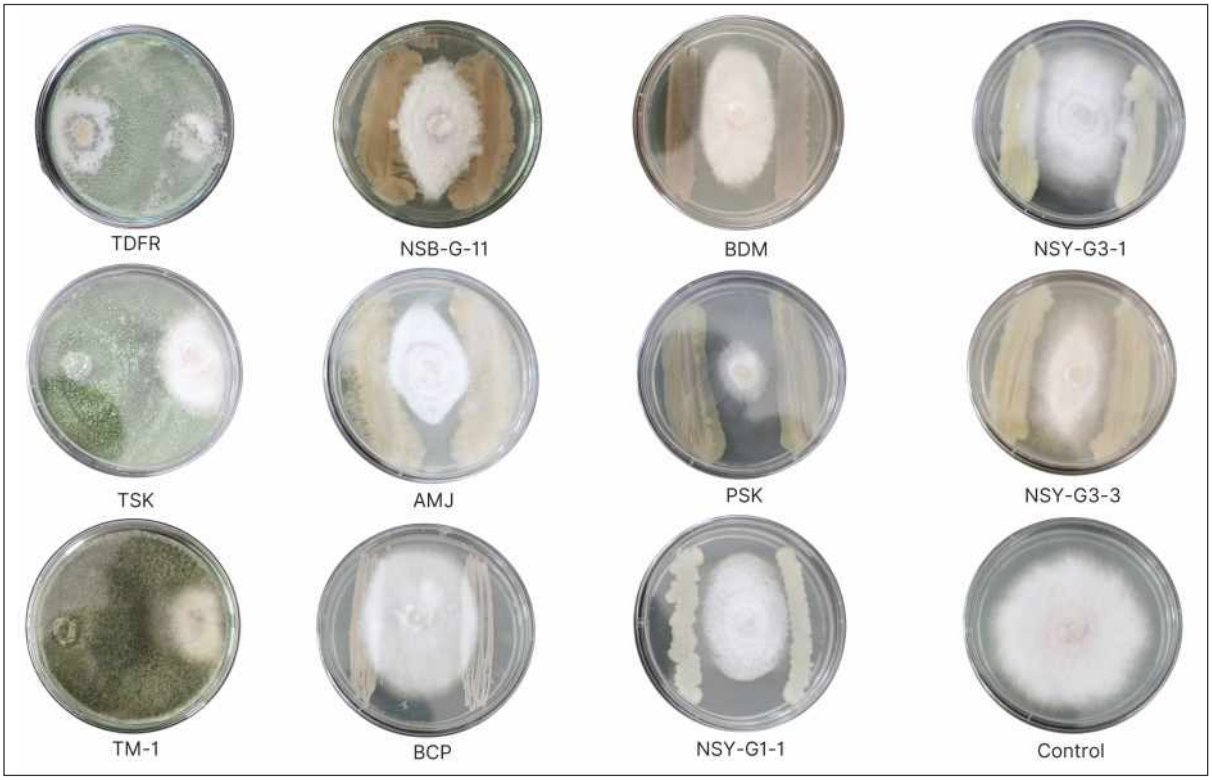


Fig.3. 31: Antagonistic potential of beneficial microbes against *Fusarium* sp. from gladiolus

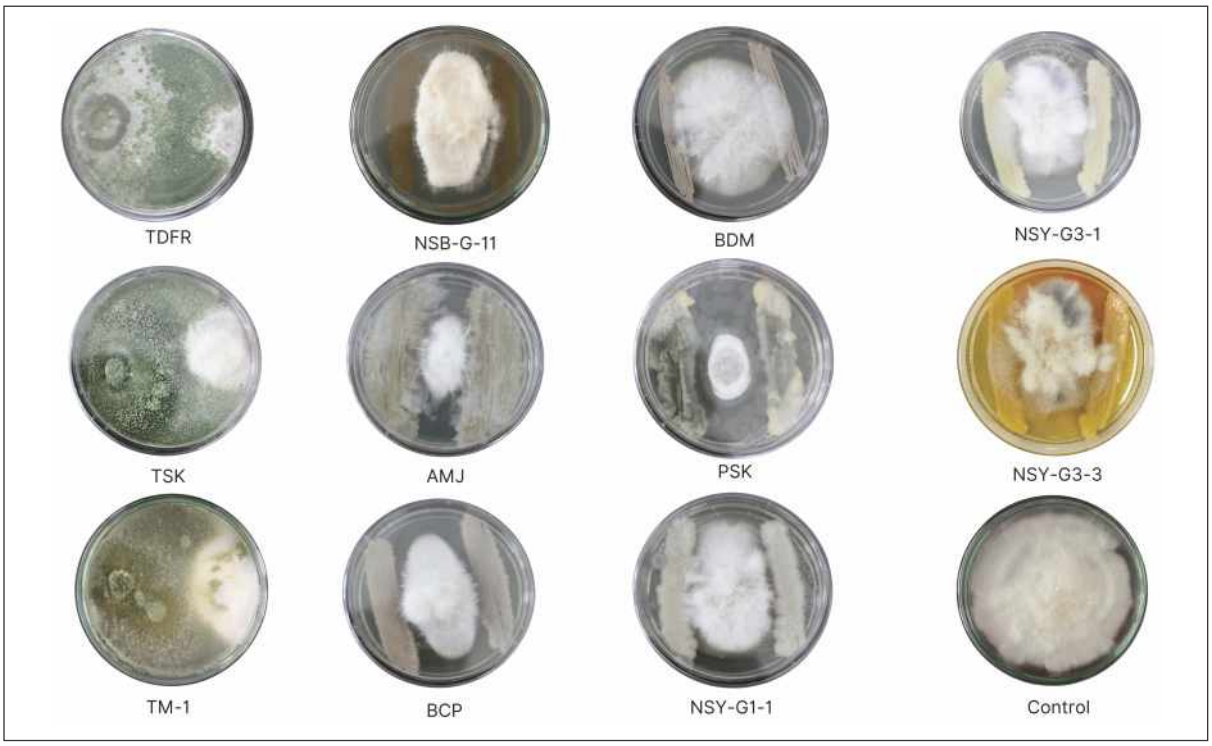


Fig. 3.32: Antagonistic potential of beneficial microbes against *Fusarium* sp. from chrysanthemum

3.7 Development of Habitat Recreative Floral Calendar with Enhanced Floral Rewards for Healthy Bee Colonies

3.7.1. DNA barcoding revealed occurrence of endangered butterfly species, *Spindasis* (*Cigaritis*) *elima* on ornamental crops

DNA barcoding of different butterfly species revealed the occurrence of *Spindasis (Cigaritis) elima* on ornamental crops. In fact, these butterfly species are abundantly available on several ornamental plant species including balsam, cosmos, and aster (Fig. 3.33). The butterfly species, *Spindasis (Cigaritis) elima* is an endangered species protected under Schedule II of the wild life protection act 1972. Therefore, the butterfly-friendly plant species can be utilized for the conservation programs of the butterflies. Further studies on its foraging ecology on ornamental crops are in progress.

Fig. 3.33. Adults of endangered butterfly species, *Spindasis* (*Cigaritis*) *elima* residing on ornamental crops

3.7.2. Diversity indices of flower visitors on different ornamental crops

Shannon-Wiener index is a most widely used diversity index in the ecology and Simpson's index is best known and earliest evenness measures of diversity. We studied the species richness and diversity of pollinators on different ornamental crops ecosystem. Based on the diversity indices of pollinators, four genotypes of Aster (DFR-Ento-9; DFR-Ento-11, DFR-Ento-12 & DFR-Ento-13), seven genotypes of Balsam, Gomphrena, Cosmos, Calendula, Celosia, Golden rod, Rantulas, Salvia and periwinkle were found to be excellent plants for conservation & enhancement of pollinators biodiversity (Fig 3.34).

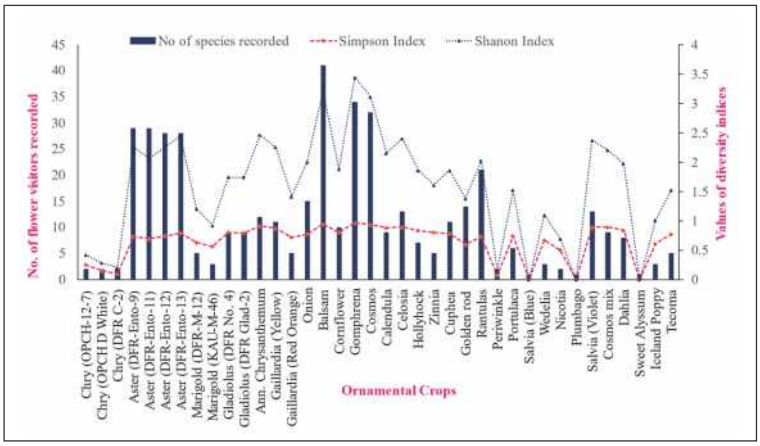


Fig. 3.34. Simpson and Shannon index of flower visitors on ornamental plants

3.7.3. Pollinator's activity on ornamental crops in different periods of the day

The activity of pollinators was studied during different periods of the day. Activity of different pollinators was significantly higher during 11.00 AM to 12.00 Noon and found to be reducing till evening hours. Higher diversity and large number of flower visitors were recorded on Gladiolus, three genotypes Chrysanthemum, four genotypes of Aster; Rantulas, Golden rod, Balsam, Cosmos, Cuphea, Salvia, Cornflower & Gomphrena (Fig. 3.35).

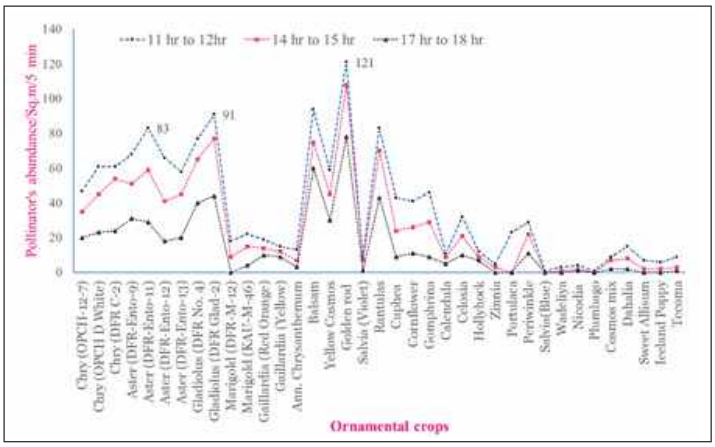


Fig 3.35. Activity of pollinators on ornamental crops in different periods of the day

3.6.4. Development of "Pollinators on Flower Crops: A Database"

Recently, pollinator decline has gained widespread public attention across the world. Wild bees and other pollinators are known to be very efficient pollinators of crop plants. For reversing pollinators decline, sincere efforts and efficient conservation strategies would be required to restore habitat and improve their health status. Ornamental flower crops have numerous species and very high levels of intra-specific diversity in terms of floral attributes, flower schemes, flowering time, floral rewards *etc*. Consequently, floricultural

crops present an ideal, easily accessible, and cost-effective resource for pollinator foraging habitats. To facilitate this, it is imperative to gather information on pollinator diversity, their preferred floral sources, and comprehensive insights into their foraging ecology and habitats. In this context, "**Pollinators on Flower Crops: A Database**" has been developed (Fig, 3.36), which currently includes the top 36 pollinator-friendly plants selected from a screening of 677 species/genotypes of ornamental plants comprising 184 genotypes of roses; 155 chrysanthemums; 88 gladioli, 36 tuberoses; 25 marigolds; 22 asters; 07 Jasmine; 58 water lilies; 58 annual flower crops; 14 perennial crops; 15 ornamental trees; 05 hedges; 05 edges; 03 creepers etc. This information will be updated regularly. The dynamic nature of this database is instrumental in offering essential details regarding the diversity, foraging ecology, and habitats of pollinators specifically on ornamental crops. Additionally, the database includes valuable information on various flowering plants, encompassing botanical knowledge and production protocols. Beyond raising awareness, this database stands as a pivotal resource for researchers and policymakers globally, providing a solid foundation for further studies and decision-making processes.

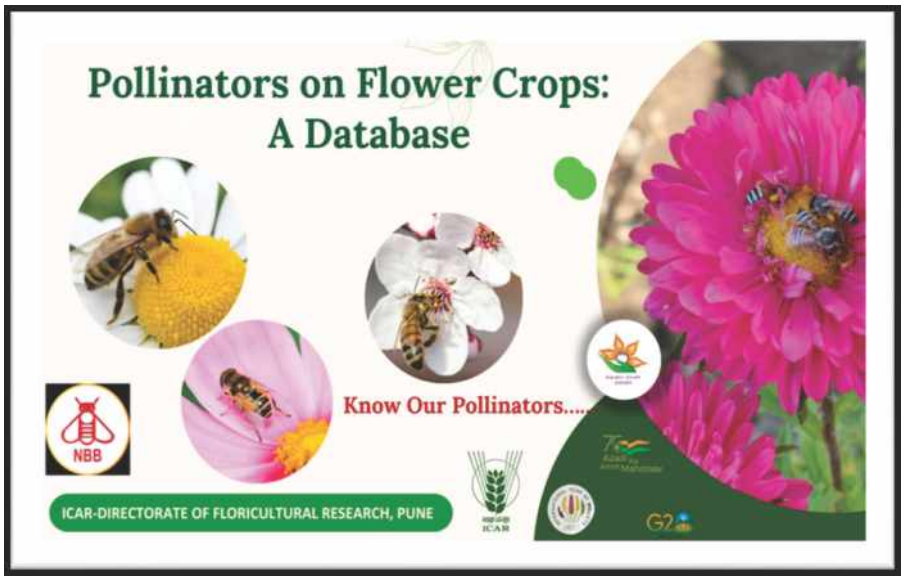


Fig 3.36. Pollinators on Flower Crops Database snapshot

3.7.5. Quantification and quality analysis of floral rewards from bee-friendly ornamental plants

3.7.5.1. Quantification and quality analysis of floral nectar from selected ornamental crops

Pollinators are dependent on plants for two important floral rewards viz., nectar and pollen. Thus, quantity and quality of available floral rewards play very significant role in pollinator's life. We determined floral rewarding potential of selected ornamental plants based on the foraging ecology studies on pollinators under field conditions.

Among all the bee-friendly plant species, the gladiolus was found to be largest nectar producing plant (Fig. 3.37). The nectar content of different gladiolus varieties varied from 15 to 75 µl/flower. Among all gladiolus varieties, DFR-Glad-3 and Candyman were found to be significantly higher nectar producing varieties (75 µl/flower each) followed by Arka Kumkum (65 µl/flower); Arka Ayush and Pusa Rajat (60 µl/flower each). TSS of floral nectar of gladiolus varieties varied from 20.6 to 34.6 Brix, being highest in varieties Arka Naveen and Punjab Flame (34.6 Brix) (Fig 3.38).

Among tuberose varieties tested, Mexican Single was found to producing significantly higher floral nectar (15.5 µl/flower) followed by Kahikuchi local (10.35 µl/flower); whereas remaining varieties produce very less quantity of nectar (<5 µl/flower). The nectar TSS of all the varieties ranged from 13.8 to 19.5 Brix, being significantly higher in Pune local (19.5 Brix) followed by in Mexican Single (17.1 Brix) (Fig 3.39). In case of

other ornamental crops (garden purpose); the floral nectar was recorded to be significantly higher in Thumbergia (55 µl/flower) and Honeysuckle (50 µl/flower) followed by in Passion fruit (10 µl/flower). Floral nectar content in remaining crops were less than 5 µl/flower (Fig 3.39).

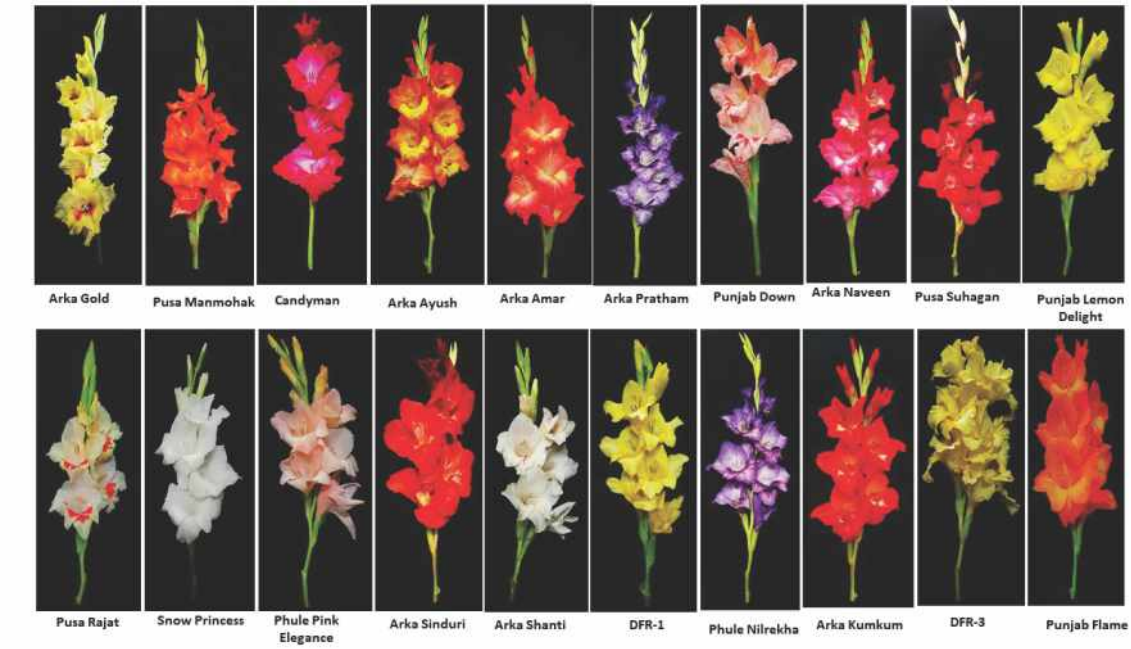


Fig. 3.37. High nectar and pollen containing gladiolus varieties

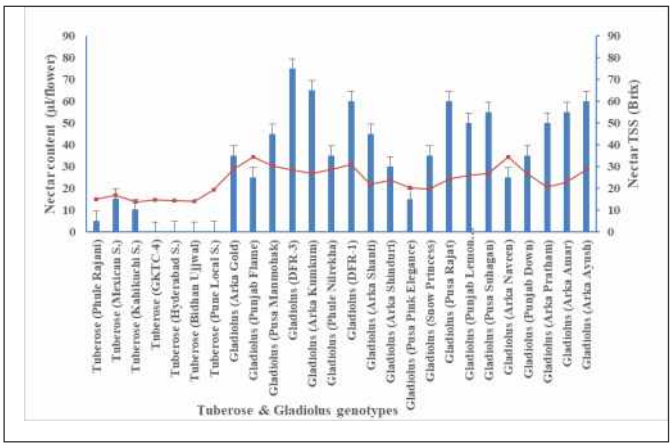


Fig 3.38. Floral nectar content & nectar TSS (floral rewards) of selected commercial ornamental crops. Bars denote nectar content and red line denotes nectar TSS.

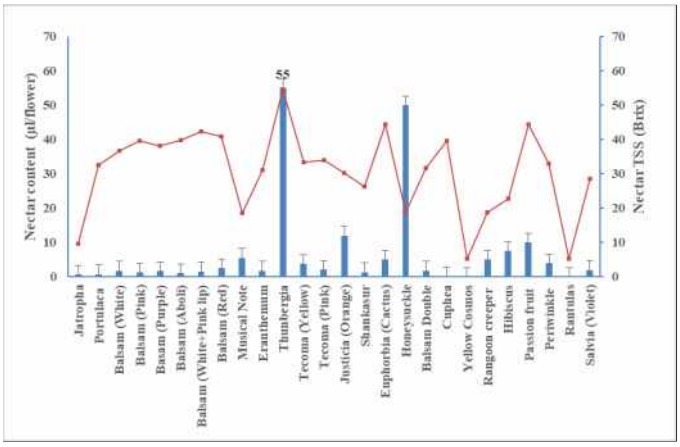


Fig 3.39. Floral nectar content & nectar TSS (floral rewards) of garden purpose ornamental crops. Bars denote nectar content and red line denotes nectar TSS.

3.7.5.2. Quantification and quality analysis of pollens from selected ornamental crops

Pollen samples were collected from 63 selected ornamental plants species consisting of high and less pollen bearing flowering plants. Different varieties of gladiolus, chrysanthemum, aster and ornamental sunflowers were found producing large quantity of pollens compared to other ornamental plants. Pollen quantity of different ornamental crops are indicated in Fig. 3.40 and 3.41.

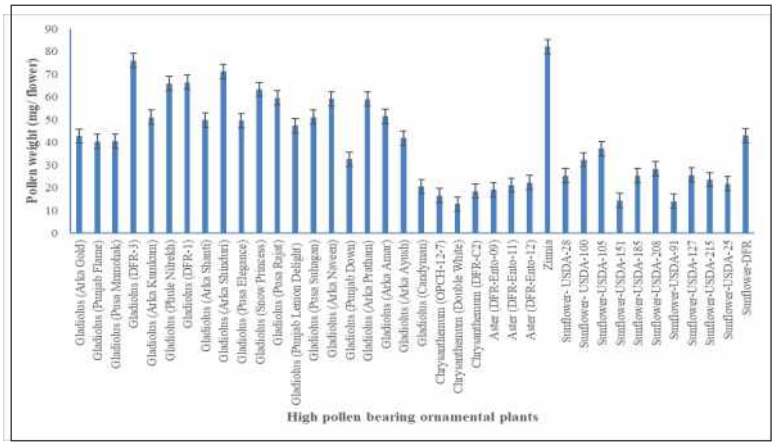


Fig 3.40. Pollen weight (mg/flower) of high pollen bearing ornamental crops

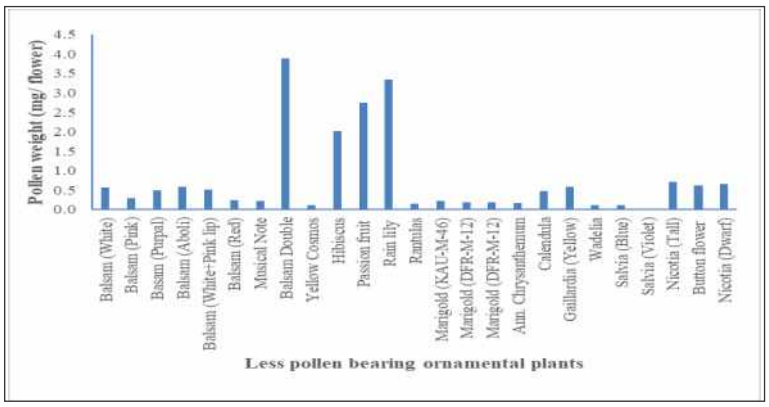


Fig 3.41. Pollen weight (mg/flower) of less pollen bearing ornamental crops

3.7.5.3. Pollinator Habitat Restoration Kit: A first of its kind package to support pollinators in a farmland

Approximately 35% of global crop production depends on insect pollination. However, pollinator populations are declining due to the loss of floral resources and habitats. Ornamental plants attract many pollinators with their vibrant colors, fragrances, and nectar. Planting diverse flower crops with optimal ratios and designs can significantly increase pollinator abundance and ecosystem services by enhancing food supply, shelter, and habitats of pollinators in various crop ecosystems. In this context, utilizing the data on pollinators diversity, their foraging ecology in relation to floral rewards and habitat suitability of ornamental plants, the '***Pollinator Habitat Restoration Kit***' has been developed to boost the abundance and ecosystem services of pollinators on farmland, leading to improved productivity and quality of produce in pollinator-dependent crops. This kit contains seasonal flower seeds and crucial information on pollinator-friendly plants and pollinator's conservation strategies. It is also beneficial for commercial beekeepers to improve bee health and sustainably increase productivity in bee products.

3.7.5.4. Empowering Ecosystems: Creating a novel 'Biodiversity Enhancement Kit for enrichment of beneficial fauna

The agricultural and horticultural landscape often lacks floral resources, significantly limiting many beneficial insects and reducing pollination and biological pest control. Flower crop mixes can enhance

biodiversity by attracting natural enemies of crop pests, pollinators, loosening soil etc. Incorporating flower crop mixes and increasing landscape biodiversity support a range of vital ecological services, such as improving pollination and biological pest control, thereby optimizing crop yield potential. In this context, utilizing vast data on floral traits, rewards and field ecological aspects of wide range of ornamental plants; the Biodiversity Enhancement Kit has been developed to improve faunal biodiversity on farmland, as well as in gardens, parks, and roadsides in urban and peri-urban areas. This kit contains seeds of biodiversity-supportive flowering annuals and essential information on cultivation and nutrient management in flower crops, beneficial insects associated with flower crops, and their conservation. The final evaluation of this unique kit will be completed shortly.

4. Post-Harvest Technology and Value Addition

4.1 (ICAR Project IXX 14263): Standardization of Post-Harvest Technology and Value addition Techniques in Ornamental Crops.

4.1.1 Standardisation of Microwave Vacuum Drying Technology for Rose Flower.

Investigated the effects of microwave at different microwave power levels (200, 300, 400, and 500 W) on rose petals physico-chemical, anthocyanin, phenolic content and antioxidant properties. We found that the maximum amount of aanthocyanin content (408 ± 0.07 mg/100g), total phenol content (289.75 ± 6.73 mg/100g) and antioxidant potential (DPPH) (92.83 ± 2.87 %) were found when we dried rose petals at 500 W (microwave power). We also studied the rate of moisture removal (g/min.) pattern after every 2 min. of drying at different microwave power levels (200, 300, 400, and 500 W). From Table 4.1., we found that the rate of moisture removal at initial stage of drying of rose petals was higher than the later stage of drying for all microwave power levels (200, 300, 400, and 500 W). In case of T1 treatment, the time required to complete the drying process was higher as compared to the other three treatments.

Table 4.1: Microwave Vacuum drying of rose petals at different microwave power levels

Sr. No.	Time (min.)	Moisture content (%)			
		T_1	T_2	T_3	T_4
1	0	82.23	82.44	82.17	80.84
2	2	80.14	80.15	79.12	77.78
3	4	79.14	78.23	76.45	74.68
4	6	78.44	75.87	74.21	71.43
5	8	77.53	72.65	73.45	60.11
6	10	75.97	69.65	71.94	51.23
7	12	74.15	67.89	63.77	37.45
8	14	72.14	65.47	54.23	22.45
9	16	71.18	62.78	47.44	16.38
10	18	67.89	58.45	40.45	15.25
11	20	64.78	53.32	36.89	14.23
12	22	63.93	45.26	31.24	13.45
13	24	62.98	41.56	28.69	11.78
14	26	55.64	38.45	21.36	10.74
15	28	51.23	33.12	15.02	9.59
16	30	48.26	28.89	9.42	9.58
17	32	44.9	23.45	9.41	9.58
18	34	41.23	16.03	9.4	
19	36	38.12	11.14	9.4	
20	38	35.21	10.36		
21	40	33.91	9.84		

Sr. No.	Time (min.)	Moisture content (%)			
		T_1	T_2	T_3	T_4
22	42	30.64	9.83		
23	44	26.47	9.81		
24	46	20.14	9.8		
25	48	17.89	9.8		
26	50	12.73			
27	52	10.24			
28	54	10.12			
29	56	10.09			

Note: T_1: Power: 200 W and Vacuum: 600 mmHg; T_2: Power: 300 W and Vacuum: 600 mmHg; T_3: Power: 400 W and Vacuum: 600 mmHg; T_4: 500 W and Vacuum: 600 mmHg

4.1.2 Standardization of Infrared and Hot-Air Drying Technology for Rose flower Petals

In the present study, we investigated the effects of infrared and forced convective air at different infrared power levels (300, 400, and 500 W) and hot air temperatures (50, 57, and 65 °C) on thin layer drying of rose petals (Fig. 4.1). Infrared drying requires 50-52% less time as compared to forced convective drying. The initial and final moisture content of rose petals were 84% (w.b.) and 4.5% (w.b.) respectively. The Midilli-Kucuk model gives a superior fit for both the drying methods followed by Avhad and Marchetti, and the Page model. The zero-order, followed by the first-order colour kinetics model gives the best fitting for L*, a*, and b* values. Moisture diffusivity was increased by infrared power (1.7308 × 10-08 - 4.1495×10-08 m^2/s) and hot air temperature (9.3715×10-09 - 1.1709 10-08 m^2/s). The activation energy obtained for rose petals in hot air dryers and infrared dryers was 51.09 kJ/mol and 6.50 kW/kg, respectively. Samples dried at 500 W infrared drying for 18 min demonstrated higher retention of colour, ascorbic acid (61.03 ± 2.6 mg/100g), and anthocyanin content (295.75 ± 65.70 mg/100g) in the rose petals.

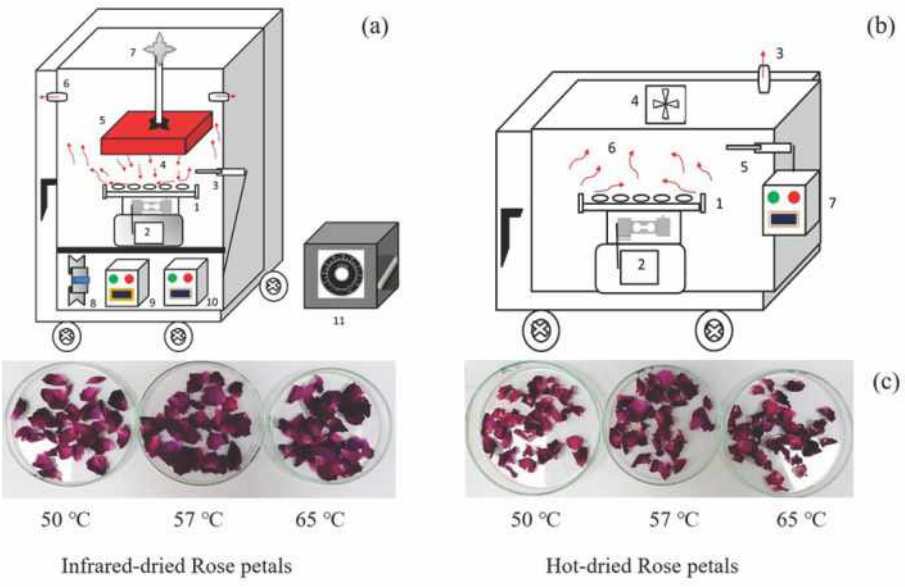


Fig. 4.1. (a) Schematic outline of the infrared drying chamber (1- sample tray, 2- auto weighing system, 3- Temperature sensor, 4- infrared radiation, 5- Infrared bulbs, 6- air outlet, 7- height adjustment, 8 - on/off switch, 9- current and voltage display, 10- control panel along with temperature and humidity display, 11 – voltage regulator); (b) Schematic outline of lab-scale hot air dryer (1- sample tray, 2- auto weighing system, 3- air outlet, 4- fan, 5- sensor, 6- hot air, 7- control panel along with temperature and humidity display); (c) Colour changes of rose petals at different infrared radiation and hot air drying temperatures

4.1.2.1 Moisture ratio and drying rate

The MR was determined from weight change in sample during drying and illustrated in Fig. 4.2. The MR of the samples fell continuously with drying time for all temperatures and infrared wattage. In all drying temperatures and infrared wattage, higher initial moisture decrease was seen due to the availability and diffusion of surface water. Furthermore, a considerably faster rate of MR loss at 65°C and 500 W may be due to a faster evaporation rate.

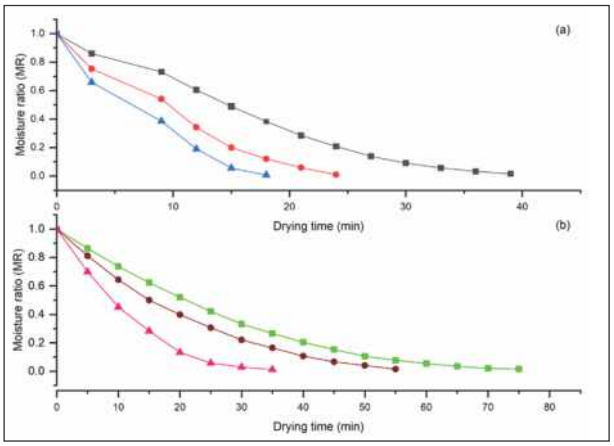


Fig. 4.2. (a) Moisture ratio (MR) vs. drying time at different infrared radiation wattage for rose petals 300 W (▪), 400 W (●) and 500 W (▲); (b) Moisture ratio (MR) vs. drying time at the different drying temperatures for the rose petals 50 °C (▪), 57 °C (●) and 65 °C (▲).

The drying time to reach equilibrium moisture in hot air drying at 50, 57, and 65 °C was 75, 55, and 35 minutes, respectively. In comparison, the time required for infrared drying at 300, 400, and 500 W was 39, 24, and 18 minutes, respectively. From Fig. 4.2, it is clear that rose petals dry faster with infrared waves than with hot air. At the same temperatures, infrared drying required 50–52% less time than hot air drying. Radiation heat transfer, the fastest mode of heat transfer, outperforms natural or forced convective heat transfer in hot air dryers, making infrared drying faster. The moisture removal rate is increased when infrared radiation is directly applied to the product and is absorbed by water molecules on and near the surface of the sample. Moreover, in contrast to hot air drying, the rapid removal of moisture is enabled by the porous structure facilitated by infrared waves.

The sample's moisture content at a particular period and the initial moisture content were used to compute the DR, and the results are shown in Fig. 4.3. The DR consistently decreased with an increase in drying duration and a decrease in moisture content in infrared and hot air drying. No constant drying was observed in both drying method and thus entire drying process falls under the falling rate (Fig.4.3 a and b).

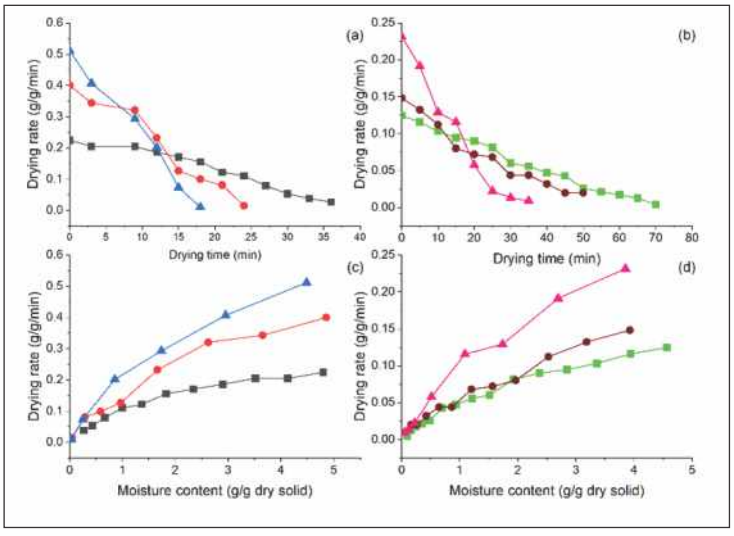


Fig. 4.3. Drying rate vs. drying time at different infrared wattage (a) 300 W (▪), 400 W (●) and 500 W (▲) and temperature; (b) 50 °C (▪), 57 °C (▲) and 65 °C (●) for rose petals; Drying rate vs. moisture content at different infrared wattage (c) and temperatures (d).

Fig. 4.3a and b indicate that in both dryings, the DR decreased due to an increase in internal resistance for moisture diffusion. Two falling phases were observed from Fig. 4.3; the DR was higher in the initial falling phase in both drying methods and relied on internal and external mass transfer rates. This is attributed to the available free moisture, which is removed more quickly at the surface of rose petals. After 12 minutes in infrared drying and 15 minutes in hot air drying, the DR decreased drastically with a decreased moisture content of the samples. During the second falling phase, rose petals were unsaturated and hindrance to moisture movement was increased due to reduced porosity caused by the gradual shrinkage of the sample as well as the collapse of cells. In the hot air-drying sample, the resistance to transport of a water molecule from the moist region to the surface was higher than in the infrared drying sample. As a result, hot air drying had a longer drying time and a lower drying rate. In a hot air drying, average DR for 50, 57, and 65 °C were 0.060, 0.070, and 0.096 (g/g dry solid. min), respectively. The average DR in a hot air dryer increased as the temperature increased. In hot air drying, the rate of mass transfer was higher at 65 °C temperature, as compared with the other two temperatures. Similarly, the average DR was increased with an increased infrared power level. In the infrared dryer, the average DRs for 300, 400, and 500 W were 0.131, 0.202, and 0.249 (g/g dry solid. min), respectively. Compared to hot air drying, infrared drying had a higher DR. The faster rate of drying is induced by the impact of radiation on the exposed petal surface, which finally induces internal heating via the vibration of an internal molecule.

4.1.2.2 Mathematical modelling of rose flower petal drying

The behaviour of rose petals is described by comparing the data from experiments with the data predicted by the model under given drying methods and conditions.

Table 4.2. Statistical analysis of the selected models at different infrared radiation and hot air temperatures.

Model	Wattage (W)	Infrared drying					Hot air drying			
		χ2	RSS	R^2	RSME	Temp. (°C)	χ2	RSS	R^2	RSME
Lewis	300	0.00621	0.07452	0.94432	0.0788	50	0.0017	0.02548	0.98357	0.04121
	400	0.00469	0.03281	0.96315	0.06847	57	0.000982	0.0108	0.99057	0.03133
	500	0.00402	0.02008	0.97292	0.06337	65	0.00169	0.01185	0.98692	0.04115
Page	300	0.000806	0.00887	0.99338	0.02839	50	0.000183	0.00256	0.99835	0.01351
	400	0.00294	0.01763	0.9802	0.05421	57	0.00025	0.0025	0.99782	0.01581
	500	0.00433	0.01734	0.97662	0.06583	65	0.000233	0.0014	0.99846	0.01527
Modified page	300	0.00621	0.07452	0.94432	0.0788	50	0.0017	0.02548	0.98357	0.04121
	400	0.00469	0.03281	0.96315	0.06847	57	0.0009815	0.000982	0.99057	0.03133
	500	0.00402	0.02008	0.97292	0.06337	65	0.00169	0.00169	0.98692	0.04115
Henderson and Pabis	300	0.00591	0.06498	0.95145	0.07686	50	0.0014	0.01954	0.9874	0.03736
	400	0.00529	0.03177	0.96432	0.07276	57	0.000903	0.00903	0.99211	0.03005
	500	0.005	0.005	0.97305	0.07068	65	0.00176	0.01053	0.98838	0.01053
Midilli Kucuk	300	0.000563	0.00507	0.99621	0.02373	50	0.000067	0.000802	0.99948	0.00817
	400	0.00216	0.00836	0.99098	0.04652	57	0.000028	0.000224	0.9998	0.00529
	500	0.00218	0.00437	0.99411	0.04073	65	0.000729	0.00292	0.99678	0.027
Avhad and Marchetti	300	0.000576	0.00576	0.9957	0.02399	50	0.000162401	0.00211	0.99864	0.01274
	400	0.00306	0.01532	0.98279	0.05536	57	0.000263066	0.00237	0.99993	0.001622
	500	0.00569	0.01706	0.97699	0.07541	65	0.000274122	0.00137	0.99849	0.00137
Logarithmic	300	0.00147	0.0147	0.98902	0.03834	50	0.000251727	0.00327	0.99789	0.01587
	400	0.00168	0.00838	0.99059	0.04093	57	0.0000345	0.000311	0.99973	0.00588
	500	0.00248	0.00743	0.98998	0.04976	65	0.000577068	0.000577	0.99682	0.02402

Table 4.2 gives an idea about the comparison of statistical parameter values of R^2 (Coefficient of determination), χ^2, RMSE (Root mean square error), and RSS (Residual Sum of Squares) of selected seven drying models. The data depicts that all the applied drying mathematical models well explained the drying behavior of rose petals in both drying methods. In the infrared dryer, for all model the statistical values of $\chi 2$, RSS, R^2, and RMSE varies from 0.000563 - 0.00621, 0.00437 - 0.07452, 0.94432 - 0.99621, and 0.02373 - 0.0788, respectively. Similarly, in hot air dryer, statistical parameter values varied from 0.000028 - 0.00176, 0.000224 - 0.02548, 0.94432 - 0.99993, and 0.00137 - 0.04121, respectively. Midilli-Kucuk shows the highest R^2 and lowest $\chi 2$, RSS, and RMSE values, giving the best fitting among the seven models for both drying methods. Midilli-Kucuk model values for infrared power 300, 400, and 500 W had respective coefficients of variation of 0.99621, 0.99098, and 0.9941. Similarly, for hot air dryers, 50, 57, and 65 ℃ were 0.99948, 0.9998, and 0.99678, respectively. Midilli-Kucuk model model shows the highest R^2 and lowest χ^2, RSS, and RMSE values and give the best fitting among 7 models for both drying methods. The Avhad and Marchetti, and the Page model also closely fit with experimental data followed by Midilli-Kucuk model in both drying methods. The fitness of the models being comparable with that of the Midilli-Kucuk model. Figure 4.4 a-f depicts the Midilli-Kucuk model predicted data vs. the experimental MR of hot air and infrared drying. These graphs portray that the projected data are closely clustered around a straight line, demonstrating the aptness of these models in understanding the drying behaviour of rose petals.

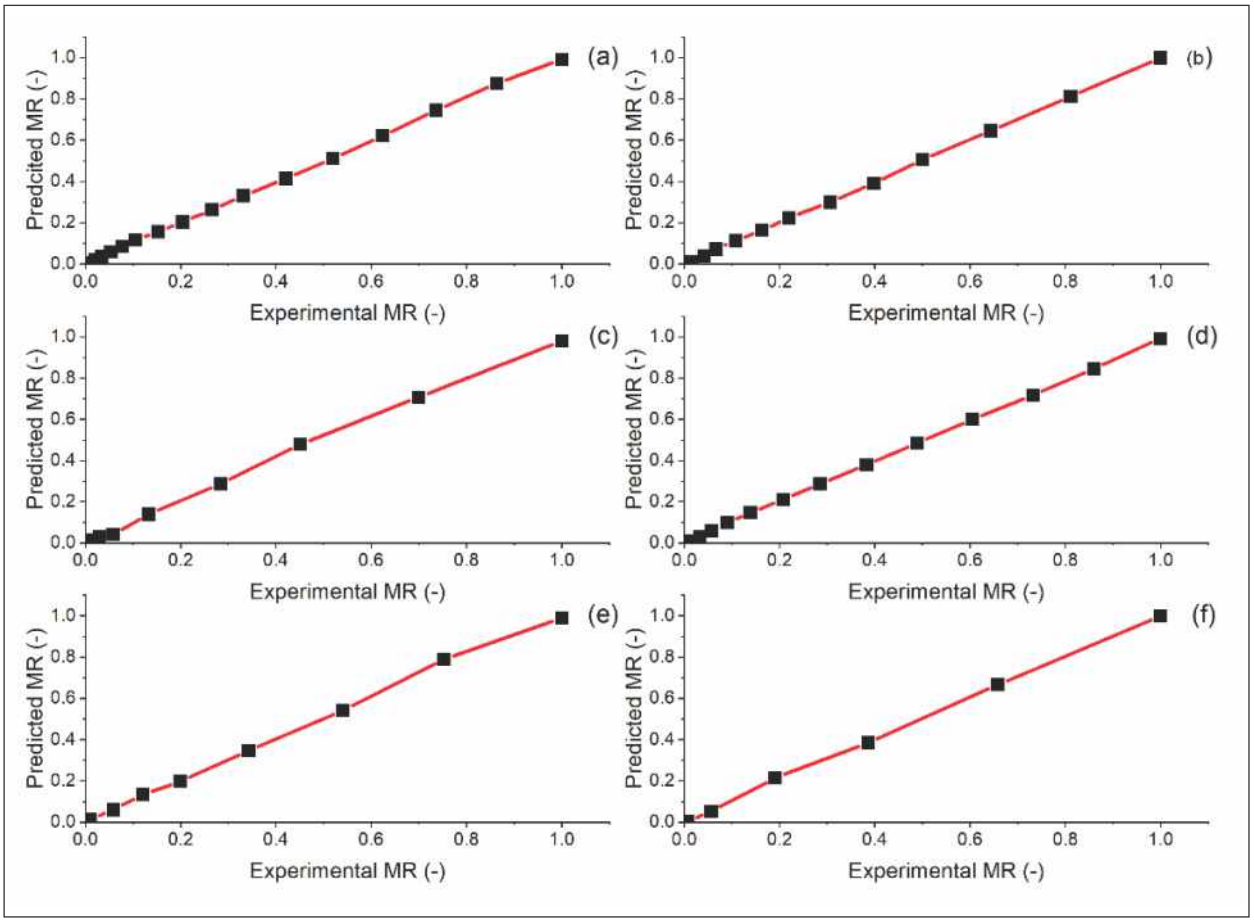


Fig. 4.4. Predicted moisture ratio by Midilli-Kucuk model versus experimental moisture ratio of the rose petals at the drying temperatures of (a) 50 °C; (b) 57 °C; (c) 65 °C; (d) 300 W (e) 400 W and (f) 500 W (■) predicted moisture ratio and (–) regression line.

However, other models also hold a higher prediction rate for experimental data in infrared drying. The drying constants obtained from these models are presented in Table 4.3.

Table 4.3. Model constants obtained by fitting experimental data of rose petals by infrared and hot air drying.

Model	Model constant	Infrared drying wattage (W)			Hot air-drying temperature (°C)		
		300	400	500	50	57	65
Lewis	k	0.05877	0.09829	0.13806	0.03804	0.0496	0.08835
Page	k	0.00908	0.03748	0.09894	0.01536	0.02844	0.04326
	n	1.62451	1.37273	1.14538	1.26364	1.17561	1.27179
Modified page	a	0.24243	0.31358	0.37156	0.19503	0.22275	0.29724
	k	0.24243	0.31357	0.37156	0.19502	0.22272	0.29724
Henderson and Pabis model	a	1.07354	1.0274	1.00887	1.05606	1.03326	1.03264
	k	0.06262	0.10063	0.13915	0.04007	0.05121	0.09089
Midilli	a	0.96202	0.98969	0.99931	0.99142	0.99956	0.97882
	b	-0.000840	-0.00933	-0.02571	-0.000493721	-0.00118	-0.07595
	k	0.0077	0.06346	0.15865	0.01746	0.03657	0.01607
	n	1.64353	1.0045	0.56632	1.20507	1.06094	1.16519
Avhad and Marchetti	a	0.95509	0.9531	0.98355	0.98197	0.98908	0.99488
	k	0.00588	0.02411	0.09065	0.01336	0.02644	0.04209
	n	1.75318	1.52436	1.17643	1.29851	1.19484	1.28017
Logarithm	a	1.54763	1.4455	1.32467	1.12707	1.11891	0.99488
	k	0.02905	0.049	0.07435	0.03914	0.0715	0.04209
	c	-0.5288	-0.45685	-0.34833	-0.12178	-0.10531	1.28017

The drying constant is a key parameter since it correlates the drying process with the rate of moisture removal from the rose petals. As demonstrated in Table. 4.3 the drying constant, k, fluctuates with temperatures and infrared power level and increases with infrared power level and forced convective air temperatures. The infrared power level and convective air temperatures affect the values of the parameters k_0, a, n, b, C, and N. For this model and both drying parameters, there was no apparent upward or decreasing trend. Drying temperature and time-dependent drying process development can adequately describe the drying behavior and characteristics of the final product of rose petals.

4.1.2.3 Colour change of rose petal during drying

A product's colour is an essential factor in consumer acceptance and marketability. Acceptability of the dried product is negatively affected by its shrinkage and dark brown colour. The colour change is directly related to drying temperatures, product characteristics and product moisture level, which all affect enzymatic and non-enzymatic browning in the products. Colour values of *L**, *a**, and *b** values of fresh rose petals were 36.49, 48.761, and 1.933, respectively. In drying, infrared power level, hot air temperature, and drying time significantly affect the colour of the final dried product. In Figs. 4.5 a-d and 7 a-d, respectively, the colour values of *L**, *a**, *b** and ΔE for infrared and hot air drying are shown.

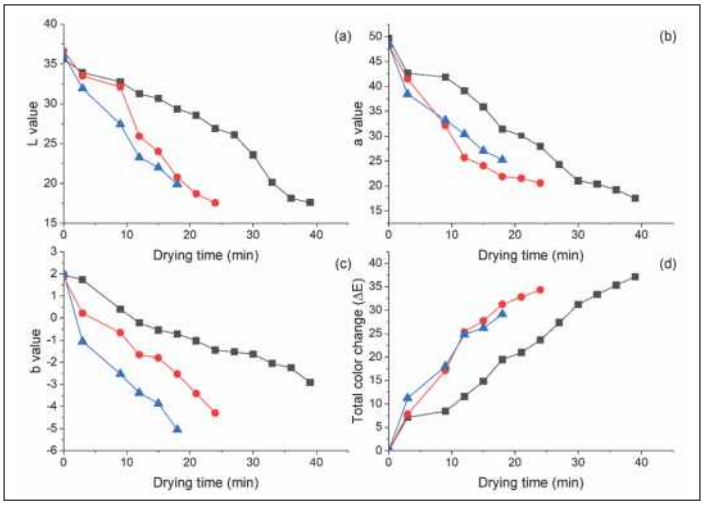


Fig. 4.5. Kinetics of change in the colour characteristics: (a) L value, (b) a value, (c) b value, and (d) Total colour change (ΔE) of rose petals as a function of infrared radiation wattage at 300 W (•), 400 W (•) and 500 W (▲).

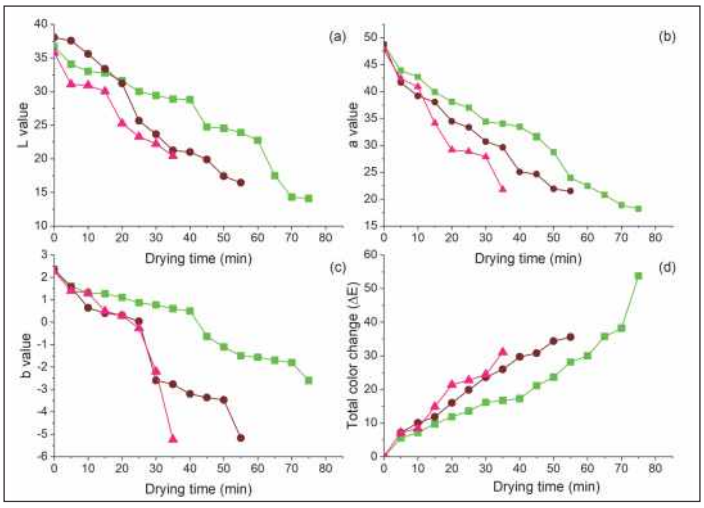


Fig. 4.6. Kinetics of change in the colour characteristics: (a) L value, (b) a value, (c) b value and (d) Total colour change (ΔE) of rose petals as a function of drying time at 50 °C (■), 57 °C (●) and 65 °C (▲).

The L* value is the indicator of browning and represents the lightness of the sample. In both drying methods, the lightness of the sample decreased under progressive removal of moisture content from the sample resulting in increased absorbance and refraction and less reflectance in the sample. Increase in infrared radiation power and hot air temperature resulted in a fall in the L* value. A non-enzymatic reaction in the finished product and a decline in sample luminance are both indicated by a fall in L* values. A thin dark red spot appearance was observed at the end of drying (Fig.4.1 c). The average L* values of the dried rose petal sample were 17.60, 17.56, and 19.88 for 300, 400, and 500 W, respectively. Similarly, final L* values in a hot air dryer were 14.10, 16.43, and 20.42 at 50, 57, and 65 °C, respectively. There was no statistically significant difference ($P>0.05$) between the infrared-dried samples at various wattages. For samples dried at 50 °C and 65 °C, there was a significant difference ($P<0.05$) for L* values in hot air drying. While the sample dried at 57 °C and 65 °C did not significantly differ from one another. At 50 °C and 500 W, a significant difference ($P<0.05$) was found between hot air drying and infrared drying. Compared with hot air drying, the infrared-dried sample shows higher L* values. The sample's low moisture content increases the temperature of the drying chamber in hot air, and continuous penetration of infrared radiation in the infrared dryer increases the non-enzymatic browning reactions. The non-reducing sugar, amino acid, and temperature reaction accelerated the Millard reaction.

Likewise, when drying time, infrared power, and convective air temperatures increased, a* values decreased. The results for hot air and infrared drying ranged from 17.51 to 25.27 and 18.20 to 21.76, respectively. In infrared drying, the final values of a* were 17.51, 20.55, and 25.27 at 300, 400, and 500 W, respectively. The hot air-drying value of 'a' were 18.20, 21.50, and 21.76, respectively. The sample dried at 500 W was significantly different from those dried at the other two wattages (300 and 400 W). While in hot air-drying sample dried at 50 °C showed a significant difference with other two temperatures (57 °C and 65 °C). Redness in the sample dried at 500 W shows a distinct significant difference between hot air-drying temperatures. The decrease in a value related to chroma indicates the browning rate of rose petals. Lower a* value indicates a higher browning in the dried petals. When compared to hot air drying, infrared drying has higher values of a*. The red color in roses is mostly due to the presence of the pigment anthocyanin, which is found in abundance in phenolic groups. The rose petals' greenness in the samples, which is reflected in the negative and lower values of a*, shows that the anthocyanin content of the petals has decreased.

The sample's yellowness or blueness is indicated by the b* value. The b* value continuously dropped until the drying process was complete in both drying processes. The bluish colour of the rose petals was due to the degradation of carotenoids. The b* values of the final dried product for hot air drying (50, 57 and 65 °C) and infrared drying (300, 400, and 500 W) were -2.92, -4.30, -5.05, and -2.60, -5.17, and -5.23, respectively.

Infrared-dried samples at various wattages showed no discernible difference. In hot air drying, for b* values significant difference (P<0.05) was found between samples dried at 50 °C and other 2 temperatures (57 °C and 65 °C). In hot air drying and infrared drying, a significant difference (P<0.05) was found between 50 °C, 65 °C, and 500 W. Light blue and slight brown colour were observed for 300-500 W and 50-65 °C temperature. The colour has more appeared on increasing temperature (65 °C) and infrared radiation power levels (500 W). As comparison to the hot air-dried sample, infrared-dried samples had a more saturated red color. It might be the decomposition of carotenoid and anthocyanin pigment present in the sample and the nonenzymatic Maillard reaction.

The colour values of L^*, a^*, and b^* were less influenced and more appealing colours were observed at 65 °C and 500 W. A less appealing red colour and more browning were observed at lower infrared radiation levels and hot air temperatures. It was caused by the higher exposure period to temperature, as rose flower petals are sensitive to temperature. The retention of colour was more at higher temperatures and higher infrared power levels. The degree of color variance across raw and dried rose petal samples was determined using the total color change. Total colour changes for infrared dried rose petals were presented in Fig. 4.6d. Total color changes in rose petals were increased with increasing infrared power level, ranging from 29.14 to 37.15. Similarly hot air-drying colour increased with drying temperature and varied between 31.06 to 53.77. Compared to hot air drying, infrared drying showed lower total color change values. 500 W showed the least degree of colour change in comparison to the other two power levels and hot air-drying temperatures. Color change happens after drying as a result of non-enzymatic browning and other thermal damages that cause darkening in the rose petals.

Chroma for both drying methods were exhibited in Fig. 4.7 a-b. Chroma represents the color saturation or purity and are proportional to color intensity. In both the drying methods, the chroma of the product decreased with increasing temperature and infrared radiation power level. For convective drying and infrared drying, the chroma values varied from 17.78 to 25.77 and 18.38 to 22.38, respectively. Higher chroma values, which indicate the surface colour saturation, were found at 65 °C (22.38) and 500 W (25.77) and are proportional to color intensity. The surface of dried rose petals has a dark red color, which may be seen when the chroma value is increased. The color and optical properties of the finished product are impacted by the amount of moisture present as well as the drying circumstances. The overall colour change was higher at 50 °C in hot air drying and 300 W in infrared drying. Infrared drying results in less color change in the final dried rose petals than hot air drying. Comparable tendencies for improved color retention were identified between infrared and hot air drying of rose petals.

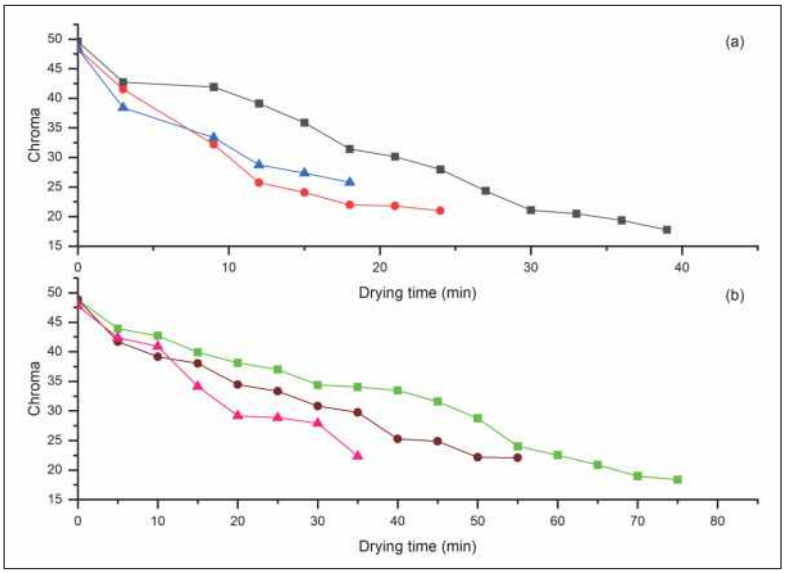


Fig. 4.7. Kinetics of change in the Chroma value of rose petals as a function of drying time at (a) 300 W (■), 400 W (●) and 500 W (▲); (b) 50 °C (■), 57 °C (●) and 65 °C (▲).

4.1.2.4 Effect of drying methods on ascorbic acid

The ascorbic acid content of infrared and hot air-dried petals is shown in Table. 4.4. Ascorbic acid content for hot air and infrared dried samples varies from 39.73- 59.10 (mg/100 gm) and 59.10 - 61.03 (mg/ 100 gm), respectively. No Significant difference ($P>0.05$) was observed in infrared wattage. While in hot air drying, a discernible difference between ($P<0.05$) was observed with drying temperatures. The ascorbic acid value increased with drying temperature and infrared wattage. The increased value implies that drying time, along with temperature, has a detrimental effect on the ascorbic acid content of samples. Conversely, a decreasing trend of ascorbic acid in rose petals was observed from 70 -100 °C drying temperature.

4.1.2.5 Effect of drying methods on anthocyanin

Anthocyanins give flowers, fruits, and vegetables their red-violet hue. Due to their potential health-promoting effects and defence against free radicals, plant-based anthocyanins are in high demand. Our investigation found the highest anthocyanin content in 500 W infrared drying (295.758 mg/100g). The anthocyanin content of infrared and hot air-dried rose petals was shown in Table 4.4. Anthocyanin content for hot air and infrared dried samples varies from 109.39 - 140.54 (mg/100g) and 65.33- 295.75 (mg/100g), respectively. A significant difference ($P<0.05$) was observed in both infrared and hot air-drying methods. With increasing drying temperature and infrared wattage, anthocyanin content increased, suggesting that drying time and temperature influence the anthocyanin content of dried rose petals.

Table 4.4. Ascorbic acid and anthocyanin content of infrared and hot air-dried rose petals.

Treatment	Ascorbic acid (mg/100 gm DW)	Anthocyanin (mg/100g)	Colour attributes		
			L	a	b
50°C	39.73 ± 3.9^{a}	109.39 ± 30.29^{a}	14.17 ± 0.29^{c}	17.93 ± 0.22^{c}	-2.57 ± 0.04^{a}
57°C	52.31 ± 5.1^{b}	120.77 ± 15.71^{b}	16.31 ± 0.12^{ab}	21.76 ± 0.18^{b}	-5.12 ± 0.10^{b}
65°C	59.10 ± 5.5^{c}	140.54 ± 28.41^{c}	20.77 ± 0.22^{a}	21.92 ± 0.13^{b}	-5.28 ± 0.15^{b}
300 W	59.10 ± 3.8^{c}	65.33 ± 22.96^{d}	17.17 ± 0.20^{ab}	17.52 ± 0.31^{c}	-2.92 ± 0.08^{a}
400 W	60.06 ± 6.8^{c}	131.75 ± 35.58^{c}	17.39 ± 0.19^{ab}	20.25 ± 0.34^{bc}	-4.30 ± 0.14^{ab}
500 W	61.03 ± 2.6^{c}	295.75 ± 5.70^{f}	20.36 ± 0.26^{a}	25.32 ± 0.23^{a}	-5.04 ± 0.12^{b}

Values are mean ± standard deviation. Values bearing different alphabets are significantly different at five percent level of significance.

4.1.3 Standardization of process for making of rose candy.

Standardized the process for making of rose candy from rose flowers. Firstly, prepared rose extract from fresh rose petals after properly washed the petals with distilled water (Rose to water ratio: 2:1 will get 25 ml rose extract by boiling method). Prepared different combination of (Sugar+liquid glucose+Rose extract+water) as per the experiment design and boiled for 15 min to get optimum consistency. Keep the sample with silicon candy at room temperature for 2hrs to get hard consistency. Results of the sensory evaluation indicate that the rose candy prepared with 15 ml of rose extract was found to be the best.

4.1.4 Standardization and optimization of microwave assisted extraction technology for rose flowers.

Investigated and optimized the Microwave time (min.), Microwave power (W), Ethanol concentration (%) and Solid to liquid ratio (g/ml). Based on the preliminary experiments, we selected different 3 levels for each independent parameters *viz.* Microwave time (2, 4, 6 min.), Microwave power (280, 420, 560 W), Ethanol concentration (50, 70, 90%) and Solid to liquid ratio (0.01, 0.03, 0.05g/ml).

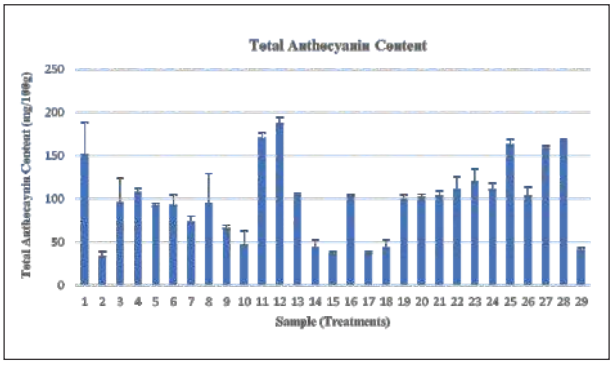


Fig. 4.8 Total Anthocyanin content of rose extract

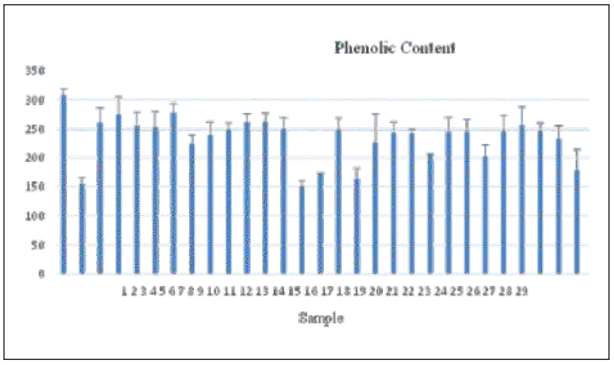


Fig. 4.9 Total Phenolic content of rose extract

From Fig.4.8, it is clear that the highest value of anthocyanin content 187.49 mg/L was found in sample 12 (microwave power 420 W, microwave time 4 min, 90% ethanol, solid to liquid ratio 0.05). The lowest value of anthocyanin content 34.349 mg/L was found in sample 2 (microwave power 420 W, microwave time 2 min, 70% ethanol, solid to liquid ratio 0.01). High anthocyanin content was observed in deep pink color extracts followed by orange, pink, yellow color extracts. Highest anthocyanin content 170.52 mg/L was observed in sample 11 when microwave time was 6 minutes and lowest anthocyanin content 34.349 mg/L was observed in sample 2 when microwave time was 2 minutes. Total anthocyanin content increases as time increases this is because longer the material exposed to radiation, it releases solute into the solvent. Highest anthocyanin content 158.81 mg/L was observed in sample 27 when microwave power was 560 W and lowest anthocyanin content 37.867 mg/L was observed in sample 17 when microwave power was 280 W. The higher microwave power resulted the higher effect of microwave energy on biomolecules which results in higher anthocyanin content in sample. Highest anthocyanin content 187.49 mg/L was observed in sample 12 when ethanol concentration was 90 % and lowest anthocyanin content 43.684 mg/L was observed in sample 18 when ethanol concentration was 50%. Highest anthocyanin content 187.49 mg/L was observed in sample 12 when solid to liquid ratio was 0.05 and lowest anthocyanin content 34.349 mg/L was observed in sample 2 when solid to liquid ratio was 0.01.

From Fig. 4.9, it is clear that the highest phenolic content 308.04 mg/g was found in sample 1 (Microwave power 280 W, Microwave time 4 min, 70% ethanol, solid to liquid ratio 0.05). Lowest phenolic content 150.95 mg/g was found in sample 14 (Microwave power 420 W, Microwave time 4 min, 90% ethanol, solid to liquid ratio 0.01). The findings showed that the extract of light colours exhibited less phenolic content, while the extract with bright red colours exhibited greater phenolic content in the petals. Highest phenolic content 261.59 mg/g was observed in sample 11 when microwave time was 6 minutes and lowest phenolic content 155.52 mg/g was observed in sample 2 when microwave time was 2 minutes. Total phenolic content increases as time increases this is because longer the material exposed to radiation, it releases solute into the solvent. Highest phenolic content 256.75 mg/g was observed in sample 26 when microwave power was 560 W and lowest phenolic content 163.84 mg/g was observed in sample 17 when microwave power was 280 W. The higher microwave power resulted the higher effect of microwave energy on biomolecules which results in power dissipated in solvent and material. Highest phenolic content 262.66 mg/g was observed in sample 12

when ethanol concentration was 90 % and lowest phenolic content 226.68 mg/g was observed in sample 18 when ethanol concentration was 50 %. As we increase the ethanol concentration, it absorbs the compounds in plant material which results in high content of phenols in the sample. Highest phenolic content 308.04 mg/g was observed in sample 1 when solid to liquid ratio was 0.05 and lowest phenolic content 150.95 mg/g was observed in sample 14 when solid to liquid ratio was 0.01.

Fig. 4.10. Rose samples extracted through MAE

4.1.5 Protocol for standardisation of rose syrup

Rose flowers are rich in essential oils, vitamins, minerals, polyphenols and all of which shown to significantly improve human health. Taking into consideration of above facts, protocol was standardised to develop a nutritionally enriched rose syrup from fresh rose petals. First of all, cleaned and washed the rose petal (150g) with water. After that boiled cleaned rose petals (150g) in water (0.4 litre) for 5 min. The boiled rose petals and rose extract were separated and filtered rose extract with whatman filter paper. The sugar syrup (400g sugar + 100 ml water) was prepared separately. Finally, added rose extract in sugar syrup and boiled for 5 min to get thick consistency of syrup and got 350 ml of rose syrup. Ready to serve rose syrup can be prepared by dilutes 10 ml of syrup in 100 ml of water (1:10 ratio). It acts as a body coolant and also very effective to treat stomach disorders.

Fig. 4.11 Rose Syrup

4.2 Design and Development of Tools and Gadgets for Floriculture

4.2.1 Modification and performance evaluation of hand-held transplanter

Modified and tested the Hand-held Transplanter. We found that transplanting 100 seedlings with a hand-held transplanter took 8.25 minutes, but manually planting 100 seedlings took 16.8 minutes. Plant Survival rate for both the methods is near about same i.e. 98%. From Table 4.5, it is clear that the efforts required for transplantation seedlings with help of hand-held transplanter are less as compared to the manual transplantation of seedlings because three operations (Making hole, inserting seedlings and planting) done simultaneously in case of hand-held transplanter.

Table 4.5. Testing and comparison of handheld transplanter with manual transplanting of seedlings

Sr. No.	Parameters	Planting of seedlings by Hand-held Transplanter	Manually Transplanting of seedlings
1	Time required to plant 100 seedlings (min.) (Spacing: 25cm)	8.25	16.8
2	Plant Survival rate	95%	98%
3	Efforts required for plantation	Less as three operations (Making hole, inserting seedlings and planting) done simultaneously	More as three operations (Making hole, inserting seedlings and planting) done one-after-one

4.2.2 Testing of modified loose flower plucker

We modified the Loose flower plucker by adding the metal gruf at upper side of plucker for tightening and loosening of cutting blade. This modification was done after getting feedback from the farmers. We found that the plucking rate (g/min) was more in case of harvesting of marigold flowers with the help of modified loose flower plucker than the hand plucking of marigold flowers. The pain experience and plucking efforts required during harvesting of marigold flowers were minimum in case of modified loose flower plucker than hand plucking of marigold flowers.

Fig. 4.12 Modified loose flower plucker

4.3 (ICAR Project Code IXX 18590): Exploration of Phytochemical Diversity (essential oil and pigments) in Important Flower Crops (Chrysanthemum, Marigold, Rose and Tuberose)

4.3.1 Essential oil content in selected *C. morifolium* genotypes

Phytochemical diversity in terms of essential oils (EO) yield and phytochemical composition was investigated in different genotypes of *Chrysanthemum morifolium*. A total of 120 chrysanthemum lines were chemically screened for essential oil content, and identified top 23 essential oil-yielding genotypes which are selected for further investigation. Floral traits of these 23 genotypes (Fig 4.13) included average number of flowers per plant, average flower weight (g), average flower yield (g/plant), average oil yield (g/plant) and its chemical profile were also documented.

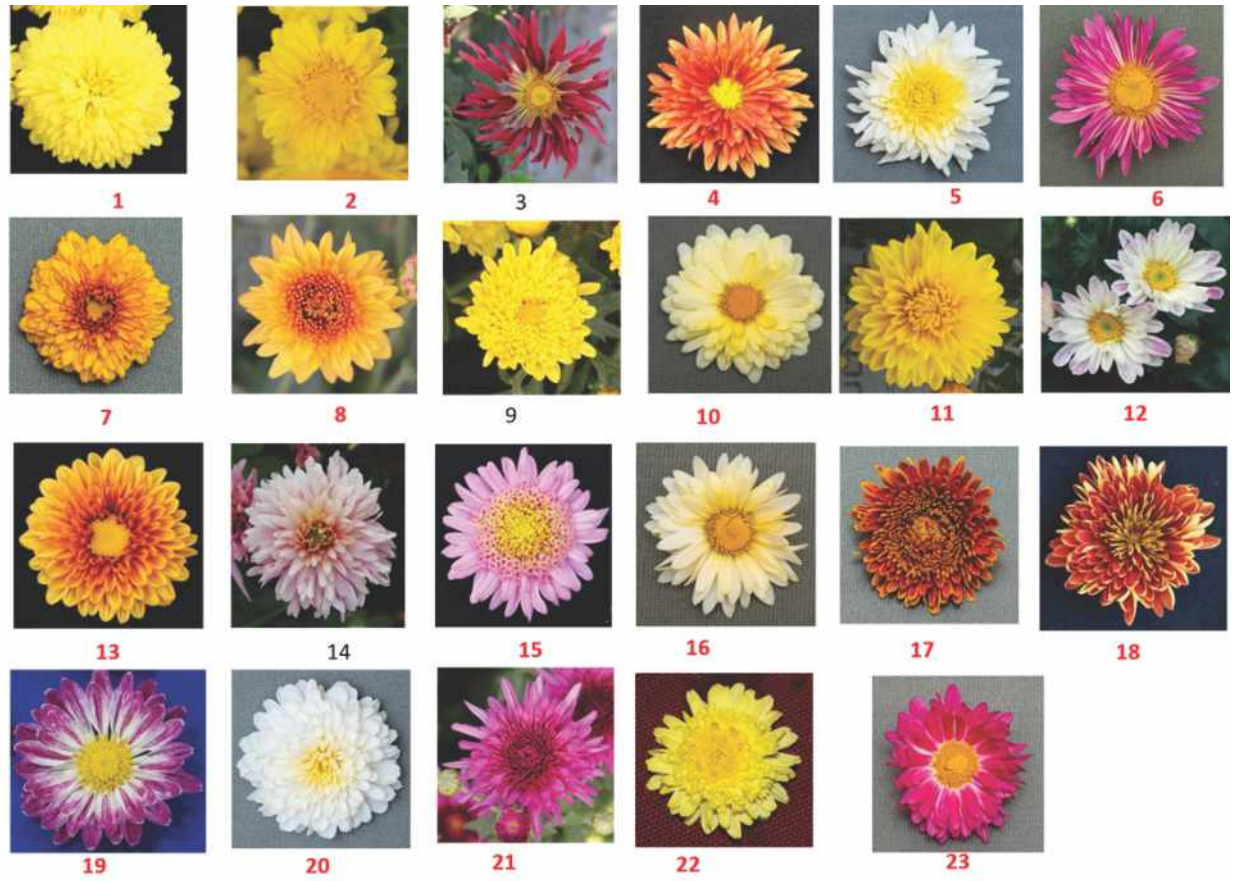


Fig. 4.13. Identified top 23 essential oil-yielding genotypes

1.Liliput; 2.Preet Shringar; 3.Garden Beauty; 4.Charlie; 5.Acc. -6; 6.OPCH 12-2; 7.NBRI-Little Orange; 8.Mini Jessie; 9.Yellow Delight; 10.DFR -C-2; 11.DFR-GM-1; 12.DFR-C-EB-3; 13.Pusa Guldasta; 14.Karnal Pink; 15.Silk Brocade; 16.OPCH 13-2; 17.CSIR-IHBT-CH-14-2; 18.Bidhan Agnisikha, 19.DFR-C-EB-1; 20.Acc.-11; 21.Magenta; 22.Basanti; 23.OPCH -12-7

Significant variations in essential oil content among the selected 23 genotypes was recorded. On fresh weight basis, the highest oil yield was observed in Liliput (0.3061±0.0074 %) and lowest oil being noticed in ACC-11 (0.061±0.0037 %). Similarly, on a dry weight basis, the oil content varied significantly among the genotypes with Liliput exhibiting the highest oil content (1.56 ± 0.02) and DFR-OPCH-12-7 containing the lowest (0.32 ± 0.0014) (Fig 4.14).

On dry weight basis, the pattern of best five essential oil genotypes are Liliput (1.5565 ± 0.0197 %) Preet Shringar (1.046 ± 0.0755), Charlie (0.7652 ± 0.0087), Garden Beauty and Karnal Pink (0.5725± 0.0203). The ANOVA analysis showed a significant difference between the groups for oil content based on both fresh weight [$F(23, 24) = 206.33$, $p < 0.001$) and dry weight ($F(23, 24) = 73.74$, $p < 0.001$)] measurements. The variation recorded across *C. morifolium* varieties can be used as a viable tool to determine the chemotypes.

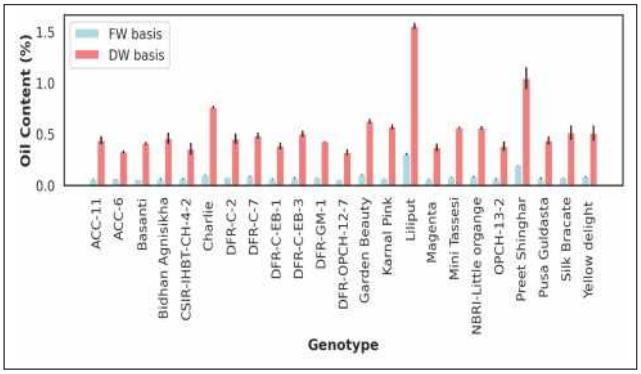


Fig. 4.14 Essential oil content of different genotypes

The genetic variation in plants is important to exploit the heterosis in selecting and development of new varieties (breeding programs). Hodaei et al., (2017) studied the EOs variation as one of the tools for estimation of diversity in medicinal plants. In this study, the EOs content varied in 23 varieties ranging from 0.1 to 0.56 % (w/w). In our study, Liliput contained the highest oil content (0.306 % on a fresh weight basis and 1.56 ± 0.02 on a dry weight basis) and lowest was observed in DFR-OPCH-12-7 implies the EO content varied significantly from different genotypes of *C. morifolium*.

4.3.2 *C. morifolium* genotypes characteristics

In this study, to deduce the relationship between the morphological characteristics and EO content, parameters such as average number of flowers per plant, average flower weight (g), average flower yield (g/plant) and average oil yield (g/plant) have been studied. Pertinent to number of flowers per plant parameter, Magenta and Yellow Delight showed 536.7 and 455.0 flowers per plant, respectively. In contrast, CSIR-IHBT-CH-14-2 produced fewer flowers with 30.0 flowers per plant (Fig 4.15a). With respect to mean flower weight (g), Karnal Pink and Pusa Guldasta had with high mean flower weight of 3.4 and 2.6 g, respectively. Conversely, Bidhan Agnisikha and Liliput recorded lower mean flower weights at 0.7 and 0.5 g, respectively (Fig. 4…15).

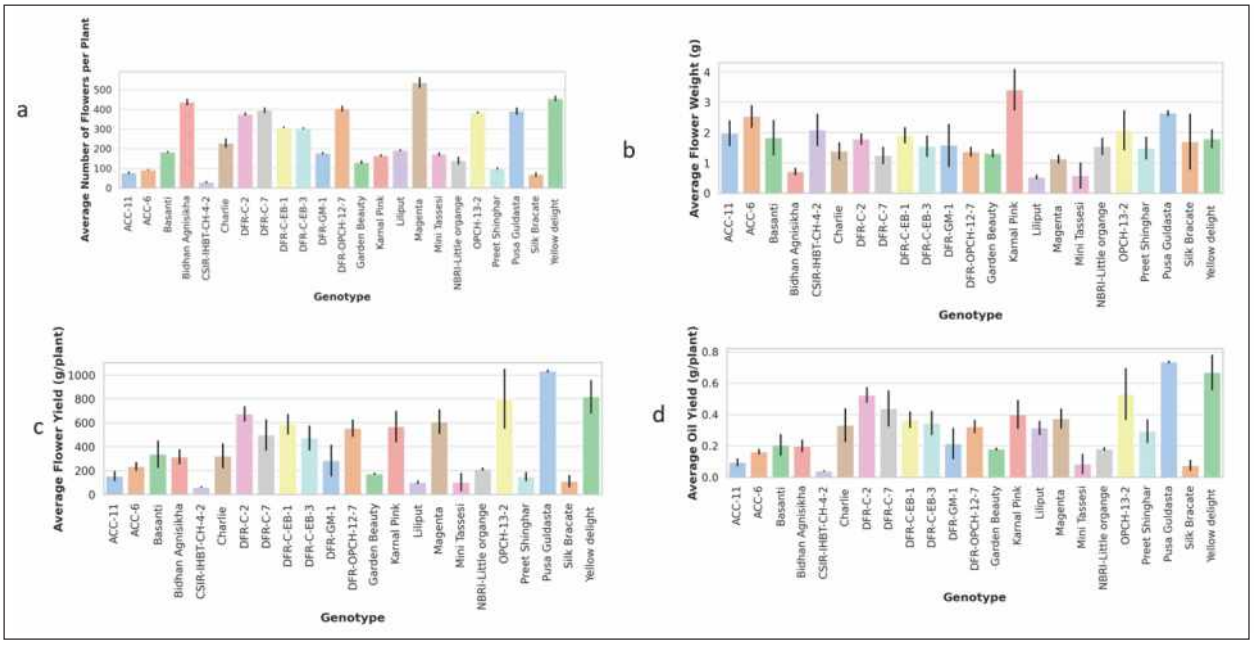


Fig. 4.15 Variation in Chrysanthemum morifolium genotypes a) Number of flowers per plants b) Average flower weight (g) c) Average flower yield (g/plant) and Average oil yield g/plant)

Another important yardstick for selection of elite genotype is flower yield (g/plant), which is an important characteristic for farmer/flower industry. In our study, Pusa Guldasta yielded 1033.9 g/plant and lowest yield was observed in CSIR-IHBT-CH-14-2 with 61.0 g/plant (Fig. 4.15). These results are of great significance, especially for industries focused on flower production, as they highlight genotypes with superior yield potential. The oil yield (g/plant) varied significantly, indicating diversity in oil production capabilities. Pusa Guldasta and Yellow Delight produced the higher oil yield with 0.7 g/plant and CSIR-IHBT-CH-14- 2, silk brocade and ACC-11 produced relatively lower oil yields with 0.1 g/plant (Fig 4.15d).

Significant variations were also observed among genotypes for flower characteristics, including the number of flowers per plant [$F(23, 48) = 429.47$, $p < 0.001$ for the number of flowers per plant)], mean flower weight [$F(23, 48) = 5.47$, $p < 0.001$ for mean flower weight)], flower yield per plant [$F(23, 48) = 5.47$, $p < 0.001$ for

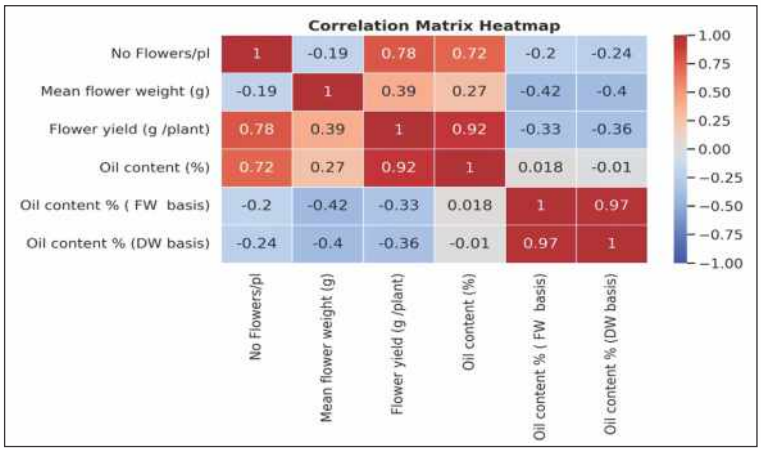


Fig. 4.16 Correlation of matrix of flower characters and oil content of *C. morifolium* genotypes

mean flower weight)], and oil yield per plant $F(23, 48) = 19.20$, $p < 0.001$ for oil yield per plant]. The p value implies the significance of the model.

In our study, the differences between varied plants characteristics explicitly demonstrate the role of genotype and geographical distribution in determining the desirable traits that ultimately useful in breeding programs to enhance essential oil production with improved phytochemical composition.

The correlation analysis revealed significant relationships among various parameters in *C. morifolium*. The number of flowers per plant (NF) exhibited a strong positive correlation with flower yield (FY) per plant ($r = 0.788$, $p < 0.0001$) and oil yield (OY) per plant ($r = 0.728$, $p = 0.0007$) (Fig 4.16). FY and OY were also strongly correlated ($r = 0.921$, $p < 0.0001$). However, the NF negatively correlated with mean flower weight (MFW) ($r = -0.212$, $p < 0.0001$). Oil content on a fresh weight (OCF) basis and oil content on a dry weight (OCD) basis exhibited a highly positive correlation ($r = 0.974$, $p < 0.0001$). There was a strong positive correlation between the NF with FY and NF with OY suggesting that genotypes with a higher NF are likely to have increased flower and oil production. This property implies that the high returns can be tapped upon selection of high flower-yield coupled with EO yield. Additionally, a negative correlation was observed between the NF and MFW indicating a trade-off between flower quantity and size.

MFW positively correlated with FY ($r = 0.39$, $p < 0.0001$) and OY ($r = 0.27$, $p < 0.001$). However, it had negatively correlated with OCF ($r = -0.42$, $p < 0.001$), OCD ($r = -0.40$, $p < 0.001$) and NF ($r = -0.19$, $p < 0.001$). Significant negative correlation was found between OCD with NF ($r = -0.24$, $p < 0.0001$), MFW ($r = -0.4$, $p < 0.0001$), and FY ($r = -0.36$, $p < 0.0001$).

4.3.3 Chrysanthemum chemotypes from selected *C. morifolium* genotypes

The comprehensive analysis of EOs across varied *C. morifolium* genotypes depicted rich tapestry of phyto-constituents shedding light on the chemical diversity (Table 4.6). As illustrated in Table 4.6, major compounds such as camphor (45.9 %, DFR-OPCH-12-7), borneol (40.38 %, NBRI-little orange), trans-chrysanthenyl acetate (23.15 %, magenta), cis- chrysanthenyl acetate (18.67, OPCH-13-2), (+)-α-pinene (17.83 %, charlie) and eucalyptol (12.85 %, basanti) were noticed. Besides, other compounds that are beneficial in varied industries could be tapped by selecting suitable genotype. Heat map depicts the abundance of phytochemicals (strong green colour) such as camphor, borneol, terpineol, chrysanthenol, α- pinene and eucalyptol across C. morifolium genotypes (Fig. 4.17).

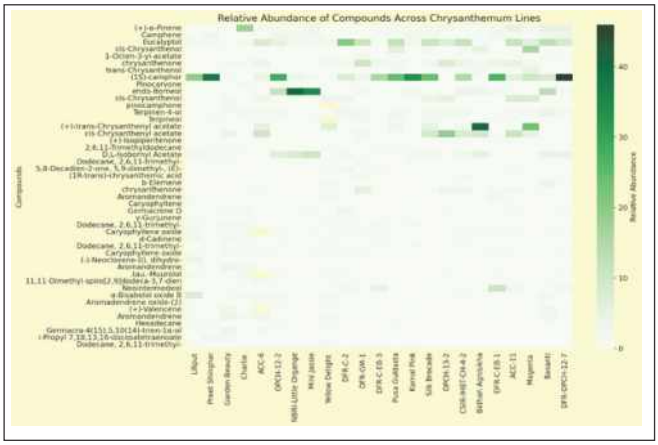


Fig. 4.17 Phytochemical profile of *C. morifolium* genotypes

In toto, the heatmap depicted the relative abundance of 47 major phytochemicals across 23 different genotypes. These genotype-specific compounds have varied applications in industries ranging from perfumery to herbal medicine (aromatherapy). Based on EO content and relative abundance of phytochemicals across 23 C. morifolium genotypes, the hierarchical clustering of C. morifolium genotypes were grouped into four distinct groups (Fig. 4.18). Group I consisted of 9 genotypes comprises of DFR-GM-1, DFR-C-2, Basanti, ACC-11, ACC-6, OPCH-13-2, Yellow Delight, Garden Beauty and Charlie are predominantly rich in eucalyptol and (1S)-camphor (except OPCH-13-2, yellow delight, charlie). Group II consists of magenta and Bidan Agnisikha that are rich in camphene, α- pinene and chrysanthenone. Group III include Mini-Jessie and NBRI-little orange characterized by cis-chrysanthenol and cis-chrysanthenyl acetate. Group IV consists of DFR-C-EB-3, Liliput, DFR-C-EB-1, CSIR-IHBT-CH-14-2, Silk Brocade, Pusa Guldasta, Karnal Pink, Preet Shringar, DFR-OPCH-12-7 and OPCH-12-2 are endowed with neointermedeol, α- bisabolol oxide B-, and acetic acid, 1,7,7-trimethyl-bicyclo[2.2.1]hept-2-yl ester. Group V comprised Preet Shringhar, Karnal Pink, and DFR-OPCH-12-7, exhibiting the highest levels of -(1S)-camphor.

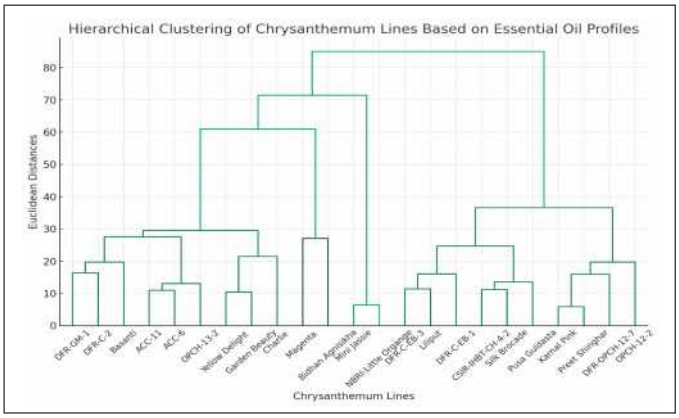


Fig. 4.18 Hierarchical clustering of *C. morifolium* genotypes based on essential oil profiles

4.4 Harnessing Natural Pigments from Flower Crops for Making Value Added Products from Grapes

4.4.1 Comparative analysis of VOCs and gene expression in fragrant and non-fragrant rose cultivars

Analysed flowers of fragrant and non-fragrant rose hybrid teas (*Rosa hybrida*) and one scented cultivar Edward (*Rosa bourboniana*) for chemical volatile compounds and corresponding gene expression using HS-SPME-GC×GC-ToF/MS and quantative real time PCR respectively at full bloom stage. In GC-MS analysis, identified 253 volatile organic compounds, including 29 prominent compounds such as 9 monoterpenoids, 7 sesquiterpenoids, and 6 esters. Fragrant cultivars showed higher abundance of monoterpenes and sesquiterpenes compared to non-fragrant ones. In qRT-PCR analysis, gene expression patterns correlated with specific VOC types, suggesting hereditary lineage from European and Chinese scents (Fig.4.19). Cultivars displayed a co-evolutionary trajectory concerning fragrance. Principal component analysis and hierarchical clustering effectively differentiated fragrant and non-fragrant cultivars. In this study, seven VOC-based biomarkers were identified, offering insights for scent rejuvenation in unscented rose hybrids and cultivar selection for industrial cultivation in cosmetics and perfumes.

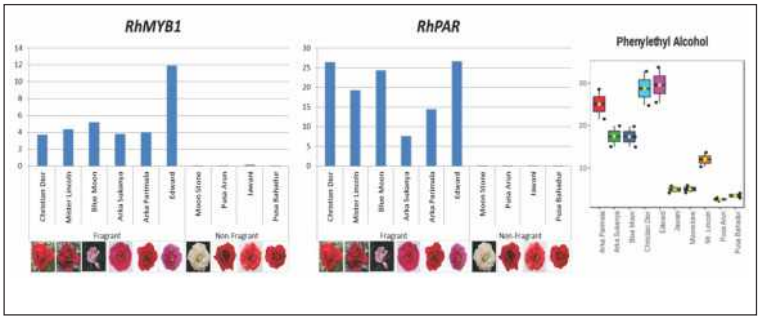


Fig. 4.8 4.19 Relative Expression of RhMYB1 and RhPAR box plot of Pheylethyl Alcohol

4.4.2 Comparative analysis of volatile compound composition and gene expression in tuberose cultivars

A comparative analysis of VOCs and gene expression was conducted on eight popular single-type tuberose cultivars using HS-SPME-GC×GC-ToF/MS. Sixty-four significant VOCs were identified, comprising terpenoids, alcohols, esters, aldehydes, ketones, and phenols. The alcohol and ester contents were notably higher than aldehydes, ketones, and olefins in the studied varieties, with Hyderabad Single exhibiting the highest alcohol content among all varieties. Phule Rajani and Prajwal stood out as the most scented varieties, with esters dominating their VOC profiles and lower levels of alcohols and terpenes. Selected genes based of the shikimate and benzenoid biosynthesis pathway namely, *PtBEBT*, *PtIEMT*, *PtDAHPS*s, and *PtBCMT2* were analysed for relative expression in all the tuberose cultivars. Among them *PtIEMT*, *PtDAHPS1*, and *PtBCMT2* were up-regulated in all varieties, albeit with varying relative expression levels. Cultivar Prajwal displayed the highest relative expression of these genes (Fig. 8).

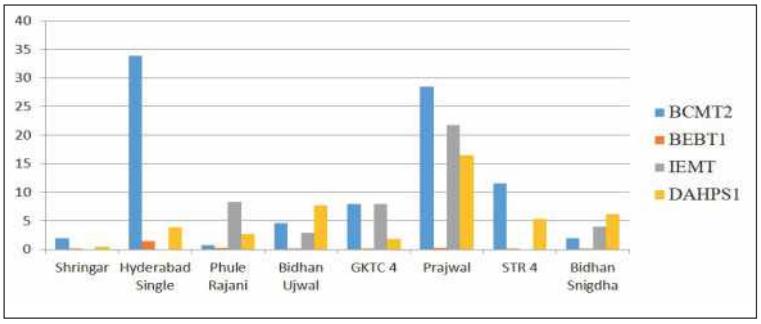


Fig. 4.20 Relative expression of Shikimate and benzenoid biosynthesis pathway gene

4.4.3 Biochemical and molecular analysis for assessing salt stress tolerance in chrysanthemum genotypes

Assessed salt stress tolerance in ten chrysanthemum genotypes at both molecular and biochemical levels. Variability in tolerance levels was observed among the genotypes, with Bidhan Lalima and Bidhan Sabita exhibiting high salt tolerance, while Vanity Pink and Bidhan Jayanti showed high susceptibility. Biochemical analysis revealed differences in enzyme activities and lipid peroxidation levels, shedding light on salt stress response mechanisms (Fig. 9a). Molecular analysis identified distinct gene expression patterns, emphasizing the potential roles of genes such as *CmSOD*, *CmWRKY10-DL*, *CmNCED3A*, *HSFA4*, and *CmHSP70* in salt tolerance (Fig. 9b). This study underscores the importance of selecting and cultivating salt-tolerant chrysanthemum varieties for sustainable agriculture in saline environments.

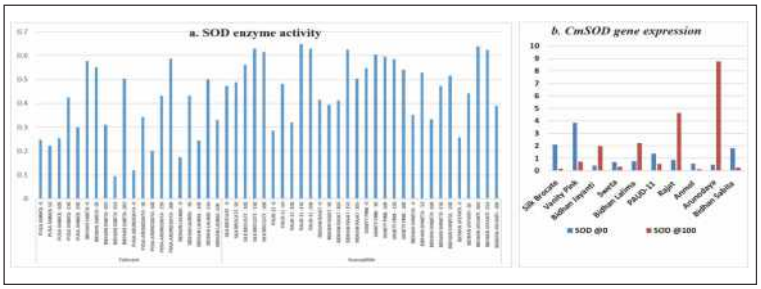


Fig. 4.20 Relative SOD activity (a) gene expression b) pattern of 10 chrysanthemum genotype

4.4.4 Potential Assessment of Chrysanthemum Cultivars as Source of Natural antioxidants and Bioactive Compounds

The phytochemical composition and antioxidative properties of 22 distinct Indian Chrysanthemum morifolium Ramat cultivars were studied. The cultivars viz., Bidhan Protima, Mauve Sarah, Silk Brocate, Diamond Jubilee, and Mahatma Gandhi displayed remarkable levels of phenolic compounds, tannins,

saponins, and carotenoids, emphasizing their superior antioxidant capacity. This study also presents the first quantitative determination of total saponin content in C. morifolium. Hierarchical analysis categorized cultivars into three groups based on their phytochemical profiles. Correlation analysis underscored the importance of anthocyanins and phenolic compounds in antioxidative attributes. Additionally, variations in carotenoid content unveiled astaxanthin, zeaxanthin, mutatochrome, canthaxanthin, neoxanthin, violaxanthin, and auroxanthin as potential biomarkers in differentiating cultivars. The research elucidates the rich phytochemical diversity of Indian Chrysanthemum cultivars, positioning them as invaluable resources for nutraceuticals and pharmaceuticals, with potential benefits for human well-being.

4.4.4.1. Total phenol and total flavonoid contents

The phenolic content exhibited a considerable range, spanning from 0.83 µg/g GAE to 23.08 µg/g GAE among the 22 Chrysanthemum cultivars. Among these cultivars, Diamond Jubilee contained the highest total phenol content (TPC), followed by Silk Brocade and PAU B-43, while Bidhan Sabita had the lowest TPC. On the other hand, the total flavonoid content (TFC) among the same 22 Chrysanthemum cultivars ranged from 10 to 555 mg/g CE. The highest TFC was recorded in HYDC-42, followed by Bidhan Protima, with the lowest TFC observed in Bidhan Sabita. A correlation analysis revealed a robust relationship between phenol and flavonoid content (r=0.38, n=22). In our study, Diamond Jubilee, characterized by its deep yellow colour, exhibited the highest phenolic content, followed by Silk Brocade (pink) and PAU-13-46 (pale purple).

4.4.4.2 Total carotenoid contents

The study of 22 Chrysanthemum cultivars identified 11 distinct carotenoids, including β-carotene, α-carotene, lycopene, antheraxanthin, astaxanthin, auroxanthin, canthaxanthin, violaxanthin, mutatochrome, neoxanthin, and zeaxanthin. Among these, Mahatma Gandhi, Bidhan Agnidev, and Bidhan Purna cultivars exhibited the highest α- carotene and β-carotene levels, while Mini Jessie and Big Violet had the lowest concentrations of these carotenoids. Notably, Bidhan Agnidev showed the highest content of all other carotenoids. Additionally, Mahatma Gandhi had the highest antheraxanthin content, while Mini Jessie had the lowest levels of α-carotene, lycopene, violaxanthin, neoxanthin, and zeaxanthin. Big Violet contained relatively low amounts of β-carotene and antheraxanthin, and Mauve Sarah had the lowest mutatochrome content.

4.4.4.3. Total tannin content

Among the 22 cultivars, the cultivar Mahatma Gandhi has displayed the highest tannin content, followed by Diamond Jubilee cultivar and Silk Borocate. In contrast, PAU B-43 had the lowest tannin content.

4.4.4.4 Total anthocyanin content

In our investigation, we observed that the Mauve Sarah cultivar exhibited the highest anthocyanin content, followed by Bidhan Protima and Punjab Anuradha, whereas Mini Jessie displayed the lowest anthocyanin levels. Furthermore, our findings indicate a close correlation between anthocyanin content and the antioxidant potential of the cultivars. Anthocyanins exhibit potent antioxidant activity by scavenging free radicals, activating antioxidant enzymes, and chelating metal ions.

4.4.4.5 Total saponin content

In the case of the 22 chrysanthemum cultivars under investigation, the saponin content exhibited a range from 0.6% to 1.5%. Among these cultivars, Silk Brocade, Diamond Jubilee, Bidhan Sabita, and HYDC 56 displayed the highest saponin percentages, while the Mini Jessie cultivar had the lowest saponin content. To the best of our knowledge, this study represents the first quantitative determination of total saponin content in *C. morifolium*.

5.Social Science

5.1 (ICAR project IXX 18592) Extension Strategies in Floriculture Sector for Enhancing

5.1 Farmers Income

Initially, the survey was undertaken to study the economics of chrysanthemum and marigold cultivation. The study was initiated in Pune district of Maharashtra. From the study area, 30 farmers were selected randomly those who are cultivating chrysanthemum and marigold flower crops and data pertaining to socio economic, cost of cultivation of flower crops was collected by personal interview of the respondents.

5.2 Socio-economic profile of farmers

From Table 5.1, it could be seen that a large number (53.33%) of respondents were middle age (36-50 years) followed by old age (>50 years) (26.67%) and young age who were less than 35 years (20.00%) of age. The study revealed that most of the sample farmers (76.66%) had their formal education ranging from higher secondary to graduation.

The study shows that respondents had agriculture (floriculture + crop farming) as the primary occupation (100.00%). The Table 5.1 clearly reveals that, size of landholding (53.33 %) falls is in marginal category, while followed 36.67 % had small land holding.

Table. 5.1 Profile the flower growers

Sl. No.	Particulars	Category	Frequency*	Per cent
1	Age of farmers	Young (18-35 years)	6	20.0
		Middle (36-50 years)	16	53.33
		Old (>50 years)	8	26.67
2	Land holding	Marginal (upto 1 ha)	16	53.33
		Small (1 -2 ha)	11	36.67
		Medium (2-10 ha)	3	10.0
		Large (above 10ha)	0	0.0
3	Education	Illiterate	0	0.0
		Primary	2	6.67
		Secondary	5	16.67
		Higher Secondary	16	53.33
		Graduate and above	7	23.33
4	Primary occupation	Floriculture + crop farming	30	100.0
		Floriculture + crop farming + Business	3	10.0
		Floriculture + crop farming + service	2	6.67
5	Experience in floriculture	Less than 5 years	6	20.0
		5-10 years	13	43.33
		more than 10 years	11	36.67

5.2 Economic analysis of chrysanthemum crop

5.2.1 Cost of cultivation of chrysanthemum

It was observed that the cost of cultivation of Chrysanthemum was Rs 3,97,440/- out of this, 92.06 per cent was variable cost. The major variable cost was of planting materials i.e., Rs. 90,000/- followed by human labour (Rs.75000/-), mulching cost (Rs. 33250.0), fertiliser cost (Rs. Rs. 30000), drip irrigation cost (Rs. 30000), interest on working capital (Rs. 27500) farm yard manure (Rs. 22500), land preparation and electricity charges each (Rs. 12500), intercultural operations (Rs. 10500.0) and transportation (Rs. 6250) respectively. Hence the results clearly indicate that the share of variable cost to the total cost was high. This may be attributed to high planting materials cost, use of more labour by the respondent growers and high cost of inputs such as fertilizers, mulching, drip irrigation setup etc.

The average fixed cost per acre was Rs. 31590.0 which accounted for 7.94 per cent of total cost of cultivation. The major items of fixed cost incurred by the farmers were, rental value of land amounting to Rs. 17500.00 per acre which formed (55.40%). The depreciation charges of pump sets and other implements accounted for Rs. 11250 (35.61%) and land revenue Rs. 500 per ha. (1.58%), managerial cost was taken at 8.00 per cent of the working capital i.e., Rs. 2340.0 per ha. (7.41%) based on the interest charged by the banks in the study area.

Table. 5. 2 Cost of cultivation of chrysanthemum crop.

Sr. no.	Component	Chrysanthemum	
		Cost/acre	%
1	Seedlings & planting materials (12000)	90000	24.60
2	Land preparation (roter, levelling bed preparation)	12500	3.42
3	Mulching (7 rolls @ 1400+fixing @ 500) 1900	33250	9.09
4	Drip irrigation	30000	8.20
5	Transplantation (7-8 labours)	6250	1.71
6	Intercultural operations (18 labours @300	10500	2.87
7	Labour (manure application, weeding, irrigation &	75000	20.50
8	Manure cost/FYM	22500	6.15
9	Fertilizer cost	30000	8.20
10	Pesticide cost	16250	4.44
11	Electricity charges	12500	3.42
12	Total working capital	338750	
13	Interest on working capital (@ 8 % of VC for 12 months) excluding market cost	27100	7.41
14	Total variable cost	365850	100.00
15	Depreciation charges	11250	35.61
16	Land revenue	500	1.58
17	Rental value	17500	55.40
18	Fixed Capital	29250	
19	Interest on fixed capital (@ 8 % of VC for 12 months)	2340	7.41
20	Total fixed cost	31590	100.00
21	Total cost of cultivation (VC + FC)	397440	

5.2.2 Yield and returns

The average yield, gross and net returns per hectare of Chrysanthemum among the sample farmers are shown in Table 5.3. It indicated that the average yield of Chrysanthemum was 13.75 tonne per ha. The average price realised by the respondents was Rs. 50,000 per tonne. The gross returns on chrysanthemum production were Rs. 687500. Total cost (which include TVC+TFC) was Rs. 399440.0/ha. Hence, the net returns was Rs. 290060.0, due to good yield and good management practices followed and adopted by the chrysanthemum growers. The analysis of cost and returns indicates that the net return per rupee of expenditure in marigold production was Rs. 1.73. Therefore, cultivation of chrysanthemum is considered as profitable venture.

Table. 5. 3 Yield and return of Chrysanthemum crop

Sr. no.	Particular	Per ha
1	Yield (ton)	13.75
2	Price (Rs/ton)	50000
3	Gross return (Rs)	687500
4	Total cost (Rs)	397440
5	Net return (Rs)	290060
6	B:C ratio	1.1.73

5.3 Economic Analysis of Marigold Crop

5.3.1 Cost of cultivation of marigold

The study revealed that the cost of cultivation of marigold was Rs 2,60,280/- out of this, 92.59 per cent was variable cost. The major variable cost was of harvesting of flower (labour) i.e., Rs. 56,250/- followed by planting material cost (Rs.52,500), farm yard manure (Rs. 21250), fertiliser cost (Rs. Rs. 20000), irrigation cost (including electricity) (Rs. 20000), interest on working capital (Rs. 17340), pesticide cost (Rs. 16250) land preparation and human labour each (Rs.12500) and transportation charges (Rs. 5500) respectively. Hence the results clearly indicate that the share of variable cost to the total cost was very high. This attributed was mainly high planting materials cost and use of more labour by the respondent growers etc.

It was observed that, the average fixed cost per acre was Rs. 26190, the major cost incurred by the farmers were, rental value of land accounting for Rs. 17500 per acre which formed (66.82%). The depreciation charges accounted for Rs. 6250 (23.86%) and land revenue Rs. 500 per ha. (1.91%) of the total fixed cost.

Table. 5. 4 Economic analysis of marigold crop

Sr. no.	Component	Chrysanthemum	
		Cost/acre	%
1	Seedlings & planting materials	52500	22.43
2	Land preparation	12500	5.34
4	Irrigation + electricity	20000	8.54
5	Transplantation charges	5500	2.35
7	Labour (manure application, weeding, irrigation etc.)	12500	5.34
8	Manure /FYM cost	21250	9.08
9	Fertilizer cost	20000	8.54
10	Pesticide cost	16250	6.94
11	Harvesting labour	56250	24.03

Sr. no.	Component	Chrysanthemum	
		Cost/acre	%
12	Total working capital	216750	92.59
13	Interest on working capital (@ 8 % for 12 months) excluding market cost	17340	7.41
14	Total variable cost (TVC)	234090	100.00
15	Depreciation charges	6250	23.86
16	Land revenue	500	1.91
17	Rental value	17500	66.82
18	Fixed capital	24250	92.59
19	Interest on working capital (@ 7.5% of VC for 12 months) excluding market cost	1940	7.41
20	Total fixed cost (TFC)	26190	100.00
21	Total cost (TVC +T FC)	260280.0	

5.3.2 Yield and returns from Marigold cultivation

The average yield, gross and net returns/ha of marigold among the sample farmers indicated that the average yield of marigold was 16.25 tonne per hector. The average price realised by the respondents was Rs. 30,000.0 per tonne. The gross returns obtained from Marigold production were Rs. 487500. A Total cost (which include TVC+TFC) was Rs. 260280/ha. Hence, the net returns were Rs. 227220, mainly due to advanced marigold production technologies adopted by the farmers. The analysis of cost and returns indicates that the net return per rupee of expenditure in marigold production was Rs. 1.87. Therefore, cultivation of Marigold is one good avenue to get additional income along with other crops.

Table. 5.5 Yield and return of Marigold crop

Sr. no.	Particular	Per ha
1	Yield (ton)	16.25
2	Price (Rs/ton)	30000
3	Gross return (Rs)	487500
4	Total cost	260280
5	Net return	227220
6	B:C ratio	1:1.87

During this period several extension/ outreach activities were organized to disseminate and showcase DFR technologies to various stakeholders through Webinars, Campaigns, Exhibitions, Field days or Farmers days etc.

For celebration of *Azadi ka Amrut Mahotsav (75 Years of Independence)* of India, ICAR-DFR organized different Webinar series on different topics such National Dialogue on Diseases Transmitted from Plants to Humans (*Phytonoses*); "Conservation of Pollinators in Urban and Peri-urban Landscapes on occasion of World Bee Day; Modern Breeding Strategies for Improvement of Flower Crops etc. More than 250 stakeholders participated in Webinars. ICAR-DFR organized workshops such as 'Synergy of Innovation and Incubation in Agri Start-up Ecosystem jointly organized ICAR-NRC, ICAR-DOGR, ICAR-DFR, Pune and R-ABI ICAR-CIRCOT, Mumbai; Opportunities for Entrepreneurship Development in Floriculture: Focus on FPOs/Start-up Formation" on occasion of DFR Foundation Day celebration; "Women and IP: Accelerating Innovation and Creativity" on occasion of World WIPO day. ICAR-DFR celebrated important National/ International Days such as International Women Day, Yoga Day and National Farmers Day and different crops specific days such as Gladiolus, Chrysanthemum Day and Anuual flowers day

ICAR- DFR also organized a number of training programmes on different aspects of floriculture such Training-cum-awareness Program on Protection of Plant Varieties & Farmers Rights (PPV&FR) Act 2001; Hands on Training on Value Addition in Flower Crops; Training on Beekeeping etc. The ICAR-DFR participated in different exhibitions to showcase of DFR technologies at "108th Indian Science Congress - Pride of India Expo – 2023, RTMN University, Nagpur; GLOBAL KRUSHI MAHOTSAV-Live Demos and Agri Exhibition conference 2023, KVK, Narayangaon; Technology Day 2023, NAAS Complex, New Delhi and 14th AGROVISION EXPO – 2023, Nagpur. Monthly field visits were organized in MGMG villages and other villages to disseminate DFR technologies. Conducted demonstrations of Agri Spray Drone on flower crops such as chrysanthemum, marigold in Pune district.

Ornamental nursery visits at Sartopwadi

Agri Spray Drone Demonstration at Kusur village

6.Externally Funded Project

Title: Enrichment of honey & its value-added products by nutraceutical pigments & essential oils from floricultural crops. (Funded by National Bee Board, Department of Agriculture & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India) (Total grant: 227.41 lakh)

1.Standardization of process for ROMIHO (Rose-Millet-Honey) Cookies

Fig. 6.1 ROMIHO (Rose-Millet-Honey) cookies

Honey is a natural sweetener that comes directly from bees, high nutritional value (contains trace amounts of vitamins, minerals, and antioxidants), enhance flavor, act as a natural preservative and promotes browning in baked products due to its natural sugars and enzymes. The appealing rose aroma and the presence of multiple bioactive compounds in edible rose flowers have drawn more attention to them as food additives in recent years. Rose flowers are rich in nutraceutical pigments (anthocyanins, polyphenols, and flavonoids), which can significantly improve human health and they are also abundant in amino acids, essential oils, vitamins, and minerals. The three popular millets, sorghum (Jowar), pearl millet (Bajra) and finger millet (Ragi) are high in fiber and nutritional properties, low glycaemic index and have several positive health effects. They are rich in protein, vitamins, minerals (iron and zinc), fiber, and carbohydrates. Cookies are ready to eat, affordable, and have a longer shelf life. Cookies are well-liked by individuals of all ages. It is well documented that most of the ingredients used in commercial cookies lack important nutrients but there is huge demand of nutritionally enriched ready to eat cookies. Taking into consideration of above facts and need of nutritionally enriched cookies, we developed ROMIHO (Rose-Millet-Honey) cookies. The protocol was standardized to formulate cookies enriched with nutraceuticals and essential oil of fresh rose petals, Millets and Honey to satisfy the nutritional value, dietary fiber, protein, vitamins, and minerals requirements. We tested the developed ROMIHO cookies for their texture, taste, color and other sensory properties by more than 100 persons and found that the overall acceptability of cookies is good.

2.Standardization of process for making Bee wax lip-balm enriched with rose extracts.

Fig. 6.2 Bee wax Lip balm

Rose petals can be used as an effective treatment for lightning dark lips. Rose petals are good source of vitamin C, iron, calcium, vitamin A. It exhibits a curious property known as hydrophobicity. Rose petals nourish, soften and lighten our lips naturally. Rose petals are good source of natural oils, exfoliates gently and imparts smooth texture to lips. Bee wax is a stable, solid wax at room temperature and formed from a mixture of several chemical compounds. Unhydrolyzed bee wax typically consists of free acids, esters, hydrocarbons,

and other substances. Taking into consideration the importance of natural products, the present work was aimed at formulating and evaluating lip balm containing only natural ingredients. We performed various test for checking the quality and efficiency of developed lip balm. All formulations of lip balm have pH values between 4.36 and 6.20. The greasiness for each lip balm was analyzed after 24 hours (left on the filter paper) at room temperature. The greasiness of each lip balm was determined by measuring the diameter ring of oil. The initial and final diameter of ring oil was 3.7 cm and 3.8 cm, respectively. The spreadability of the lip balm formulation was found to be good.

3. Standardization of process for Rose Infused Honey

Honey has enormous therapeutic and antioxidant potential, and addition of flowers or its extracts only enhances these qualities. Rose petals and honey have numerous health advantages. Therefore, one can make medicinally enriched rose honey by infusing honey and rose petals in different combinations. In our study we infused dried rose petals of different varieties with honey. The pesticide free fresh rose flowers were harvested from ICAR-DFR research field. After that we washed and dried the rose petals and kept in airtight container. We used fragrant variety of rose i.e. Rose Sharbat and one rose species i.e. Rose Edward. In this study, we took the honey and rose petals in different ratio, temperature and different duration of time as per the experimental design for both varieties (Edward and Rose Sharbat). We used a fine mesh strainer to remove the honey after the infusion period was over. The following figures (Fig. 6.3) shows the rose infused honey produced after infusion of honey with petals of Edward and Rose Sharbat. The color of infused honey made by infusing petals of rose Sharbat variety was brightest pink than the color of infused honey produced with the help of petals of Edward rose. The petals of rose Sharbat variety are dark in color as compared to the petal color of Edward rose. Rose infused honey boosting health benefits of honey. It is enriched with anthocyanins, polyphenols and antioxidants and reduce the risk of many diseases. I add flavours in food and beverages. The rose-infused honey brings a distinct and delightful rose flavour to foods and beverages, as well as a floral note to a cup of tea. The optimized processing parameters were temperature-30°C, Honey:Rose petal ratio-5%, time-45 min. Rose-infused honey made by infusing petals of rose sharbat variety was contain higher amount of bioactive compounds than the infused honey produced by petals of Edward rose.

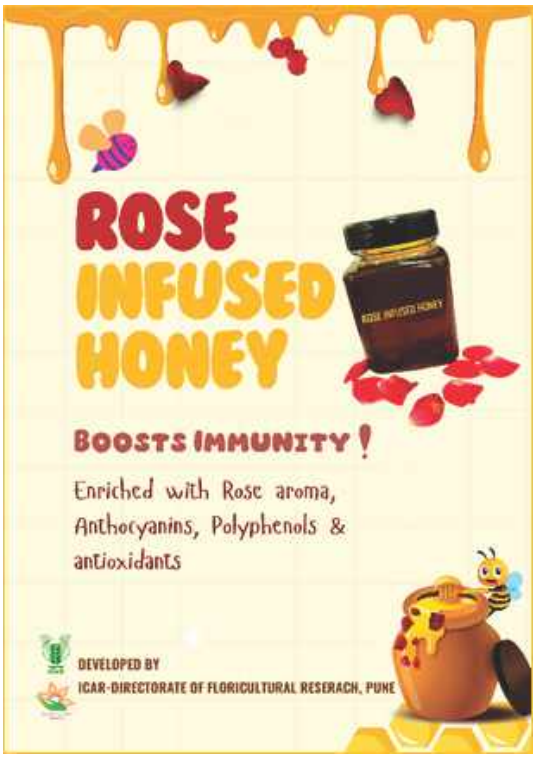


Fig. Rose Infused Honey (Variety: Edward) Rose Infused Honey (Variety: Rose Sharbat)

Fig. 6.3. Rose Infused Honey

4.Standardization of process for Honey-Rose Gulkand

Fig. 6.4 Rose-Honey Gulkand

Edible flowers, especially roses, are considered rich in nutraceuticals because of their biological and phytochemical qualities. They are used as flavouring and garnish in a variety of foods and drinks. Rose petal preserve known as gulkand is used in traditional medicine and has many nutritional and therapeutic benefits but with high in calories. We can replace sugar with honey. The cooling qualities of rose petals can help calm the respiratory system and decrease inflammation, while honey's inherent antimicrobial qualities are helpful in defending against infections. The gulkand made by combining honey and rose petals can act as an excellent anti-inflammatory agent. Honey-Rose gulkand can produce excellent flower-processed products due to its high nutritional content and flavour. We standardized the Honey-rose gulkand making process. Firstly, we took fresh rose petals, properly washed the petals with distilled water, and dried the petals with muslin cloth. After that took properly cleaned airtight glass container bottle. We added the honey and fresh rose petals alternatively. We added the first layer of honey which is chemical free in glass bottle then rose petals as per requirements, in this manner, we added the layer of honey and rose petals in a glass container. According to design of experiment, we kept the sample for different duration of time at room temperature. After specific time, the process of rose gulkand is almost ready, with fresh rose petals and honey properly infused. The Honey-Rose Gulkand is very beneficial to health. Honey-Rose Gulkand is very helpful in minimising heat-related issues such as tiredness, mental strain, sluggishness, and aches and pains in the muscles.

5. Standardization of protocol for Microwave Vacuum dried Honey Powder

Studies at ICAR-DFR indicated that a possible technique to produce dried honey of superior quality is microwave-vacuum (MWV) drying. We investigated into MWV drying as an innovative way to get dried honey that is of good quality. Honey Powder is simply pure honey that has been microwave vacuum-dried with different carrying material to maintain its free-flowing consistency. In a MWV dryer, liquid honey along with different additive material was heated and dried to a moisture content of less than 2%. We investigated the operating parameters of microwave–vacuum drying of honey. During MWV drying, samples were tested at various microwave power (300W, 600W) drying time (20, 25, 30 min.), material ratio ((H: Honey; M: Maltodextrin; GA: Gum Acacia powder; CP: Casein Protein) and vacuum pressure level (650 mm of Hg). The most effective drying treatment was (H:M ratio- 1:1.5, Power- 600 W, Vacuum-650 Hg mm, Time- 20 minutes). We tested the developed honey powder for different properties (Table 1). The developed honey powder can be used as alternative to sugar and artificial sweetener. It can be added to baking mixes for cakes, cookies, and bread to give them a sweet taste. It can be included in other beverages as well. It adds flavour to desserts and confectionary.

Table 6.1: Properties of Microwave-Vacuum Dried honey powder

Sr. No.	Experiment design (Treatments)	Honey Powder	Consistency	Colour	Rehydration Rate	Moisture Content (%)	
						Initial	Final
1.	H:M*- 1:2 Power- 600 W Vacuum- 650 Hg mm Time- 20 min		Medium	Light Brown	Medium	20.258	0.29
2.	H:M*- 1:1 Power- 600 W Vacuum- 650 Hg mm Time- 25 min		Medium	White	Less	19.494	0.23

Sr. No.	Experiment design (Treatments)	Honey Powder	Consistency	Colour	Rehydration Rate	Moisture Content (%)	
						Initial	Final
3.	H:M*- 1:2 Power- 600 W Vacuum- 650 Hg mm Time- 20 min		High	Brown	Less	20.364	0.21
4.	H:M*- 1:1.5 Power- 600 W Vacuum- 650 Hg mm Time- 20 min		Medium	Light Brown	Medium	18.55	0.26
5.	H:M*- 1:1.5 Power- 600 W Vacuum- 650 Hg mm Time- 20 min		High	White	Less	15.37	0.17
6.	H:GA*- 1:1 Power- 300 W Vacuum- 650 Hg mm Time- 30 min		High	White	Medium	19.32	1.47
7.	H:GA*- 1.5:1 Power- 300 W Vacuum- 650 Hg mm Time- 30 min		Less	Light Brown	High	19.63	1.9
8.	H:GA*- 1:1 Power- 600 W Vacuum- 650 Hg mm Time- 20 min		High	Dark Brown	Less	18.89	1.72
9.	H:CP*- 1:1 Power- 600 W Vacuum- 650 Hg mm Time- 25 min		Less	Dark Brown	Very High	19.15	1.70

Note: *(H: Honey; M: Maltodextrin; GA: Gum Acacia powder; CP: Casein Protein)

AICRP on Floriculture

Annual Group Meeting

The XXXI Annual Group Meeting of All India Coordinated Research Project (AICRP) on Floriculture was held in virtual mode during January 18-20, 2023. The main objective of this Group Meeting was to review the research work done at Coordinated Centres (22 nos.) during last year (2021-22) and to consolidate the technical programme for next two years 2022-23 to 2023-24. Dr. A. K. Singh, Deputy Director General (Hort.-Science), ICAR was the Chief Guest and Dr. Sudhakar Pandey, ADG (HS-I) was the Guest of Honour in the program. Other dignitaries include Dr. R. L. Misra, Former PC (Flori.); Dr. K. V. Bhat, Rtd. PS, ICAR-NBPGR & Member, QRT (2013-18); Dr. S. P. Das, Director, ICAR-NRC for Orchids; Dr. M. Kannan, Rtd. Prof. (Hort.), Directorate of Research, TNAU, Coimbatore. There were six technical sessions besides inaugural and plenary.

Dr. A. K. Singh, in his address appreciated the good work done by the centres and encouraged the centres to transfer the technologies to the farmers. He emphasized upon tapping the potential of floriculture amidst several challenges. Floriculture potential, apart from aesthetic and landscaping domains, is tremendous particularly on edible flowers, which may not only address the nutrient deficiency but also ensures nutritional security. He further emphasized on means to cut down import of floricultural produce and to devise suitable strategies for development of eco-friendly solutions.

He advocated that the research under AICRP (F) should be market driven, hence must diversify accordingly; should develop technologies/ varieties that are environment friendly and also address Sustainable Development Goals (SDGs). He also emphasized that there is a need to phase out old and routine experiments and take up emerging areas like edible flowers, Artificial Intelligence, drones, block chain etc. and there is need to develop certification standards for flowers/planting material/seeds/packaging/pot plants, etc.

Dr. Sudhakar Pandey, ADG (HS-I), ICAR and Guest of Honour on this occasion lauded the Director & Staff of ICAR-DFR and AICRP team for their efforts in bringing viable technologies to the end users. In his address, he has suggested to conduct planned research, on production, multiplication and distribution of quality planting material particularly in annual commercial flower crops. Besides, he elaborated to focus on edible flowers and indoor plants to address emerging challenges.

2.2. E - Release of Publications

The Annual Report 2021-22 of AICRP on Floriculture (PDF format) was released by the dignitaries virtually. Further the session ended with the vote of thanks by Dr. P. Naveen Kumar, Principal Scientist (Hort.), ICAR-DFR, Pune.

Table. List of Coordinated Centers along with the year of their establishment and mandate crops

S. No.	Centre	Year of Start	Crops
Budgetary Centres			
1.	Floricultural Research Station (SKLTSHU), Hyderabad, Telangana	1987	Chrysanthemum, Crossandra, China Aster, Jasmine, Tuberose, Rose, Dahlia, Under exploited ornamentals (Heliconia, Bird of Paradise)
2.	Horticultural Research Station (AAU), Kahikuchi, Guwahati, Assam	2001	Orchids, Tuberose, Gerbera, Marigold, Underexploited ornamentals (Heliconia, Bird of Paradise, lotus), Fillers (Fern)
3.	Bidhan Chandra KrishiViswavidyalaya, Kalyani, District-Nadia, WB	1972	Chrysanthemum, Orchids, Tuberose, Marigold, Dahlia, Gladiolus, China Aster, Gerbera, Fillers (Fern)
4.	Birsa Agricultural University, Ranchi, Jharkhand	2001	Rose, Marigold
5.	Dr.Y.S.Parmar University of Horticulture &Forestry,Nauni, Solan, Himachal Pradesh	1975	Rose, Gladiolus, Carnation, Gerbera, Chrysanthemum, Tulip, Daffodil, Lilium, Alstroemeria, Underexploited ornamentals (Bird of Paradise, Ginger lily, Lotus), Fillers (Asparagus, Dracaena, Gypsophila, Ferns)
6.	G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand	2001	Rose, Gladiolus, Chrysanthemum, Tuberose, Dahlia
7.	Kerala Agricultural University, Vellanikkara, Thrissur, Kerala	1975	Orchids, Anthurium, Crossandra, Jasmine, Marigold, Underexploited ornamentals (Bird of Paradise, Ginger lily & Lotus), Fillers (Asparagus, Dracena, Gypsophila & Ferns)
8.	National Agricultural Research Project (MPKV), Ganeshkhind, Pune, Maharashtra	1975	Rose, Gladiolus, Carnation, Tuberose, Gerbera, Marigold, specialty flower, China Aster
9.	Punjab Agricultural University, Ludhiana, Punjab	1975	Rose, Gladiolus, Chrysanthemum, Marigold, Dahlia, Gerbera, Tuberose, Fillers (Ferns)
10.	Rajasthan College of Agriculture (MPUAT), Udaipur, Rajasthan	1980	Gladiolus, Chrysanthemum, Tuberose, Rose
11.	Orissa University of Agriculture and Technology, Bhubaneswar, Odisha	2011	Rose, Tuberose, Gerbera, Marigold, Under exploited ornamentals (Lotus)
12.	Sher-E-Kashmir University of Agricultural Sciences &Technology, Shalimar Campus, Srinagar, Jammu & Kashmir	1987	Gladiolus, Tulip, Daffodil, Lilium,Alstroemeria
13.	Horticultural College and Research Institute (TNAU), Coimbatore, Tamil Nadu	1982	Chrysanthemum, Anthurium, Tuberose, Carnation, Gerbera, Crossandra, China Aster, Jasmine, Marigold, Rose
Institutional Centres			
14.	ICAR-Indian Agricultural Research Institute, New Delhi	1971	Rose, Gladiolus, Chrysanthemum, Marigold
15.	ICAR-Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	1971	Gladiolus, Lilium, Dahlia

S. No.	Centre	Year of Start	Crops
16.	ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka	1971	Rose, Gladiolus, Carnation, Chrysanthemum, Tuberose, Gerbera, Marigold, Underexploited ornamentals (Heliconia), Crossandra, China Aster, Jasmine, Dahlia
17.	ICAR Research Complex for NEH Region, Barapani, Umiam, Meghalaya	1971	Orchids, Gerbera
18.	ICAR- Central Island Agricultural Research Institute, Port Blair	2016	Anthurium, Underexploited ornamentals (Heliconia), China aster, Crossandra, Jasmine
Voluntary Centres			
19.	College of Horticulture and Forestry (CAU), Pasighat, Arunachal Pradesh	2016	Gladiolus, Tuberose
20.	Navsari Agricultural University, Navsari, Gujarat	2016	China aster, Rose, Fillers (Asparagus, Dracaena, Gypsophila, Ferns)
21.	Indira Gandhi Krishi iswavidyalaya, Raipur, Chhattisgarh	2016	Tuberose, Marigold
22.	Dr.Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar	2010	Tuberose, Marigold, Gerbera

Post Graduate Education

ICAR-DFR has been recognized as a part of Post-Graduate Education Programme of MPKV Rahuri. Dr. P. Naveen Kumar (Floriculture), Dr. Tarak Nath Saha (Floriculture), Dr. D. M. Firake (Agricultural Entomology), Dr. Ganesh B. Kadam (Floriculture) and Dr. K. Prabha (Plant Pathology), Dr. Harish (Genetics & Plant Breeding) were identified as the faculty for Post-Graduate teaching and research guidance in College of Horticulture, Pune. During the year courses on breeding of ornamental crops, protected cultivation and value addition in flowers were taught.

Extension Activities

Trainings organized by ICAR-Directorate of Floricultural Research, Pune

1. ICAR-DFR organized Training-cum-Awareness Programme on PPV&FR Act, 2001

A training-cum-awareness Programme on Protection of Plant Varieties and Farmers Rights Act, 2001 was organized by ICAR-Directorate of Floricultural Research, Pune in collaboration with the Protection of Plants Varieties & Farmers Rights Authority, New Delhi at National Institute of Post-Harvest Technology (NIPHT) Talegaon Dabhade, Pune on July 24, 2023. The programme was aimed at creating awareness among the farmers about the importance of PPV&FR Act, 2001. The programme was started with the welcome address by Dr. K. V. Prasad, Director, ICAR-DFR, Pune. He stressed upon importance of protection of varieties in flower crops and the challenges faced by flower growers in India. Dr. D. K. Agarwal, Registrar General, PPV&FRA, New Delhi, during his inaugural speech, highlighted the importance of registration of plant varieties, farmer's rights and role of PPV& FRA in protection of farmer's varieties and rights. Dr. Vijay Mahajan, Director, ICAR-Directorate of Onion & Garlic Research (DOGR), Pune also addressed the gathering about the development of new varieties of Onion & Garlic. Dr. Agarwal, Registrar General, PPVFRA, New Delhi and Dr. K.V. Prasad, Director, ICAR-DFR responded to various queries raised by the flower farmers. Shri R. S. Sengar, Deputy Registrar, PPV&FR Authority, New Delhi In-charge, Branch Office, Pune explained the role of Pune branch office in facilitation of registration of farmers varieties. Shri. Mukund Thakar a progressive farmer and Chairman of Pawana Flower Growers Association, Yelase, Tal-Maval, Dist-Pune highlighted the benefit of such awareness programs for the farmers. He also informed about importance of group farming and FPOs. Dr. Amarjeet Gupta, Principal Scientist, ICAR-Directorate of Onion & Garlic Research (DOGR) delivered talk on development DUS guidelines and testing in Onion and Garlic and about the varieties registered with PPV&FRA, New Delhi. Dr. Roshni Samarth, Senior Scientist, ICAR-National Research Institute for Grapes (NRCG) told about the steps involved in registration of farmer's varieties. Dr. Sujata TeTali, Scientist D, Agharkar Research Institute, Pune interacted with the farmers about the provisions on farmers' rights and filling of the application form. Dr. Anil K. Gaikwad, SRF, Pune Branch Office has made a presentation about PPVFR Authority and its activities in the local language. Dr. Ganesh B. Kadam, Senior Scientist ICAR-DFR, Pune delivered talk on farmer's varieties and various challenges faced by farmers in cultivation of protected varieties.

About 100 participants including progressive farmers, exporters, scientist and students attended the awareness programme. Various issues of protection of plant varieties were thoroughly discussed and decided to encourage farmers for registration of varieties developed by them.

Address by Chief Guest, Dr. D. K. Agarwal, Registrar General, PPV&FRA, New Delhi

Release of publication during programme

Visit to poly-houses at NIPHT, Talegaon

Participants during awareness-cum-training programme

Visit to flower packaging and storage unit

Discussion with farmers on challenges faced in export of flowers

2. ICAR-DFR Organizes Hands on Training-cum-Demonstration on Value Addition in Flower Crops

One day hands on training-cum-demonstration on Value Addition in Flower Crop was organized by ICAR-Directorate of Floricultural Research, Pune on July 28, 2023 at Pavana Flower Growers Association, Yelse village, Tal-Maval, District-Pune. The training was conducted with an aim to empower the rural youth and women working in hi-tech floriculture units to diversity the product range from cut flowers to value added products.

The training was inaugurated by Dr. K. V. Prasad, Director ICAR-DFR, Pune and in his inaugural address he highlighted the importance of diversification as means of enhancing the farmers income. In order to provide end to end solutions, ICAR-DFR chose the Pavana Flower Growers Association to develop a complete value chain. He emphasized that among a number of avenues available, resin encapsulation of dry flower and making of flower arrangements, bouquets with fresh flowers are chosen for the training programme to encourage youth and women to take it up as a commercial enterprise. Dr. Mahalaxmi V Reddy, Former Professor, PJSTSAU, Hyderabad demonstrated various steps of dehydration of flowers and plant parts and encapsulation using epoxy resins online. Dr Reddy brought to the notice of the audience about the demand for encapsulated souvenirs in the country. Emotions attached to the flowers can be best preserved in resin encapsulation for generations, she explained. Dr. Nitin Khade, M/s Pimani Udyog India Pvt. Ltd, Sangali who is incubate of ICAR-CIRCOT, RABI demonstrated the dryers used for various purposes in horticultural crops including flowers.

Mr. Pandharinath Mhaske, Sneh Florist, Pune demonstrated different fresh flower arrangements popular in various festivals and celebrations. He also explained about how the fresh flowers value chain works and price get increased many fold at every step of value addition in florist industry. He trained youth in making various floral arrangements like hand bouquets, crescents and cascading bouquets, table arrangements, office corners, etc from fresh flowers like rose, tuberose, carnation, gerbera with fillers like gypsophila, murraya,

daisy, golden rod, etc. Dr. Ganesh B Kadam, Senior Scientist, ICAR-DFR Pune demonstrated the steps in selection of flowers for drying, methods used for drying of flowers, mixing of resins and embedding them in various types of molds. Dr. Renuja Katare, demonstrated press dried flower products and different jewelry items by using resin encapsulation technology. A total of 69 participants (including 47 women) participated in hands on training. Participants expressed satisfaction for organizing hand on training at their doorstep and requested for specialized trainings to group of women farmers from FPO. The training programme was coordinated by Dr Tarak Nath Saha, Dr Sanjay Kad, Dr Prabha K and Dr Rahul Yadav.

Address by Chief Guest, Dr. K V Prasad, Director, ICAR-DFR, Pune

A large number of farm women participated in the trainings

Overwhelming response from the participants

Demonstration of various flower arrangements

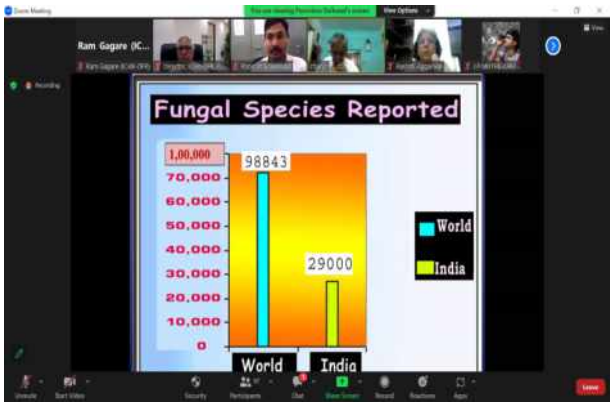
3. ICAR-DFR organized a National dialogue on Diseases transmitted from plants to humans (Phytonoses)

ICAR-DFR organized a National dialogue on Diseases transmitted from plants to humans (Phytonoses) on April 27, 2023 in virtual mode to create awareness among the stakeholders on rare but potentially dangerous occurrence of plant pathogens infecting humans.

The event was graced by Dr. R.K. Jain, an eminent Virologist and former Emeritus Scientist and Dean, ICAR-IARI New Delhi, as the Chief Guest. Dr. R Selvarajan, Director NRC Banana was the Guest of Honor. Dr. K. V. Prasad, Director, ICAR-DFR, Pune in his introductory remarks emphasized the importance of understanding and addressing the issue of diseases transmitted from plants to humans. He highlighted the rare case of silver leaf disease (that infects the members of rosaceace family including roses) infecting humans as reported in recent times where in a 61 year old Indian Mycologist was infected by *Chondrostereum purpureum*. He reiterated that the programme is aimed at taking stock of the present status and spread awareness rather than creating panic among the stakeholders. Expert speakers shed light on different aspects of the topic. Prof. (Retd.) C. Manoharachary, former Vice Chancellor and world renowned Mycologist from Osmania University, Hyderabad, talked about Plant fungi turning to human pathogens; past, present and future. Dr. (Ms.) Rashmi Aggarwal, former Dean at ICAR-IARI discussed the potential implications for public health posed by emerging phytonoses. Later, Dr. R. Selvarajan, Director, ICAR-NRC Banana focused

on rare possibility of plant viruses crossing the kingdom barrier to infect humans. Finally, Dr. K. V. Shivakumar, Scientist, ICAR-DFR, Pune examined the possibility of phytonoses arising from ornamental crops.

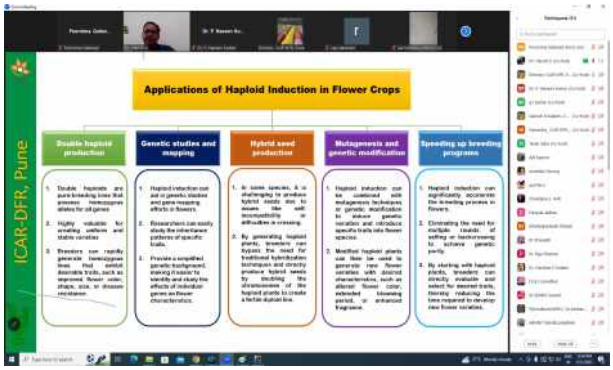
Chief Guest Dr. R.K. Jain in his concluding remarks emphasized that although it is very rare possibility of breaking of barriers of kingdoms by plant pathogens one cannot be complacent. He called up on the scientific community to forge research collaborations and exchange of knowledge between different disciplines to address the threat of phytonoses. It was also decided to bring about a base paper on such emerging threats. About 100 participants from 20 ICAR institutes/Agri. Univ. from all over India participated and contributed in the dialogue.

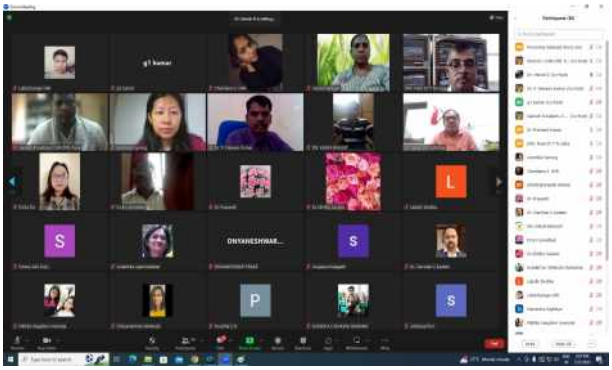


Experts delivered lecture on phytonoses

4. National webinar on "Modern Breeding Strategies for Improvement of Flower Crops"

ICAR-Directorate of Floricultural Research hosted a national webinar on July 21, 2023, as part of the Azadi ka Amrit Mahotsav, focusing on modern breeding strategies for improvement of flower crops. The webinar aimed to make aware stakeholders about recent advancements in flower crop improvement through various breeding techniques. Dr. K V Prasad, Director of ICAR-DFR, during his introductory remarks, emphasized the pivotal role of breeding in improvement of flowers using various breeding techniques. Dr Jagadish Rane, Director of ICAR-CIAH, Bikaner, elucidated high throughput phenotyping in flower crops. Dr. Ram Pal, Principal Scientist at ICAR-DFR, Vemagiri delivered a talk on Breeding of Cymbidium Orchids. Dr Naveen Kumar P, Principal Scientist at ICAR-DFR, Pune, elucidated breeding strategies tailored for developing export-grade varieties. Dr. Prashant G Kawar, Principal Scientist at ICAR-DFR, Pune, underscored the significance of Haploid Induction Technologies in flower crops. Dr S P Jeevan Kumar, Scientist at ICAR-DFR, Pune, discussed speed breeding opportunities and challenges. Dr. Harish D, Scientist at ICAR-DFR, Pune, elaborated on Advanced Breeding Tools and their application in flower crops. The webinar attracted nearly 90 participants, including students and other stakeholders.





Invited experts delivered different aspects of phytonoses

Participants during programme

5. ICAR-DFR Regional Station Organized an Interactive Meet with Nursery Growers

ICAR-DFR Regional Station Organized an Interactive Meet with Nursery Growers on August 24, 2023 at Sir Arthur Cotton Nursery Farmers Association Conference Hall at Kadiyam, Andhra Pradesh

Dr. K. V. Prasad, The Director of the Institute briefed about the ongoing research and extension activities of ICAR-DFR, Regional Station and requested the nursery farmers to flag important issues faced by nursery farmers to be worked upon by ICAR-DFR. He also emphasized that the Regional Station is working on diagnostics and control of important diseases and nematodes of the nursery crops.

Sh. Mallu Polaraju, President of the nurserymen association, Kadiyam and other nursery farmers expressed important issues *viz*., soilless and alternate potting media, decomposing methods for coco peat and agricultural waste, tools and machinery, tissue culture protocols for important ornamental nursery plants, nematodes and diseases infesting nursery plants. They also emphasized the requirement of training for nursery farmers on some important areas.

Dr. K. V. Prasad and scientists of the Regional Station briefed the nurserymen on the research work carried out on these areas and technologies available at present in these domains. A tentative month wise training calendar was proposed by the scientists to create awareness on important issues faced by the farmers. The Nursery farmers expressed their admiration for the research work carried out by the ICAR-DFR Regional Station and extended their wholehearted support in future.

Nursery growers in interactive meet

Dr. K.V. Prasad addressed to participants importance of ornamental nurseries

6. ICAR-DFR Regional Station Organized a Hands-on Training Programme – Marigold as Poultry Feed Additive

ICAR-DFR Regional Station Organized a Hands-on Training Programme – Marigold as Poultry Feed Additive" on August 25, 2023 at the Seminar Hall of ICAR-CTRI, Rajahmundry, Andhra Pradesh. Stakeholders *viz*., flower growers, poultry farmers, veterinary and village level horticulture workers and students of vocational education participated in the programme.

Dr. K. V. Prasad, The Director of the ICAR-DFR briefed about the important role of value addition in flowers for increasing the income of farmers. He highlighted that various high value nutraceuticals like lutein and value-added products viz., marigold fermented powder, herbal gulal, agarbatti can be prepared. He indicated that the pigments or pigment rich products extracted from marigold can be utilized in poultry and fisheries as a feed additive.

Dr. Suhrita Chakrborty, Professor (PHT), AICRP on Floriculture Centre, BCKV, Kalyani demonstrated the process of preparation of dried fermented powder from marigold. Dried fermented marigold powder is rich

in lutein (Pigment in marigold) and can be used as poultry feed additive which will enhance the egg yolk and broiler chicken skin colour and enhances the nutritional profile of poultry products.

Scientists of ICAR-DFR, ICAR-CTRI, ICAR-CTRI KVK, and ICAR-CIFE, Regional Station, Balabhadrapuram also participated in the programme.

Dr. K V Prasad addressed to participants about important role of value addition in flowers.

Dr. Suhrita Chakrabarty demonstrated on marigold flower value addition

7. ICAR-DFR, Pune and Mahabank RSETI organized 10 days Beekeeping Course

ICAR-Directorate of Floricultural Research (DFR), Pune, in association with Rural Self Employment Training Institute of Bank of Maharashtra, Pune, organized a 10-day training on beekeeping (Course Code: NARQ30044) from August 21-30, 2023, that is aimed at creating employment opportunities for unemployed youth aged between 18 to 45 years. A total of 22 participants from different districts of Maharashtra participated and successfully completed the course. Attendees received comprehensive training on multiple facets of beekeeping over the period of the 10 days. The course covered topics such as the historical evolution of beekeeping, diverse bee species, techniques for their care, various hive designs, tools essential for beekeeping, cultivating bee-friendly plants, and the scientific methodologies for harvesting honey and other bee-related products. Moreover, participants gained practical experience in bee handling, capturing and cultivating wild bee colonies, mastering queen-rearing methods, and engaging in meliponiculture practices during practical sessions at ICAR-DFR. They were also enlightened about the potential of beekeeping as an entrepreneurial pursuit and were introduced to various bank-sponsored schemes. The program concluded with a closing ceremony on August 30, 2023, held at the Mahabank RSETI office in Hadapsar, Pune. Dr. K.V. Prasad, Director of ICAR-DFR Pune, graced the event as the Chief Guest and presented training completion certificates to the aspiring beekeepers and future entrepreneurs. Dr. Prasad, highlighted the crucial role of bees, their contributions to ecosystem services and the importance of fostering bee-friendly flora. On this occasion, the trainees shared their viewpoints and conveyed their eagerness to venture into the beekeeping sector as part of their business endeavours. The programe was coordinated by Dr. D. M. Firake as a Course Director.

8. ICAR-DFR, Pune and Bank of Baroda- RSETI organized 10 days Beekeeping Course

ICAR-Directorate of Floricultural Research (DFR), Pune celebrated Azadi ka Amrit Mahotsav with a great zeal during 2022-23. The Directorate organized several trainings, capacity building programmes, webinars, workshops, campaigns, symposiums etc. Most recently, ICAR- DFR Pune along with Bank of Baroda-RSETI, Pune organized a 10-day course on beekeeping (Course Code: NARQ30044-AGRI) from August 5-14, 2023. This course was specifically designed to generate employment opportunities for unemployed youths from Maharashtra aged between 18 to 45 years. Over the span of a 10-day course, participants received training on different aspects of beekeeping. They were educated about the historical background of beekeeping, various bee species, methods for nurturing them, hive types, tools used in beekeeping, various types of bee-friendly plants and how to cultivate them, along with the scientific procedures for extracting honey and other bee-related products. Additionally, the trainees gained hands-on experience in handling bees, capturing wild bee colonies for cultivation, mastering queen-rearing techniques, and engaging in meliponiculture practices etc. They were also educated about beekeeping as avenue for entrepreneurship and various schemes of banks The closing ceremony of the training course was conducted along with the 77th Independence Day celebration at ICAR DFR, Pune. The budding beekeepers and future entrepreneurs were distributed the training completion certificate with the hand of Chief Guest, Dr. K.V. Prasad, Director, ICAR-DFR Pune. Trainees expressed their views and requested to conduct more such programs in near future. Shri Mangesh Mane, RSETI Bank of Baroda and Shri. Hemant Kumar Dumbre, a Master Trainer were also present during the program.

Dr. Prasad, the esteemed chief guest, emphasized the significance of bees, their ecosystem services for humanity, and the role of bee-friendly flora. He also motivated the participants by sharing diverse success stories related to entrepreneurship. A total of 137 participants attended the program and made it successful. The programe was coordinated by Dr. D. M. Firake as a Course Director.

Seminar / Webinar / Symposia / Workshop Organized

ICAR-DFR, Pune has undertaken various programmes/webinars/lecture series to celebrate of *Azadi Ka Amrut Mahotsav* on different National Campaigns and Awareness programmes of Government of India.

1. Workshop on occasion to Celebrated of World Intellectual Property Day -2023 at ICAR-Directorate of Floricultural Research, Pune held on April 26, 2023

ICAR-DFR, Pune celebrated World Intellectual Property Day-2023 by organizing an interaction on WIPO theme "Women and IP: Accelerating Innovation and Creativity" in the Conference Room of ICAR-DFR, Pune on April 26, 2023 at 11.00 am. Dr Roshni Samarth, Senior Scientist, ICAR-NRC Grapes, Pune delivered an invited talk on "IPRs in Horticulture Crops". Dr Samarth explained about different types of IPRs used in horticultural crops and role of PPVFRA in protecting farmer's varieties. She also shared her experience of working with farmers during registration process of farmer's varieties with PPVFRA, New Delhi.

Dr K V Prasad, Director ICAR-DFR, Pune and Chief Guest of programme reiterated the importance of IPRs in floricultural crops. He has shared his rich experience of working with PPVFRA, New Delhi and international organizations in terms of plant variety protection. He emphasized the need to bring more awareness on IPRs among farmers, students and academicians.

All the scientific and technical staff actively participated in the question and answer session to seek clarity on a number of issues related to IPR. A total of 28 participants including staff of Regional Station, Kadiam participated in the programme. The programme was coordinated by Dr Ganesh B Kadam, Senior Scientist, & PI-NAIF-ITMU, ICAR-DFR, Pune, Dr Naveen Kumar, PS ICAR-DFR, Pune, Dr Narendra Gajbhiye, PS, ICAR-DFR, Pune, Dr Shiva Kumar, Scientist, ICAR-DFR, Pune and Dr Sanjay Kad, Scientist, ICAR-DFR, Pune. The programme concluded with formal vote of thanks by Dr Sanjay Kad.

Dr Roshni Samarth, Senior Sceintist, ICAR-NRC Grapes, Pune delivered a guest lectures on IPRs in Horticultural crops.

ICAR-DFR staff participated in the World Intellectual Property Day-2023

2. A workshop on 'Synergy of Innovation and Incubation in Agri Start-up Ecosystem' was organized at ICAR-National Research Centre for Grapes

A workshop on 'Synergy of Innovation and Incubation in Agri Start-up Ecosystem' was organized today at ICAR-National Research Centre for Grapes, Pune in collaboration with ICAR-Central Institute for Research on Cotton Technology, Mumbai; ICAR-Directorate of Onion & Garlic Research, Pune and ICAR-Directorate of Floricultural Research, Pune.

In the inaugural session, the dignitaries highlighted the importance of innovation in the Agriculture sector and its translation to successful business ventures and networking among the institutes in the development of the agricultural and allied sectors today. Further, they stressed on Agri-startups offer critical solutions across the agricultural value chain in the form of a product, service, or application.

The Agri startup participants were briefed about RKVY RAFTAAR scheme at the workshop. Workshop was attended by more than 75 participants. Some of the participants also presented their Innovative business ideas in this workshop.

The workshop was graced by Dr Kaushik Banerjee, Director, ICAR-NRCG, Dr Vijay Mahajan, Director, ICAR-DOGR, Dr K V Prasad, Director, ICAR-DFR participated in the workshop.

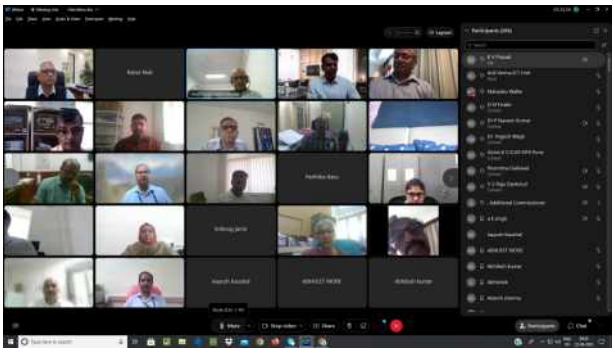
3. ICAR-Directorate of Floricultural Research, Pune participated in the inaugural programme of two-day International conference on "Enhancing Productivity and Value Additional in Millets" held during March 18-19, 2023

ICAR-Directorate of Floricultural Research, Pune participated in the inaugural programme of two day International conference on "Enhancing Productivity and Value Additional in Millets" held during March 18-19, 2023, which was inaugurated by the Hon'ble Prime Minister Shri. Narendra Modi Ji on the March 18, 2023 at NASC Complex, New Delhi. ICAR- DFR participated in this mega event virtually. During this global conference, a postal stamp, book and coin on millets was dedicated to nation by the Hon'ble PM. And ICAR-IIMR, Hyderabad has been upgraded as Global Centre of Excellence on Millets Research. Hon'ble PM highlighted importance of millets in human health and emphasized more research by ICAR to increase productivity of millets in the country. A total of 51 participants participated in the programme.

Farmers participant during addressed by Hon'ble Prime Minister of India

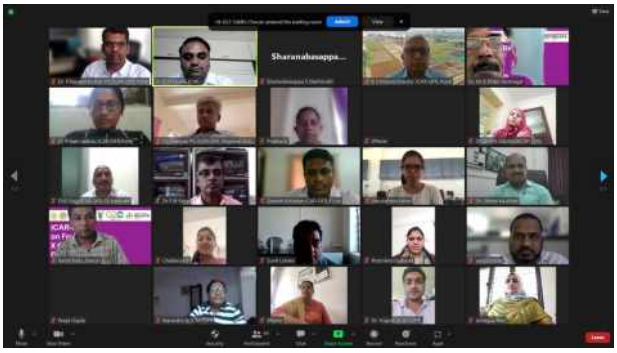
4. National Symposium on "Floriculture Nurtures Pollinators: Flower Crops for Healthy Pollinators and Value-Added Bee Products" inaugurated.

ICAR-Directorate of Floricultural Research, Pune organized two days National Symposium on "Floriculture Nurtures Pollinators: Flower Crops for Healthy Pollinators and Value-Added Bee Products" from March 23-24, 2023 on virtual mode to commemorate Azadi Ka Amrut mahotsav. Dr. A.K. Singh, Hon'ble Vice Chancellor, Chandra Shekhar Azad University of Agriculture & Technology (CSAUA&T) & Former Deputy Director General (Horticultural Science), New Delhi graced the event as Chief Guest of the inaugural



function held on 23.06.2023. He emphasized the importance of floriculture and pollinators in enhancing the sustainable crop productivity amidst climatic change induced challenges and Millennium Development Goals. On this occasion, Dr. Singh launched, 'Pollinators on Flower Crops: A Database' developed by the institute and congratulated for the development of a very useful and unique database. He advised ICAR-DFR to share the database among students/faculty and other stakeholders involved in the domain. Dr. K.V. Prasad, Director, Directorate of Floricultural Research, Pune has briefed about the backdrop of the theme and importance of floriculture in maintaining the pollinators and concomitantly the ecosystem. He also highlighted the work being carried out by ICAR-DFR in this direction. In this event, Dr. S. C. Dubey, ADG (Plant Protection & Biosafety), ICAR, New Delhi, Dr. Sachin Suroshe, Project Co-ordinator, AICRP on Honeybees & Pollinators, New Delhi and Dr. Naveen Kumar Patle, Addl. Commissioner (Horticulture) & Executive Director, National Bee Board, New Delhi participated as Guests of Honour and offered valuable suggestions. The Symposium had twelve presentations delivered by renowned experts including two experts from USA. Over 339 participants from academia, farmers, industry and ministry have attended the symposium and benefitted from topical lectures delivered by distinguished experts. Dr. D. M. Firake, Senior Scientist (Agricultural Entomology), ICAR DFR, Pune organized the symposium as Organizing Secretary.

5. ICAR-DFR organized National Webinar on the occasion of World Bee Day



ICAR-Directorate of Floricultural Research (DFR), Pune celebrated the 6th World Bee Day on May 20, 2023. On this occasion, ICAR-DFR organized a National Webinar on "Conservation of Pollinators in Urban and Peri Urban Landscapes". This program was mainly intended to create awareness about the pollinators and their ecosystem services to mankind and how can we conserve the pollinators in urban and semi urban landscapes. At the outset, Dr. P. Naveen Kumar, Principal Scientist, ICAR-DFR welcomed all participants and introduced the topic to the audience. Dr. K.V. Prasad, Director, ICAR-Directorate of Floricultural Research, Pune, and Chief Guest on this occasion emphasized the importance of the World Bee Day celebration and highlighted the scope for conservation of pollinator fauna in urban areas and farmland. He also stressed the activities of ICAR-DFR on the conservation of pollinator fauna and the scope of floriculture-based apiculture.

Dr. D. M. Firake, Senior Scientist, ICAR-DFR, Pune and Organizing Secretary of this event highlighted the importance of pollinators and explained in detail about the pollinators diversity and pollinators decline. The presentation also included a few interesting videos highlighting the different pollinator species and the interventions of ICAR DFR, Pune for the conservation of pollinators in urban and semi-urban areas. Dr M.S. Khan, Professor, GBPUA&T, Pantnagar presented a detailed account of different non-Apis (other than honeybee) pollinators, their life cycle, and essential role in the crop pollination. Dr. G.B. Kadam, Senior Scientist, ICAR-DFR highlighted the importance of a pollinator- friendly gardens for the conservation of pollinators in urban and semiurban areas. Dr. V.S. Raju Dantuluri, Principal Scientist, ICAR-DFR gave a brief account of the floral resources for the conservation of pollinators in farm and urban areas.

The webinar was registered by 169 participants across the country. The program was concluded with a vote of thanks by Dr. Tarak Nath Saha, Senior Scientist (Floriculture), ICAR-DFR, Pune.

Field Days/ Farmers Day / Kisan Gosthi / National/ International Day

1.World Soil Day celebrated by ICAR-DFR, Pune at Sortapwadi Village, Wai taluka of Satara district

World Soil Day was celebrated by ICAR-Directorate of Floricultural Research, Pune on December 5, 2023 at Sartopwadi Village, Haveli taluka of Pune district. Dr. Sanjay Kad welcomed and briefed about World Soil Day 2023 Programme. The main purpose of programme was creating awareness among ornamental nursery growers on importance of soil and water for crop production, ecosystem and human well-being and balance use of fertilizers to maintain soil health.

Dr. Ganesh Kadam, briefed DFR activities on research & extension in ornamental nursery sector. He emphasized on good soil management practices for ornamental nurseries and importance of development of standards for nursery planting materials. Dr. Md. Basit Raza explained about nutrient management in soil, media used in ornamental nurseries, how to identify nutrient deficiency symptoms in plants and importance of soil and water testing and scope of alternative media in nurseries.

Dr. Girish K. S. explained about how soil and water are carries of most diseases and pest, therefore it is essential to sterilize soil media, FYM etc at initial stage to prevent pest and diseases in ornamental plants. He also emphasized on control of soil nematodes one of the major threats in nursery industry. Sh. Sumit Shinde, Agricultural Officer, Panchayat Samiti, Haveli appealed nursery growers to take measures to conserve soil health and also informed about different state and central government schemes in floriculture and horticulture crops and soil health card importance to sustainable agriculture.

At the end of programme, shared videos of Compost making, Santulik Poshak Tatva etc. to ornamental nursery growers. About 30 farmers participated in the program.

DFR Scientists informed about soil health and its importance in ornamental nursery sector

Ornamental nursery growers participation during programme

2.ICAR-DFR, Pune Celebrated National Farmers Day

ICAR-Directorate of Floricultural Research, Pune organized *Kisan Goshthi on Diversification in Floriculture for Higher Remuneration and a Demonstration on Drone Spraying* at Jategaon village, Tal-Shirur, Dist-Pune on December 22-23, 2023 as part of celebration of National Farmers Day. Dr. Sanjay Kad welcomed and briefed about Programme.About 25farmers were participated in the program.

Dr. Ganesh Kadam, briefed about DFR activities on research & extension in floriculture sector. He focused on how traditional farming can diversify by cultivation of flower crops and explained about commercial cultivation of flower crops, value addition opportunities in floriculture to the farmers. Dr. Md. Basit Raza explained about nutrient management in flower crops specially marigold and chrysanthemum, how to identify nutrient deficiency symptoms in plants and importance of soil and water testing. Dr. Shiv Kumar explained about different diseases and pest occurance on Marigold and Chrysanthemum crops. He also emphasized on control measure to be taken to control the pests and diseases.

Dr. Sanjay Kad emphasized on importance of group farming or FPOs in floriculture sector from cultivation to marketing of flowers.

A demonstration of Drone spraying in marigold field was also organised. The importance for saving time, water compared to traditional spraying method were explained to the farmers.

The progarmme was coordinated by a team of scientists Dr. Ganesh Kadam, Dr. Sanjay Kad, Dr. Shiv kumar and Dr. Md. Basit Raza.

Visited Farmers field in Jategaon Bk. village, of Shirur talukaAgri Spray Drone Demonstration at marigold field

Agri Spray Drone Demonstration at marigold field

ICAR-DFR participation in Exhibitions

ICAR-Directorate of Floricultural Research participated in different exhibitions held by several organizations. During exhibitions, fresh flowers of different varieties of bulbous ornamentals such as gladiolus, tuberose etc. and flowering annuals; loose flowers of marigold, chrysanthemum, etc; publications and other technical information; potted plants, etc were displayed in the exclusive DFR stall at following locations.

- Participated in *"108th Indian Science Congress - Pride of India Expo - 2023* held at RTMN University, Nagpur held during January 3-7, 2023
- Participated in *GLOBAL KRUSHI MAHOTSAV*-Live Demos and Agri Exhibition conference 2023 held at KVK, Narayangaon from February 9-12, 2023.
- Participated and displayed floriculture wealth in the exhibition held in Technology Day 2023 NAAS Complex, New Delhi on July 16, 2023.
- Participated and displayed floriculture wealth in the exhibition held in G-20 Global summit at NAAS Complex, New Delhi on September 8-9, 2023.
- Participated exhibition in XVI Agricultural Science Congress EXPO- 2023 to display of DFR and AICRPs on Floriculture technologies in the exhibition held at Kochi, Kerala during October 10-13, 2023. ICAR-DFR got 3rd position among 200 exhibitors.
- Exhibition during *"10th Indian Horticulture Congress - 2023* held on November 6-9, 2023 at Assam Agricultural University, Guwahati, Assam in association with AICRP centre Kahikuchi, AAU.

- *In 14th AGROVISION EXPO - 2023* held during at PDKV Ground, Dabha Nagpur during November 24-27, 2023.
- Participated in exhibition *"National Symposium cum Industry Meet on @Agri Business in Alliums: Innovations, Promotion &Sustainability* held at MCCIA Trade Tower, SB Road, Pune organized by ICAR-DOGR, Pune during December 20-22, 2023.

Dr. Himanshu Pathak, Hon. DG, ICAR interaction in Technology Day 2023 at NASS Complex, New Delhi

Hon. Agriculture Minister, Sh. Parshottam Rupala interaction at DFR stall in Agricultural Science Congress, 2023 at Kochi

Dr. Y G Prasad, Director, ICAR-CICR, Nagpur visited exhibition stall of DFR at 108th Indian Science Congress Expo at Nagpur

ICAR-DFR participation G -20 Exhibition at NAAS Complex, New Delhi

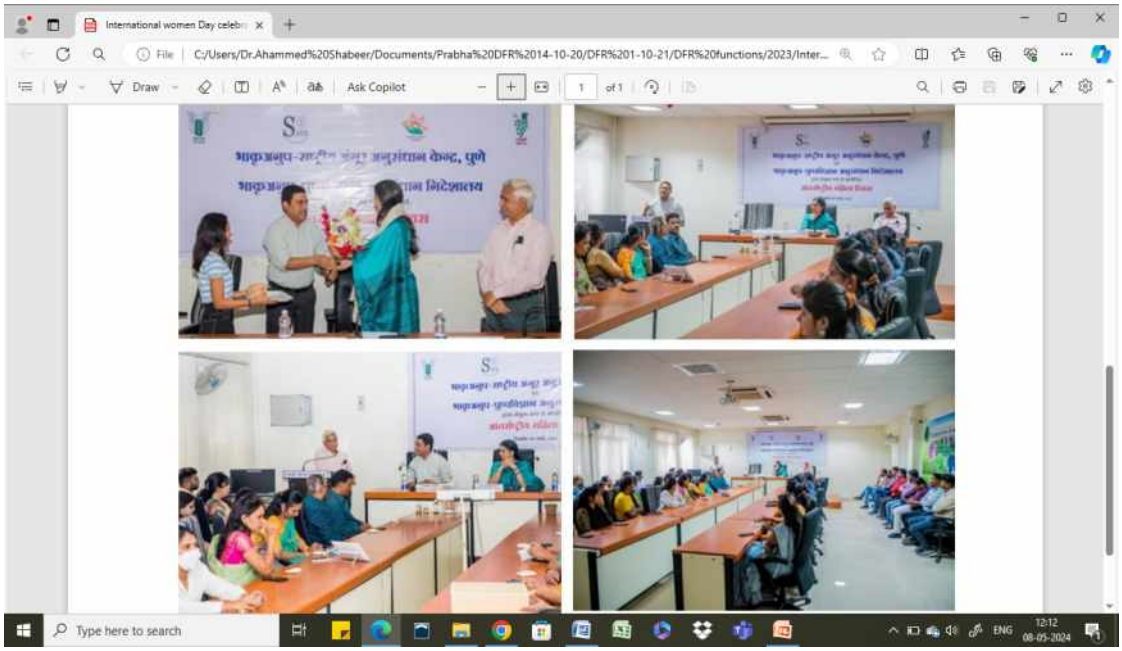
ICAR-DFR participation at National Symposium cum Industry Meet on @Agri Business in Alliums at Pune

ICAR-DFR participated in exhibition organised during 10th Indian Horticulture Congress held at College of Veterinary Sciences, Khanapara, Guwahati from November 06-09, 2023

Institutional Activities

1. ICAR-Directorate of Floricultural Research celebrated International Womens Day

International Women's Day was celebrated at ICAR- Directorate of Floriculture research on March 9, 2023 in collaboration with ICAR- National Research Centre for grapes and SAVE (Society for Advancement of Viticulture and Enology). Dr K.V Prasad, Director, ICAR-DFR highlighted the significance of the International Women's Day and highlighted the contribution of women in different sectors of science and technology specifically in horticulture. The event reached to a special height due to deliberations on the significance of adopting the organic and natural farming practices in floriculture and grape cultivation. The Chief Guest, Mrs. Monika Mohite, Joint Managing Director of Mohite Industries shared her long experience in organic farming and explained how her efforts benefited the entire community especially the farmers of the low-income group due to low input cost and a significantly higher financial returns. Dr. Banerjee shared his intriguing experience of visiting Mrs. Mohite's farm where he witnessed a comprehensive demonstration of organic agriculture, livestock farming and poultry farming. Mrs. Monika Mohite emphasized the need of adopting organic farming for a sustainable horticulture production and explained the long-term benefits of the on-farm use of the products such as Panchagavya (an organic product which acts as an immunity booster and growth promoter for plants) and Dashparni Ark (a herbal pest repellent). Her presentation on preparation and mode of action of these products was highly appreciated by the participants. Listening to her life practices and success stories, many of the young staff of the institutes got inspired to develop their entrepreneurship skills. Both institutions organized farm visits after the talk, where the organic farming practices were demonstrated to the participants.



2. ICAR-Directorate of Floricultural Research celebrated 9th International Yoga Day

ICAR-Directorate of Floricultural Research celebrated 9th International Yoga Day (IYD) in its full spirit and enthusiasm. Under the banner of Azadi Ka Amrit Mahotsav, yoga day celebration was organized with the theme 'Yoga for Vasudhaiva Kutumbakam,' effectively encapsulating our collective aspiration for 'One Earth, One Family, and One Future' on June 21, 2023 from 9.00 am to 10.30am at Hadapsar campus. Mrs.

Hashida Majithia, Mr. Nisarg Majithia and Ms. Renuja Katare Shamrao from Art of Living gave the guidance for performing the yoga protocol.

The Yoga session was followed by demonstration of Y-Break Yoga based on AYUSH guidelines. All the scientific, administrative and temporary staff of ICAR-DFR actively participated in the program

Different Yoga Asanas performed by staffs of ICAR-DFR

3. ICAR-DFR Celebrates 14th Foundation Day

The 14th foundation day of ICAR-DFR on December 10, 2023 was marked by vibrant celebrations. Dr. K.V. Prasad, welcomed the participants and highlighted the significant achievements of the Directorate of Floriculture during the last one year. Chief Guest of the function, Dr. S.D. Sawant, Former Vice Chancellor, Dr. BSKKV, Dapoli, in his remarks commended ICAR-DFR's progress and called up on the participants to pursue their passion to succeed in their entrepreneurial endeavors. He encouraged floriculture farmers to innovate and promote the use of natural flowers and strongly advocated for the banning of plastic flowers in favor of promoting live flowers for rituals, events, and festivals. Guests of honour, Dr. Anil Khar Head, ICAR-IARI, Regional Station, Pune and Dr. Panchbhai, Dean, PDKV, Akola extended their congratulations to the DFR team for the foundation day celebrations.

As part of the activities, 175 stakeholders from different segments of floriculture, including progressive farmers, nurserymen, florists, students, SMS of KVK, academia participated and some of the outstanding members were felicitated for their contribution to floriculture sector. The chief guests and guests of honor jointly launched an awareness video on the “Blossom midge: Diagnosis and management in Tuberose” developed by Dr. D. M. Firake, Senior Scientist, ICAR-DFR, Pune. This videographic advisory provides valuable insights into identifying and addressing the challenges associated with blossom midge in Tuberose cultivation which has become a menace in recent times.

As part of the celebrations a workshop on "Opportunities for Entrepreneurship Development in Floriculture: Focus on FPOs/Start-Up Formation" was conducted. Mr. Uday Kore, Business Manager at ABI, CIRCOT, delivered an informative lecture on the Agribusiness incubator under ICAR-CIRCOT and its role in promoting startups. Dr. Rajiv Kale, Senior Scientist at ICAR-DOGR, provided insights into the activities of the ICAR-DOGR Agribusiness Incubation Centre in Pune, while Dr. A.K. Sharma shed light on the initiatives undertaken by the ABI at NRC for grapes. The speakers emphasized the potential of floriculture for entrepreneurship development and promotion of FPO, SHG, Start-ups etc. A skill development session by Mr. Pandarinath Maske of Sneh florist was conducted to demonstrate floral arrangement as an option of entrepreneurship for the students, farmers and rural youth.

Participants visited the research plots having a wide diversity of varieties in crops like chrysanthemum (155), Rose (185), Tuberose (36), gladiolus (88), Aster (12) Jasmine (7), Pollinator friendly ornamentals (61), Dr. B.P. Pal National Repository of ornamental plants (75), lotus and aquatic plants (48).

The program concluded with an official vote of thanks by Dr. Prabha K., Senior Scientist at ICAR-DFR.

4. ICAR-DFR Celebrated *Hindi Pakhwada*

ICAR-DFR celebrated Hindi Pakhwada from September 14-29, 2023. Different theme based competitions like hindi word writing, essay, dictation, recitation of poem, quiz, rangoli making, etc were organized at the Directorate. The motto was to celebrate the importance of Hindi language along with creating awareness about its usage in day to day work. A workshop was also organized entitled "संसदीय प्रश्नावली" which was delivered by Dr Onkar Shukla, Senior Hindi Officer (Retd.), IITM, Pune on September 27, 2023. The concluding session was chaired by Dr Kaushik Banerjee, Director, ICAR-NRC Grapes, Pune. Dr. K. V. Prasad, Director emphasized the importance of Hindi and encouraged the staff to use Hindi in official work. The chief guest stressed upon using the Rajbhasha not only for administrative staff but also for scientific and technical staff for day to day office functioning. He also congratulated the winners of various competitions. All the winners were awarded with certificate and cash prize.

Dr.K.V. Prasad, highlighted the significant achievements of the institute

Participants in the foundation day celebrations

Essay Writing competition in Progress

5. ICAR-DFR Observed *Swachhata Pakhwada*

ICAR–DFR observed Swachh Bharat Abhiyaan on from December 16-31, 2023. Swachhata Pakhwada was celebrated by observing cleanliness in the office cabins of each scientist and administrative staff, followed by reviewing of house-keeping activities undertaken in the office on a day-to-day basis. A visit was made to the Pawana Nagar Rose growers and explained about importance of clean cultivation, composting and ecofriendly measures in cultivation. The vermicomposting unit in the institute was cleaned and everyone was made aware of proper waste management in the farm.

Team DFR during Swachhata Abhiyaan visited nurseries for imparting awareness about Good Nursery Practices

Team DFR at Swachhata Abhiyaan "Young India, Dream a Clean India" at Ghule Vidyalaya, Manjri Budruk

Mera Gaon Mera Gaurav

Under the flagship programme "Mera Gaon Mera Gaurav" of the Government of India a scheme to make scientists adopt villages to promote the best farming practices by adopting innovative technologies; ICAR-DFR, Pune has organized different activities at Kusur village (Junnar taluka) and Yelse village (Maval taluka) under MGMG. Various outreach activities were planned and executed in the adopted villages. During visit to villages, Scientists of DFR gave major emphasis on promotion of flower crops in the region and provided the scientific and technical support to the farmers. The improved varieties and technologies developed under ICAR/SAU for flower and other horticultural crops are being promoted. During 2023 under the Azadi Ka Amrut Mahotsav programme, ICAR-DFR organized different awareness campaigns such importance nano fertilizers and balanced use of fertilizers, natural farming campaign at the adopted villages, etc.

Agri-drone spraying at farmers field in Kusur village

Visit to Rose nursery in Yelse village

Distinguished Visitors

Dr. Himanshu Pathak, Hon. DG, ICAR, New Delhi visted ICAR-DFR, Pune on August 23, 2023

Hon'ble Minister of State for Agriculture & Farmers Welfare, GoI, Sh. Kailash Chaudhary Visited ICAR-DFR, Pune on January 19, 2023.

Meetings of RAC/IMC

Research Advisory Committee (RAC)

The IX ResearchAdvisory Committee (RAC) meeting of ICAR-Directorate of Floricultural Research, Pune was convened on April 12-13, 2023 at ICAR-Directorate of Floricultural Research, Pune under the Chairmanship of Dr. H.P. Singh, Former DDG (HS), ICAR & Chairman, ASSOCHAM Council of Agriculture and Food Security. The Meeting started with ICAR song, formal welcome and brief introduction of the RAC by Dr.K.V.Prasad, Director, ICAR-DFR. This was followed by self-introduction of scientific staff of ICAR-DFR; opening remarks by Dr.H.P. Singh, Hon'ble Chairman and esteemed members followed by the agenda as per the scheduled programme.

Dr. P. Naveen Kumar, Principal Scientist and Member-Secretary, RAC presented the Action Taken Report (ATR) on the recommendations of VIII RAC meeting held on February 21, 2022. The Committee discussed in-detail and expressed their satisfaction about the action taken on the recommendations and suggestions of the VIII RAC Meeting. Thereafter, Dr. K. V. Prasad, Director, ICAR-DFR, Pune has made presentation on the developments in building of the Institute.

After the presentation of salient research achievements in the in-house projects as well as externally funded projects followed by interaction of RAC with the scientists, few recommendations emerged after thorough deliberations. The recommendations made were communicated to all the participants for taking appropriate actions. The discussions were followed by the field visit (research trials as well as infrastructure created).

On April 13, 2024 a visit was conducted for the RAC members to the MGMG adopted villages about the work undertaken by the Directorate for promotion of floriculture.

Research Projects

S. No.	Projects	PI	Co-PI	Duration
Crop Improvement				
1	Project IXX 14257: Improvement of Gladiolus for Commercial Traits	Dr. Ganesh B. Kadam	Dr. Tarak Nath Saha, Dr. P. Naveen Kumar, Dr. M. R. Dhiman (ICAR-IARI, RS, Katrain) & Dr. Prabha K.	2017-18 to 2023-24
2	Project IXX 14261: Breeding of Tuberose for Quality and Yield	Dr. P. Naveen Kumar	Dr. Tarak Nath Saha, Er. Rahul Yadav, Dr. Ganesh Kadam, Dr. Prashant Kawar, Dr. D V S Raju, Dr. Dnyaneshwar Firake & Dr. Sirisha T.	2017-18 to 2023-24
3	Project IXX 14254: Improvement of Chrysanthemum for Commercial Traits	Dr. Tarak Nath Saha	Dr. Ganesh Kadam, Dr. P. Naveen Kumar, Dr. D. V. S. Raju & Dr. K. V. Prasad	2017-18 to 2023-24
4	Project IXX 14255: Improvement of Rose for Commercial Traits	Dr. Ganesh B. Kadam	Dr. D. V. S. Raju, Dr. Prashant Kawar, Dr. Harish, D., Dr. S. P. Jeevan Kumar & Dr. Narendra Gajbhiye	2017-18 to 2023-24
5	Improvement of Marigold for Commercial Traits	Dr. Harish D.	Dr. P. Naveen Kumar, Dr. D.V.S. Raju, Dr. Prashant Kawar, Dr. Narendra Gajbhiye & Dr. Tarak Nath Saha	2021-22 to 2025-26
6	Breeding of Aster for Commercial Traits	Dr. P. Naveen Kumar	Dr. D.V.S. Raju, Dr. Dnyaneshwar Firake, Dr. S. P. Jeevan Kumar, Dr. Madhavan S., Dr. Harish D. & Mrs. Poornima Gaikwad	2021-22 to 2025-26
7	Improvement of Crossandra for Commercial Traits	Dr. D.V.S. Raju	Dr. P. Naveen Kumar, Mr. Girish K. S., Dr. Sirisha T., Dr. Madhavan S. & Dr. Harish D.	2021-22 to 2025-26
8	Studies on Enhancement of Seed Vigour Indices and their Associated Mechanisms in Ornamental Crops	Dr. S. P. Jeevan Kumar	Dr. P. Naveen Kumar, Dr. D.V.S. Raju, Dr. Prashant Kawar, Dr. Ganesh Kadam, Dr. Prabha K., Dr. Uday Bhaskar (ICAR-IISS, Mau) & Dr. Sripathy (ICAR-IISS, Mau)	2021-22 to 2025-26
9	Trait specific improvement of ornamental crops through genetic engineering	Dr Prashant Kawar	Dr. Narendra A. Gajbhiye, Dr Tarak Nath Saha, Dr S.P. Jeevan Kumar, Dr Harish D	2023-24 to 2027-28

S. No.	Projects	PI	Co-PI	Duration
Crop Production				
10	Study on Determination of the Air Purification Capacity in Ornamental Plants	Dr. Kiran Bhagat	Dr. P. Naveen Kumar, Dr. Tarak Nath Saha Dr. Gursumeeran Satsangi (SPPU, Pune) and Dr. Jagdish Rane& Dr. A. K. Singh from ICAR-NIASM, Baramati	2021-22 to 2023-24
Crop Protection				
11	Viral and Bacterial Diseases of Flower Crops in India: Diagnostics and Management	Dr. Prabha K.	Dr. D. V. S. Raju, Dr. Tarak Nath Saha, Mr. Girish K. S. & Dr. Madhavan S.	2019-20 to 2023-24
12	Eco-friendly Pest Management in Commercial Loose Flower Crops	Dr. Dnyaneshwar Firake	Mr. Girish K. S., Dr. P. Naveen Kumar, Dr. Tarak Nath Saha, Dr. Sirisha T. & Dr. D.V.S. Raju	2021-22 to 2025-26
13	Exploration and Utilization of Predatory Mites and Bugs for the Management of Thrips and Mites on Commercial Flower Crops	Mr. Girish K. S.	Dr. Dnyaneshwar Firake, Dr. Prabha K., Dr. Sirisha T., Dr. Ganesh Kadam & Dr. S. P. Jeevan Kumar	2020-21 to 2024-25
14	Integrated Nematode Management in Flower and Ornamental Nursery Crops	Dr. (Mrs.) Sirisha Tadigiri	Dr. D.V.S. Raju, Dr. Madhavan S., Mr. Girish K. S. & Dr. Dnyaneshwar Firake	2020-21 to 2025-26
15	Development of Integrated Disease Management Strategy for the Ornamental Nursery Plants and Loose Flower Crops	Dr. Madhavan S.	Dr. Prabha K., Dr. Prashant Kawar, Dr. D.V.S. Raju, Dr. Sirisha T. & Dr. L. Selvarajan (ICAR-NRCB)	2020-21 to 2025-26
16	Investigating the potential of indigenous microbes as biocontrol agents to manage Insect and disease problems in flower crops.	Dr. Shivakumar K.V.	Dr. Prabha K, Dr. Madhavan, Dr. Firake D. M, Dr. Narendra Gajbhiye, Mr. Girish K. S. and Dr. Ganesh B Kadam	2022-23 to 2026-27
Post-Harvest Technology and Value Addition				
16	Project IXX 14263: Standardization of Post-Harvest Technology and Value addition Techniques in Ornamental Crops.	Er. Rahul Yadav	Dr. Ganesh Kadam, Dr. Tarak Nath Saha & Dr. P. Naveen Kumar	2017-18 to 2023-24
17	Design and Development of Tools and Gadgets for Floriculture	Er. Rahul Yadav	Dr. Ganesh Kadam, Dr. Tarak Nath Saha & Dr. Sanjay Kad	2015-16 to 2023-24
18	Exploration of Phytochemical Diversity (essential oil and pigments) in Important Flower Crops (Chrysanthemum, Marigold, Rose and Tuberose)	Dr. Narendra A. Gajbhiye	Dr. P. Naveen Kumar, Dr. Tarak Nath Saha, Dr. Ganesh Kadam, Dr. Harish D.& Dr. Ahammed Shabber TP (ICAR-NRCG, Pune)	2021-22 to 2025-26

S. No.	Projects	PI	Co-PI	Duration
Social Sciences				
19	Extension Strategies in Floriculture Sector for Enhancing the Farmers Income	Dr. Sanjay V. Kad	Dr. Ganesh Kadam, Dr. P. Naveen Kumar, Dr. TarakNathSaha, Dr. Dnyaneshwar Firake, Dr. Prabha K. & Er. Rahul Yadav	2021-22 to 2025-26
Inter-institutional projects				
1	Developing unique DNA fingerprints of flower crops	Dr. Prashant G. Kawar	Dr. Tarak Nath Saha, Dr. Ganesh B. Kadam, Dr. DVS Raju & Dr. P. Naveen Kumar from ICAR-DFR and Dr. Amol Kumar Solanke from ICAR-NIPB, New Delhi	2016-17 to 2023-24
2	Harnessing Natural Pigments from Flower Crops for Making Value Added Products from Grapes	Dr. K.V. Prasad	Dr. Prashant G. Kawar & Er. Rahul Yadav from ICAR-DFR and Dr. Ahammed Shabeer TP, Dr. A.K. Sharma & Dr. Kaushik Banerjee from ICAR-NRCG, Pune.	2016-17 to 2023-24

Publications

Research Publications

1. Aradwad, P., Yadav, R., Arun Kumar, T. V., Shabeer, T. A., Raju, D. V. S., Kumar, P. N., & Sahoo, M. (2023). Mass transfer and color change kinetics of infrared drying of rose petals and its impact on p hysico - chemical properties. *Journal of food process engineering*, *46*(7), e14359. [NAAS rating: 8.89]

2. Basak, BB; Chinchmalatpure, Anil R; Saha, Ajoy; Lodaya, Darshan H; Patel, Pooja; Gajbhiye, NA; (2023) Integrated nutrient management fostered economic yield and bioactive principle of medicinal herb (*Cassia angustifolia* Vahl.) in saline soil of semi-arid region of Western India, *Communications in Soil Science and Plant Analysis*, 54 (5), 611-626 (NAAS Rating 7.80)

3. Chavan, P., Yadav, R., Sharma, P., & Jaiswal, A. K. (2023). Laser Light as an Emerging Method for Sustainable Food Processing, Packaging, and Testing. *Foods*, *12*(16), 2983. [NAAS Rating: 10.7]

4. Dukare, A., Sharma, K., Kautkar, S., Dhakane-Lad, J., Yadav, R., Nadanathangam, V., & Saxena, S. (2023). Microbial xylanase aided biobleaching effect on multiple components of lignocelluloses biomass-based pulp and paper: A review. *Nordic Pulp & Paper Research Journal*, *38*(3), 459-480. [NAAS Rating: 7.2]

5. Dutta S, Jeevan Kumar S. P., Banerjee R (2023) A comprehensive review on astaxanthin sources, structure, biochemistry and applications in the cosmetic industry. Algal Research, p.103168. NAAS Rating: 11.40, IF: 5.276.

6. Firake D.M., Behere G.T. and Ghate H.V. 2023. Rediscovery and redescription of Urostylis *parapunctigera (Hemiptera: Urostylididae) infesting Magnolia champaka trees* in northeast India. *Entomological News* (The American Entomological Society). 130(5):437-444

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Book Chapters

1. Ganesh B Kadam, Sanjay Kad, Tarak Nath Saha, P. Naveen Kumar, Kunal Gaikwad, Girish K S, Narendra Gajbhiye and K.V. Prasad (2023). Extension Folder: पीक वाण संरक्षण आणि शेतकरी हक्क कायदा-2001 (in Marathi).

2. Jadhav, P.R., Aglawe, S.B., Harish, D. et al. Improvement of floricultural traits in ornamental crops using genome editing tools. J. Plant Biochem. Biotechnol. 32, 773–790 (2023). https://doi.org/10.1007/s13562-023-00851-3.

3. Kulvinder Bajwa, Narsi R. Bishnoi, Muhammad Yousuf Jat Baloch, S.P. Jeevan Kumar (2023) Advancement in algal biomass based biobutanol production technologies and research trends. Anita Singh, Richa Kothari, Somvir Bajar, Vineet Veer Tyagi (Eds) Sustainable Butanol Biofuels. Pp.225-237. CRC Press, Florida, United States. ISBN 978-0-367-76077-9.

4. Madhu, G.S., Harish, D., Mir, J.I., Nabi, S.U., Sharma, O.C. (2023). Conservation and Use of Temperate Fruit and Nut Genetic Resources. In: Rajasekharan, P.E., Rao, V.R. (eds) Fruit and Nut Crops. Handbooks of Crop Diversity: Conservation and Use of Plant Genetic Resources. Springer, Singapore. https://doi.org/10.1007/978-981-99-1586-6_6-1.

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Technical Articles/Populer Articles/ leaflet

1. Firake D.M. and Prasad K.V. 2023. Reversing Pollinator's Decline: Improvement of Pollinator's Health and Habitat Restoration Using Ornamental Crops. *Agriculture World*. 9(7):44-46

2. Ganesh B Kadam, Sanjay Kad, Tarak Nath Saha, P. Naveen Kumar, Kunal Gaikwad, Girish K S, Narendra Gajbhiye and K.V. Prasad (2023). Extension Folder: पीक वाण संरक्षण आणि शेतकरी हक्क कायदा-2001 (in Marathi).

3. Madhavan S., Sakthivel K., Rajesha G and Sankari Meena K. Zinc solubilizing bacteria and its application in agriculture.11/10/2023. *Vikaspedia*.

4. Plant parasitic nematodes associated with rose and their management. T. Sirisha, S. Madhavan, D.V.S. Raju and Rampal. Souvenir. All India Winter Rose Show, ICAR-IARI, New Delhi, 23rd-24th December, 2023. Page No: 70-73

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7. Sirisha T., Madhavan S., Raju D.V. S. and Rampal. 2023. Plant parasitic nematodes associated with rose and their management. In. Souvenir. All India Winter Rose Show 2023. pp.58-61.

Compilation and documentation

1. K. V. Prasad, P. Naveen Kumar, Tarak Nath Saha, D.V.S. Raju, Ganesh B Kadam, K. Prabha, Kiran Bhagat, Girish K.S., Harish D. and Poornima Gaikwad (2023) Proceedings of the XXXI Annual Group Meeting of AICRP on Floriculture held on January 18-20, 2023. Pp.57.

2. K. V. Prasad, D.V.S. Raju, Tarak Nath Saha, P. Naveen Kumar, Sirisha Tadigiri, Madhavan, Ganesh B Kadam, Sanjay Kad, S.P.Jeevan Kumar, Girish and D.M.Firake (2022). DFR Annual Report 2022, Published by Director, ICAR-Directorate of Floricultural Research, Shivajinagar, Pune, pp.152.

3. K. V. Prasad, D.V.S. Raju, Tarak Nath Saha, P. Naveen Kumar, Sirisha Tadigiri, Madhavan, Ganesh B Kadam, Sanjay Kad, S.P.Jeevan Kumar, Girish and D.M.Firake (2022). आईसीएआर – डीएफआर एनुअल रिपोर्ट (2022) Published by Director, ICAR-Directorate of Floricultural Research, Shivajinagar, Pune, pp.152.

4. P. Naveen Kumar, Tarak Nath Saha, Dnyaneshwar Firake, D.V.S. Raju, Harish, D., Prabha K., Kiran P. Bhagat, Ganesh B. Kadam, Girish K.S., Poornima Gaikwad and K. V. Prasad (2022-23) AICRP (Floriculture) Annual Report – 2022-23, Published by Director, ICAR-Directorate of Floricultural Research, Shivajinagar, Pune, pp. 783.

Presentation in Conferences/ Symposia/ Seminars/ Others

1. D M Firake, K V Prasad., AA Chavan., Y B Wagh., U D Bhosale., P Naveen Kumar., R S Yadav., Harish D., T N Saha., G B Kadam and Girish K S. Ornamental crops as pollinator-friendly habitats: investigating their role in pollinators conservation and biodiversity enhancement. at 10th Indian Horticulture Congress-2023 held during 06 to 09th November at college of veterinary science campus, assam agricultural university, Khanapara, Guwahati.

2. Ganesh B Kadam (2023) Bee-friendly landscapes for urban and peri urban areas at National Symposium on Floriculture Nurtures Pollinators: Flower Crops for Healthy Pollinators and Value Added Bee Products organized by ICAR-DFR, Pune from 23-24 June, 2023.

3. Ganesh B Kadam (2023) Drying and resin encapsulation of flower crops in one day hands on Training on Value Addition In Flower Crops (For FPO-Pavana Phool Utpadak Sangh, Yelase) at Yelase, Tal-Maval, District, Pune on 28th July 2023.

4. Ganesh B Kadam (2023) Improved Cultivation Technology of Chrysanthemum in GLOBAL KRUSHI MAHOTSAV -Live Demos, Agri. Exhibition and Crop organized by KVK Narayangaon, Pune (II) on 11th February 2023.

5. Ganesh B Kadam (2023) Pollinator's friendly gardens for urban and peri-urban areas" In: National Webinar on "Conservation of Pollinators in Urban and Peri Urban Landscapes on 20th May 2023.

6. Ganesh B Kadam (2023) Post Harvest Management and Value Addition in Flower Crops a blooming industry IN National webinar on 'Recent Advances and opportunities in Post- harvest Technology'- organised by Deccan Education Society's Kirti M. Doongursee College of Arts, Science & Commerce (Autonomous) Department of Botany on 21st January 2023.

7. Ganesh B Kadam (2023) Post-Harvest Handling and Management Practices for Flower Crops in training under MAGNET Project for FPOs and VCOs on Post-Harvest Management of Flower organised by National Institute of Post-Harvest Technology (NIPHT), Pune from 3-4 October 2023

8. Ganesh B Kadam (2023) Role of PPVFRA in protection of farmers varieties in one day Training-cum-Awareness Program on PPV&FR Act 2001 and Flower Crops at NIPHT, Talegaon, District, Pune jointly organized by PPVFRA, New Delhi and ICAR-DFR, Pune on 24th July 2023.

9. Ganesh B Kadam (2023) Scope and importance of floriculture organised by Institute of Agricultural Science, SAGE University, Indore on May 15th 2023 through online mode.

10. Ganesh B Kadam, DVS Raju, TN Saha, Shabeer TP, Pritam Jadhav, P Naveen Kumar, Narendra Gajbhiye, S.P. Jeevan Kumar and KV Prasad (2023) Effects of drying methods and storage duration on nutraceuticals compounds in Hibiscus tea In: International Seminar on Exotic and Underutilized Horticultural Crops: Priorities & Emerging Trends" held at ICAR-IIHR, Bengaluru from October 17-19, 2023

11. Ganesh B. Kadam, DVS Raju, T N Saha, Shabeer T P, Pritam Jadhav, P Naveen Kumar, Narendra Gajbhiye, S.P. Jeevan Kumar, K.V. Prasad (2023) Effects of drying methods and brewing conditions on flavonoids, phenolics, anthocyanins and antioxidant content in rose tea. In the 10th Indian Horticulture Congress, Assam Agricultural University, Guwahati during 06 to 09th November, 2023.

12. Ganesh B. Kadam, K.V. Prasad, T.N. Saha, P. Navven Kumar, S.P. Jeevan Kumar (2023) Novel gladiolus hybrids for better market acceptability and sustainable production. In the Global conference on Precision

horticulture for improved livelihood, nutrition and environmental services, Jain Irrigation Systems Limited, Jalgaon, Maharashtra, India during 28-31 May, 2023.

13. Harish D., P Naveen Kumar., Tanveer Rajoddin Shaikh., S P Jeevan Kumar., Tarak Nath Saha., D M Firake and K V Prasad. Study on differential gene expression and pathway analysis for flower colour in Tuberose (*Agave amica*) at 10th Indian Horticulture Congress-2023 held during 06 to 09th November at college of veterinary science campus, assam agricultural university, Khanapara, Guwahati.

14. K.V. Prasad, **S**. P. Jeevan Kumar (2023) Pigments as components of functional foods: lab to commercial production. In the XVI Agricultural Science Congress & ASC Expo – 2023, Kochi during 10th – 13th October, 2023.

15. K.V. Prasad, S.P. Jeevan Kumar (2023) Advances in precision production systems of flower crops. In the Global conference on Precision horticulture for improved livelihood, nutrition and environmental services, Jain Irrigation Systems Limited, Jalgaon, Maharashtra, India during 28-31 May, 2023.

16. Kawar PG (2023) Fundamentals of Biotechnology and its Applications. Refresher Course Winter School in Basic Science from 06.12.2023 to 19.12.2023, organized by the Malaviya Mission Teacher Training Centre, Kannur University, Kerala.

17. Md Basit Raza, Siba P. Datta, Debasis Golui, and Mandira Barman (2023). Application of industrial wastes for reducing bioavailability of arsenic in soil. In: National Seminar on Development of Soil Science at the 87th Annual Convention of Indian Society of Soil Science held at ICAR-IISS, Bhopal (3-6th October, 2023).

18. Md Basit Raza, Siba P. Datta, Debasis Golui, and Mandira Barman (2023). Bio-accessibility of arsenic in cooked rice grain grown in steel slag amended arsenic contaminated soil. In: National Seminar on Development of Soil Science at the 87th Annual Convention of Indian Society of Soil Science held at ICAR-IISS, Bhopal (3-6th October, 2023).

19. P Naveen Kumar., D M Firake., Harish D., S P Jeevan Kumar., D V S Raju., Tanveer R Shaikh., Pushpanjali B. Bhosale and Poornima Giakwad. Development of promising aster lines through conventional breeding at 10th Indian Horticulture Congress-2023 held during 06 to 09th November at college of veterinary science campus, assam agricultural university, Khanapara, Guwahati.

20. P.G. Kawar, Ahammed Shabeer T.P. 2, P.R. Jadhav1, R.S. Yadav1, D.V.S. Raju1, K.V. Prasad (2023). Comparative Analysis of Volatile Compound Composition and Gene Expression in Fragrant and Non-fragrant Rose Varieties. Int. Conference on Biochemical and Biotechnologcal Approaches for Crop Improvement (IBBACI 2023). Oct 30-Nov 01, 2023.

21. S P Jeevan Kumar., Ganesh B Kadam., P Naveen Kumar, D V S Raju, Harish D., Dyaneshwar M. Firake and K V Prasad. Anthocyanin extraction, Charcaterization and evaluation of its antioxidant potential from gladiolus (Gladiolus grandiflora) spikes: A potent nutraceutical source. at 10th Indian Horticulture Congress-2023 held during 06 to 09th November at college of veterinary science campus, assam agricultural university, Khanapara, Guwahati.

22. Tarak Nath Saha, Ganesh B. Kadam, P. Naveen Kumar, D.V.S. Raju, R Ramajeyam and K.V. Prasad (2023). Invited Oral entitled "Underutilized elite inter-specific ornamental banana hybrids (Musa spp.) for aesthetics" during the International Seminar on Exotic and Underutilized Horticultural Crops: Priorities & Emerging Trends held at ICAR-IIHR, Bengaluru from October 17-19, 2023. (Adjudged Second Best Oral)

23. Tarak Nath Saha, K.V.Prasad, Ganesh B. Kadam, P. Naveen Kumar and D.V.S. Raju (2023) Invited Oral entitled "Development of Potted Chrysanthemum (Chrysanthemum morifolium Ramat.) using Electron Bean Irradiation" during the Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Services held at JISL, Jalgaon, Maharashtra from 28th to 31st May, 2023.

Awards and Recognitions

1. Exhibition stall of ICAR-DFR got 3rd best Agri-Expo stall among 200 Exhibition stalls during the Agricultural Science Congress during October 10-13, 2023 organized by NAAS and CMFRI, at Kochi.
2. Dr. K Prabha received "Best Oral Presentation Award" in National Conference on 'Generative AI in Practice for Empowering Agricultural Research Productivity' (September 11- 12, 2023).
3. Dr. K Prabha received "Best Oral Presentation Award" in VIROCON-2023: Advancements in Global Virus Research Towards One Health from December 1-2, 2023.
4. Dr. Jeevan Kumar Selected for DST-SERB SIRE Fellowship to conduct research work on anthocyanin extraction and its stabilization at University of Vigo, Spain for a period of 06 months.
5. Dr Jeevan Kumar recognized as Teaching and Research Faculty as part of ICAR-IARI (NIASM HUB, Baramati) for Molecular Biology and Biotechnology specialization.
6. Dr. Jeevan Kumar nominated as Internal expert in Institute Biosafety Committee of ICAR-Directorate of Floricultural Research, Pune.
7. Dr. D. M. Firake, Senior Scientist (Agricultural Entomology) is elected as 'Fellow of National Academy of Agricultural Sciences w.e.f. 1st January 2024
8. Dr. D. M. Firake, Internal expert as part of Institute Biosafety Committee of ICAR-Directorate of Floricultural Research, Pune.
9. Tarak Nath Saha, K.V.Prasad, Ganesh B. Kadam, P. Naveen Kumar and D.V.S. Raju (2023) Invited Oral entitled "Development of Potted Chrysanthemum (Chrysanthemum morifolium Ramat.) using Electron Bean Irradiation" during the Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Services held at JISL, Jalgaon, Maharashtra from May 28-31, 2023.
10. Tarak Nath Saha, Ganesh B. Kadam, P. Naveen Kumar, D.V.S. Raju, R Ramajeyam and K.V. Prasad (2023). Invited Oral entitled "Underutilized elite inter-specific ornamental banana hybrids (Musa spp.) for aesthetics" during the International Seminar on Exotic and Underutilized Horticultural Crops: Priorities & Emerging Trends held at ICAR-IIHR, Bengaluru from October 17-19, 2023. (Adjudged Second Best Oral presentation)
11. Ganesh B. Kadam, DVS Raju, T N Saha, Shabeer T P, Pritam Jadhav, P Naveen Kumar, Narendra Gajbhiye, S.P. Jeevan Kumar, K.V. Prasad (2023) Effects of drying methods and brewing conditions on flavonoids, phenolics, anthocyanins and antioxidant content in rose tea. In the 10th Indian Horticulture Congress, Assam Agricultural University, Guwahati during November 6-9, 2023. (Adjudged Second Best Oral).
12. Md. Basit Raza reviewed research papers in Environmental Science and Pollution Research, Pedosphere, Soil and Sediment Contamination-An International Journal, and Environmental Geochemistry Health.
13. Md. Basit Raza has been admitted as faculty and research guide under ICAR-IARI, Baramati Hub by the PG School, IARI, New Delhi.
14. Md. Basit Raza has joined as editorial board member in "Discover Agriculture" journal published by Springer Nature.

Training and Capacity Building

Sr. no	Name of staff	Name of training attended	Duration and date	Training institute
1.	Narendra A. Gajbhiye	NABL Assessors' Training Course on ISO/IEC 17025:2017	May 15-19,2023	ICAR-CIFE,Mumbai
2.	Dr. Prashant G. Kawar	Training on Gene Editing and Technology Management	July 10-14 ,2023	CAR-NAARM & ICAR-IIRR, Hyderabad
3.		'Measurement of Uncertainty and Decision Rule as per requirement of ISO/IEC-3 days17025:2017	30th to1st-02-2023.	ICAR-NRC Grapes
4.	Dr. V S Raju Dantuluri	National Training on Organic/natural Farming Principles and Practices Short course (NAHEP)	November 15-24,2023	NAHEP
5.	Dr. Prabha K	NABL Assessors' Training Course on ISO/IEC 17025:2017	May 15-19,2023	ICAR-CIFE,Mumbai
6.	Dr. Ganesh B Kadam	Startup Masterclass Series	April 24 –May18,2023	Pusa Krishi, ZTM & BPD Unit, in collaboration with ICAR, New Delhi - 110012, India
7.	Dr. Ganesh B Kadam	SRIJAN: Orientation programme	January 17-19,2024	ICAR-ZTMCs/ ITMUs held on January 17-19, 2024 at lecture Hall, 02nd Floor, NASC Complex, New Delhi- 110012
8.	Girish K S	Identification of plant associated mites	January 8-13 ,2024	PC Unit AINP on Acarology, GKVK, UAS Bengaluru
9.	Dr. Sirisha Tadigiri	Biosecurity and Biosafety: Policies, Diagnostics, Phytosanitary Treatments and Issues"	September 4-14, 2023	ICAR- National Bureau of Plant Genetics Resources, New Delhi
10.	Dr. Jeevan SP	Pedagogy development programme on enhancing pedagogical competencies for agricultural education	November 20-24,2023	National Academy of Agricultural Science, New Delhi
11.		"Development, evaluation and biosafety assessment of genome edited crops: Hands-on Training"	20th January to 09th Feb 2023.	ICAR-Indian Institute of Rice Research, Hyderabad
12.	Dr. Harish D	Pedagogy development programme on enhancing pedagogical competencies for agricultural education	April 1-5 ,2023	National Academy of Agricultural Science, New Delhi

Sr. no	Name of staff	Name of training attended	Duration and date	Training institute
13.	Shivakumar K V	Mastering Molecular Techniques: Microbial Identification to Diversity Analyses	December 6-13 ,2023	ICAR-NBAIM, Mau, U.P.
14.	Md Basit Raza	FOCARS (112)	April 11 to July 10, 2023	ICAR-NAARM, Hyderabad
15.	Md Basit Raza	Orientation	July, 24 to Aug 23	ICAR-DFR, Pune
16.	Md Basit Raza	Professional Attachment Training	August 24 to November 24, 2023	ICAR-Indian Institute of Soil Science, Bhopal
17.	Lakshmipathy M	FOCARS (112)	April 11 to July 10, 2023	ICAR-NAARM, Hyderabad
18.	Lakshmipathy M	Professional attachment training	August 23 to January 1, 2024	ICAR-Indian Institute of Horticultural Research, Hessaraghatta
19.	Mr Deepak Verma	Vigilance Awareness Campaign	November 1-3, 2023	ICAR-NAARM, Hyderabad

Participation In Conference / Symposia / Seminars / Others

S. No.	Particulars	Staff Attended
1.	Global Conference on Precision Horticulture for Improved livelihood, Nutrition and Environmental Services held at JISL, Jalgaon, Maharashtra from 28th to 31st May, 2023.	K.V. Prasad, Rampal, P. Naveen Kumar, Tarak Nath Saha, D M Firake and Ganesh B. Kadam
2.	International Seminar on Exotic and Underutilized Horticultural Crops: Priorities & Emerging Trends held at ICAR-IIHR, Bengaluru from October 17-19, 2023,	K.V. Prasad, Rampal, Tarak Nath Saha and Ganesh B. Kadam
3.	Int. Conference on Biochemical and Biotechnologcal Approaches for Crop Improvement (IBBACI 2023) Oct 30-Nov 01, 2023.	Prashant Kawar
4.	10th Indian Horticulture Congress-2023 held during 06 to 09th November at college of veterinary science campus, assam agricultural university, Khanapara, Guwahati	K.V. Prasad, D. M. Firake, Ganesh B. Kadam, Jeevan S.P. and Harish D.
5.	Comparative Analysis of Volatile Compound Composition and Gene Expression in Fragrant and Non-fragrant Rose Varieties. Int. Conference on Biochemical and Biotechnologcal Approaches for Crop Improvement (IBBACI 2023). Oct 30-Nov 01, 2023.	K.V. Prasad, Dr. Prashant Kawar, D.V.S. Raju, R.S. Yadav, P.R. Jadhav
6.	VIROCON-2023: Advancements In Global Virus Research Towards One Health from December 1-2, 2023, by Indian Virological Society at NRC Banana, Trichi, Tamil Nadu	Dr. Prabha K
7.	International Conference on Plant Health Management ICPHM 2023 - Innovation & Sustainability to be held from November 15-18, 2023, Organized by Plant Protection Association of India, At Professor Jayashankar Telangana State Agricultural University Auditorium, Rajendranagar, Hyderabad, India	Dr. Prabha K
8.	National Conference on 'Generative AI in Practice for Empowering Agricultural Research Productivity' (September 11- 12, 2023) at NRCG, Pune	Dr. Prabha K
9.	International Conference on Frontiers in Tobacco and Commercial Agriculture towards Preparedness for Future Farming organized by ICAR-CTRI during 14-16 at Adi Kavi Nannaya University, Rajahmundry	K. V. Prasad D.V. S. Raju, S. Madhavan, Sirisha Tadigiri, D. Harish, Ram Pal

Radio /TV Talks

1. Ganesh B Kadam: TV Talk on "खरिपामध्ये फुलांची लागवड आणि काळजी " in Krishi Darshan Program on DD Sahyadri Live telecasted on June 01, 2023 (6.00 PM)
2. Ganesh B Kadam: TV Talk on फुलांपासून ड्राय फ्लॉवर्स आणि नैसर्गिक रंग करण्याच्या पद्धती in Krishi Darshan Program on DD Sahyadri Live telecasted on February 01, 2023 (6.00 PM)

Personnel

S. No.	Name	Designation	Particulars
1.	Dr. K. V. Prasad	Director	-
2.	Dr. P. Naveen Kumar	Principal Scientist (Horticulture-Floriculture)	Upto July 13, 2023
3.	Dr. D V S Raju	Principal Scientist (Horticulture-Floriculture)	-
4.	Dr. Narendra Gajbhiye	Principal Scientist (Agricultural Chemicals)	-
5.	Dr. Prashant G. Kawar	Principal Scientist (Genetics & Plant Breeding)	-
6.	Dr. Tarak Nath Saha	Senior Scientist (Horticulture-Floriculture)	-
7.	Dr. Dnyaneshwar M. Firake	Senior Scientist (Agricultural Entomology)	-
8.	Dr. Ganesh B. Kadam	Senior Scientist (Horticulture-Floriculture)	-
9.	Dr. Kiran Bhagat	Senior Scientist (Plant Physiology)	-
10.	Dr.(Mrs.) Prabha K.	Senior Scientist (Plant Pathology)	-
11.	Mr. Girish K. S.	Scientist (Agricultural Entomology)	-
12.	Dr. Sanjay V. Kad	Scientist (Agricultural Extension)	-
13.	Dr. S. Prashant Jeevan Kumar	Senior Scientist (Agricultural Biotechnology)	-
14.	Dr. (Mrs.) Sirisha Tadigiri	Senior Scientist (Nematology)	-
15.	Er. Rahul S. Yadav	Scientist (Agricultural Structure and Process	-
16.	Dr. S. Madhavan	Scientist (Plant Pathology)	-
17.	Dr. Harish D.	Scientist (Genetics and Plant Breeding)	-
18.	Dr (Ms) Uzma Mehraj	Scientist (Floriculture & Landscaping)	From April 11, 2023
19.	Md. Basit Raza	Scientist (Soil Science)	From July 21, 2023
20.	Dr Lakshmipathy M.	Scientist (Floriculture & Landscaping)	From July 20, 2023
21.	Dr. (Ms.) Pritam Jadhav	Technical Assistant (T-3)	-
22.	Mrs. Poornima Gaikwad	Technical Assistant (T-3)	-
23.	Mrs. Vijaya Bhumkar	Finance and Accounts Officer	-
24.	Mr. Deepak Verma	Assistant Administrative Officer	-
25.	Mr. Rupesh Kumar Pathak	Assistant Administrative Officer	-
26.	Mr. Mahadev B. Walke	Assistant	-
27.	Mr. Ram Shinde	Upper Division Clerk	-

Budget (2022-23)

The details of the Budget of ICAR-DFR including AICRP on Floriculture are tabulated as under:

(Rs. Lakhs)

Head of Account	ICAR-DFR		AICPR on Floriculture	
	Budget	Expenditure	Budget	Expenditure
A. Recurring				
Establishment charges	610.79	607.51	565.90	565.90
TA	8.00	7.55	3.50	3.50
HRD	2.00	1.01	0.00	0.00
Other Charges	200.00	196.85	91.50	91.50
SCSP	0.00	0.00	0.00	0.00
NEH	0.00	0.00	0.00	0.00
TSP	0.00	0.00	2.00	2.00
Total (A)	**820.79**	**812.92**	**662.90**	**662.90**
B. Non-Recurring				
Equipment	75.00	23.93	4.00	3.00
Works	125.00	85.66	0.00	0.00
Furniture	0.00	0.00	0.00	0.00
Library Books and Journals	0.00	0.00	0.00	0.00
Total (B)	**200.00**	**109.59**	**4.00**	**3.00**
Grand Total (A+B)	**1020.79**	**922.51**	**666.90**	**665.90**

ICAR -DFR @ XVI Agricultural Science Congress

ICAR DFR GOT THIRD BEST AGRI EXPO STALL

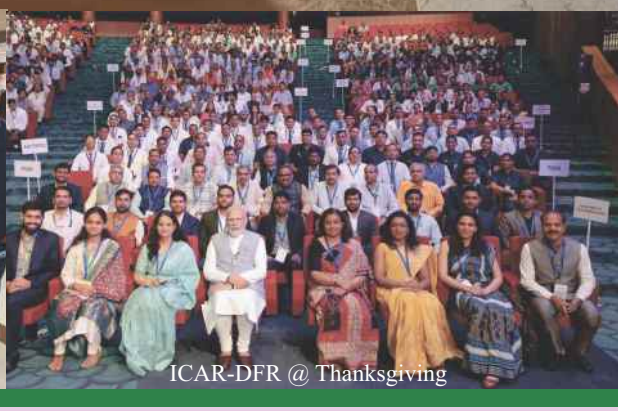
ICAR-DFR @ G20 Exhibition

Floral diversity of India comprising of traditional, cut flowers and their value added products were displayed

ICAR-DFR created a floral replica of Chandrayan 3 in honour of its successful launching during G20 Summit

ICAR-DFR @ Thanksgiving

Dignitaries at the display



ICAR-DFR @ Thanksgiving

भा.कृ.अनु.प.– पुष्पविज्ञान अनुसंधान निदेशालय

ICAR-Directorate of Floricultural Research

(An ISO 9001: 2015 Certified Institute)

जेड कॉर्नर, मुंडवा मंजरी रोड, मुंडवा, पुणे 411 036, महाराष्ट्र, भारत

Zed Corner, Mundhwa Manjri Road, Mundhwa, Pune 411036, Maharashtra, India.

दूरभाष/Phone: 020-29997184

ईमेल/E-mail: director.dfr@icar.gov.in, directordfr@gmail.com

वेबसाईट/Website: http://dfr.icar.gov.in