Standard Operating Procedures for

Conducting Field Experiments Under AICRP on Floriculture

ICAR-Directorate of Floricultural Research
All India Coordinated Research Project on Floriculture
(Indian Council of Agricultural Research)
College of Agriculture Campus, Shivajinagar, Pune-411005, Maharashtra, India

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Foreword

Systematic efforts to initiate scientific research on floriculture were materialized with the start of All India Coordinated Research Project on Floriculture during IV-Five Year Plan in 1970-71 at 5 Centres located at Indian Agricultural Research Institute (IARI), New Delhi; Indian Institute of Horticultural Research (IIHR), Hessaraghatta; IARI, Regional Station; Katrain, Botanical Survey of India (B.S.I.), Howrah (Kolkata) and B.S.I., Shillong. Emerging challenges from time to time resulted in rationalization of number of centers and the crops. At present the AICRP on Floriculture operates at 21 centers (15 Budgetary + 4 Institutional and 2 Voluntary) with focus on 13 crops.

Bringing in uniformity in conducting the experiments, analysis and interpretation of data is paramount for the success of coordinated research. Therefore the Horticultural Science Division of Indian Council of Agricultural Research has encouraged all the AICRP's that are operating under the SMD to prepare Standard Operating Procedures (SOP's). Similar manuals are already in place for AICRP on Potato and AICRP on Fruits.

I am happy that the AICRP on Floriculture under the overall guidance of Dr.T.Janakiram, ADG (HSII) has taken the initiative and prepared this manual STANDARD OPERATING PROCEDURES FOR CONDUCTING FIELD EXPERIMENTS UNDER AICRP ON FLORICULTURE. I complement Dr.T.Janakiram, Team DFR and other AICRP group members for their sincere effort in bring out the publication which I am sure would help all those involved in the Floricultural Research.

(A.K.Singh)

Dr. T. Janakiram
Assistant Director General (Horticultural Science II)

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Foreword

The All India Coordinated Research Project on Floriculture was initiated with 60 projects in 25 crops, which were finalized in the first workshop held at Indian Agricultural Research Institute, New Delhi in February 1971 during the IV Plan. The utility and efficiency of these programs were reviewed critically during the end of each Five Year Plan and the number of crops was subsequently reduced to 15 and 5 during the VI and VII Plan periods, respectively. The number of research projects was reduced to 43 and 26, respectively, during the above plans for increasing the functional efficiency of the project. At the fifth workshop held at I.A.R.I., New Delhi in the year 1982 it was decided to concentrate and intensify research efforts on only five crops identified for their export potential viz., rose, gladiolus, orchid, carnation and chrysanthemum. In view of the changed priorities, research work was also initiated during VII Five-Year Plan on few seasonal flowers and bulbous plants. During the VIII Plan, two important commercial crops viz. gerbera and anthurium were included in the Coordinated Project. The XVII Group Meeting held at YSPUHFT, Solan in July 2005 shortlisted 44 research projects in 12 crops namely rose, gladiolus, chrysanthemum, carnation, orchid, anthurium, tuberose, gerbera, tulip, lilium, daffodils and alstroemeria. Emerging challenges necessitated changes from time to time in number of crops and number of experiments.

While I was reviewing the XXIV Group Meeting at Srinagar during 2015 a strong need was felt to rationalize the number of projects and the number of crops. Accordingly the number of experiments was rationalized. Need was also felt to bring in harmony in reporting and to have uniform statistical analysis. An expert on Agricultural Statistics Dr. Dandapani was invited during the XXV Group Meeting at Rajahmundry held in June 2016 to suggest and guide the group on statistical requirements. In order to bring harmony in conduct of experiments, treatments, statistical analysis and reporting, a manual for Standard Operating Procedures was the need of the hour.

The present manual on Standard Operating Procedures for Conducting Field Experiments under AICRP on Floriculture is the culmination of concerted efforts of the Horticultural Science Division of ICAR, Team DFR and other colleagues from the AICRP centers.

I sincerely hope that the manual would be handy for the AICRP personnel to conduct, analyze and organize their data more productively.

(T.Janakiram)

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Preface

Floriculture is becoming important for domestic and export markets and the demand is ever increasing. Opportunities for floriculture and landscape gardening are increasing due to urbanization and enhanced expendable income. In the fast changing global context, managing the change on a time scale, by converting weakness into opportunities to become internationally competitive is considered important. The increasing demand for both cut flowers and potted plants in Western countries will result in the production gain from our country. The scope expands further by increasing the production of exiting product as well as expanding the product range. There has been an appreciable increase in floriculture, but potentialities, which exit in the sector, have not been harnessed. The sector has lot of potential to address social and economic issues including employment generation, private sector investment, entrepreneurship, job for unemployed educated youths and women empowerment.

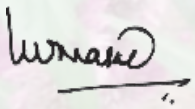
The All India Coordinated Research Project on Floriculture was started during IV-Five Year Plan (in the year 1970-71) to initiate scientific research on floriculture. Initially there were 5 centres which were reorganized from time to time and at present the coordinated project has 21 Centres which includes 15 budgetary, 4 Institutional and 2 Voluntary, covering 17 states of India. Since its inception, the AICRP has made substantial progress in development of new and improved varieties of flower crops, standardization of production technology including improved plant protection measures and post harvest management.

The mandate of AICRPs is not only the testing of verities and agrotechniques but also identification of location specific problems and their solutions. When experiments are conducted at many locations and many personnel are involved, it is necessary that common methodology is followed so that the results can be compared across locations. Proper care has also to be taken in recording observations so that we can understand the crop phenology vis a vis the environment. There, is a need to delineate a uniform set of essential observations that have to be recorded in all the experiments which would help express the phenology of the crop affected by the environment or treatments. Moreover, such a systematic list of observations would help to adopt a systematic analysis protocol. Further, the personnel conducting the trials at different centers are of widely different background, hence, well described protocols for conduct of the trials as well as recording observations would reduce the human errors in recording of observations. Hence, a need was often felt to develop a technical manual on standard operating procedures that will give clear cut guidelines for the personnel involved in conduct of field

experiments and recording the observations. An effort is therefore made to bring about this publication entitled Standard Operational Procedures for Conducting Field Experiments under AICRP on Floriculture.

I would like to express my sincere gratitude to Dr. T. Mohapatra, Secretary DARE and Director General ICAR for his valuable guidance, support and overall leadership. The support, cooperation and guidance received from Dr. A. K. Singh, Deputy Director General (Hort. Science) and Dr. N. K. Krishna Kumar, former Deputy Director General (Hort. Science) is enormous. ICAR-DFR places on record our sincere gratitude to him. Dr. T. Janakiram, Assistant Director General (Hort.) of the Indian Council of Agricultural Research, Krishi Anusandhan Bhavan II, New Delhi is instrumental in encouraging us to prepare the guidelines and we are deeply indebted to him for his keen interest, constant inspiration and encouragement.

I am highly thankful to all my colleagues Drs Ganesh Kadam, Tarak Nath Saha, Prasanna.H, Girish,K.S, Prabha.K, Nitika Gupta, Rahul Yadav and Shilpashree. K.G, of the Directorate of Floricultural Research for their help and cooperation rendered in compilation of this technical manual.



(K.V.Prasad)

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Chapter 1

Introduction

1. Preamble

All India Coordinated Research Project on Floriculture was established during IV Five-Year Plan in the year 1970-71 to carryout nation-wide interdisciplinary research by linking ICAR Institutes with State Agricultural Universities (SAU's). The necessity of the project has been reviewed from time to time in view of growing importance and potential of floriculture in different regions of the country and the number of Coordinated Centers as well as the research programme was modified accordingly. At present the Coordinated Project has 21 Centers which includes 15 budgetary, 4 institutional and 2 voluntary Centres. The project has been upgraded to a full-fledged institute named Directorate of Floricultural Research during XI Plan.

The establishment of an independent institute 'Directorate of Floricultural Research' by ICAR at Pusa, New Delhi, was a positive step to strengthen the existing network of AICRP on Floriculture and also in making them more focused and research oriented. The Directorate of Floricultural Research with the help of AICRP network is playing an important role in strengthening floricultural research and augmenting the technological base in floriculture in different regions of the country. Outreach of the technologies and creating awareness about the benefits of practicing floriculture among rural population is the need of the hour, which would be achieved through the network of coordinated centres spread all over the country.

1.1. All India Coordinated Research Project on Floriculture

The systematic efforts to initiate scientific research in floriculture were materialized with the start of All India Coordinated Research Project on Floriculture during IV-Five Year Plan in 1970-71 at 5 Centres located at Indian Agricultural Research Institute (IARI), New Delhi; Indian Institute of Horticultural Research (IIHR), Hessaraghatta; IARI, Regional Station; Katrain, Botanical Survey of India (B.S.I.), Howrah (Calcutta) and B.S.I., Shillong. During fifth five year Plan, four more centres viz. Punjab Agricultural University (PAU), Ludhiana; Dr. Y.S. Parmar University of Horticulture & Forestry (Dr. YSPUHF), Solan; Kerala Agricultural University (KAU), Vellanikkara; and Mahatma Phule Krishi Vidyapeeth (M.P.K.V.), Pune were added. The two centres of the project located at B.S.I. Shillong and B.S.I. Calcutta were transferred to ICAR Research Complex for N.E.H. Region, Barapani, Shillong and Bidhan Chandra Krishi Viswavidyalaya (B.C.K.V.), Kalyani during April and October 1977, respectively. There were 26 Voluntary Centres, besides these 9 regular centres during 1973-1977 and the voluntary centres were Agricultural Institute, Allahabad; University of Agricultural Sciences, Bangalore; Govt. Lal Bagh Garden, Bangalore; Orissa University of Agriculture & Technology, Bhubaneswar; The Agri-Horticultural Society, Calcutta; Hill Fruit Research Station, Chaubattia; Tamil Nadu Agricultural University, Coimbatore; Sim's Park, Coonoor; Llyod Botanic Garden, Darjeeling; Directorate of Parks and Gardens, Gandhi Nagar; Haryana Agricultural University, Hisar; Andhra Pradesh Agricultural University, Hyderabad; Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur; Parks and Gardens, Jemshedpur; Assam Agricultural University, Jorhat; IARI Regional Station, Kalimpong; C.S.Azad University of Agriculture and Technology, Kanpur; National Botanic Gardens, Lucknow; Govt. Botanical Garden Ootacamund; G.B.Pant University of Agriculture & Technology, Pantnagar; College of Agriculture, Sabour; Fertilizer Corporation of India, Sindri; Bhabha Atomic Research Centre, Trombay; University of Udaipur, Udaipur; Banaras Hindu University, Varanasi and Botanical Survey of India, Yercaud. During VI Five Year Plan, four new centres were started to strengthen the coordinated project at Rajasthan Agricultural University (R.A.U.), Udaipur; Horticultural Experiment and Training Centre (HETC), Chaubattia (Ranikhet); Tamil Nadu Agricultural University (TNAU), Coimbatore and Orchid Sanctuary, Kalimpong under BCKV, Kalyani (presently under UBKV, Coochbehar),

Under Tamil Nadu Agricultural University, Coimbatore two sub centres were operating at Horticultural Research Stations located at Kodaikanal and Yercaud.

During VII Five Year Plan, the Coordinated Project was further strengthened with the addition of two more centres at Andhra Pradesh Agricultural University (APAU), Hyderabad and Sher-E-Kashmir University of Agricultural Sciences and Technology (S.K.U.A.S.T.), Srinagar to give better representation of the agro-climatic regions not covered by the project earlier. In order to cover the coastal region of eastern India, Regional Plant Resource Centre (R.P.R.C.), Bhubanewar was also included in the Coordinated Project during the VIII plan period, which started functioning from 1st April,1996. During the Vlll Plan, one existing centre viz. Horticultural Experiment and Training Centre (H.E.T.C.), Chaubattia was dropped from the Coordinated Project. One sub centre at Kodaikanla (Under T.N.A.U.) was dropped in 1997 and hence in TNAU, apart from the main centre at Coimbatore, there is only one sub-centre at Yercaud. During lX Plan, 3 new centres were approved to represent three more states viz. G.B.Pant University of Agriculture & Technology, Pantnagar (Uttarakhand); Assam Agricultural Unviersity, Kahikuchi (Assam) and Birsa Agricultural University, Ranchi (Jharkhand). The AICRP on Floriculture has 21 centres at present which includes 15 budgetary centres, 4 institutional centres and 2 voluntary centres (Table 1).

Table 1. List of Coordinated Centres along with the year of their establishment and mandate crops

S. No.	Centre	Year of Start	Mandate Crops
Budgetary Centres			
1.	Bidhan Chandra Krishi Viswavidyalaya, Mohanpur	1972	Chrysanthemum, orchids, anthurium, tuberose, gerbera, turf grass, gladiolus, marigold, china aster, landscape plants, foliage plants, dry flower
2.	Dr.Y.S. Parmar University of Horticulture & Forestry,Solan	1975	Gladiolus, carnation, tulip, daffodils, lilium, alstroemeria, specialty flowers, turf grass, marigold, china aster, native ornamentals, dry flower
3.	Kerala Agricultural University, Vellanikkara	1975	Orchids, anthurium, turf grass, specialty flowers, fillers, native ornamentals, landscape plants, foliage plants, dry flower
4.	Mahatma Phule Krishi Vidyapeeth, Pune	1975	Rose, gladiolus, carnation, tuberose, gerbera, marigold, crossandra, china aster, specialty flower
5.	Punjab Agricultural University, Ludhiana	1975	Rose, gladiolus, chrysanthemum, tuberose, fillers, turf grass, landscape plants, foliage plants
6.	Maharana Pratap University of Agricultural Sciences and Technology,	1980	Gladiolus, chrysanthemum, tuberose
7.	Tamil Nadu Agricultural University, Coimbatore Sub-centre: Horticultural Research Station (TNAU), Ooty	1982	Chrysanthemum, anthurium, gerbera, tuberose, china aster, marigold, foliage plants, landscape plants, lilium, alstroemeria, fillers, gladiolus, carnation
8.	Uttar Banga Krishi Viswavidyalaya, Kalimpong	1985	Orchids, gerbera, alstroemeria
9.	Sri Kondalakshman Telangana State Horticultural University, Hyderabad	1987	Gladiolus, chrysanthemum, tuberose, turf grass, crossandra, china aster, marigold, carnation, specialty flowers, fillers
10.	Sher-E-Kashmir University of Agricultural Sciences &Technology, Srinagar	1987	Gladiolus, tulip, daffodils, lilium, alstroemeria, china aster

S. No.	Centre	Year of Start	Mandate Crops
11.	Asam Agricultural University, Kahikuchi, Guwahati	2001	Orchids, chrysanthemum, tuberose, gerbera, marigold, specialty flowers, fillers, native ornamentals, foliage plants, dry flower
12.	Odisha University of Agriculture and Technology, Chiplima	2011	Rose, chrysanthemum, marigold
13.	G. B. Pant University of Agriculture & Technology, Pantnagar	2001	Chrysanthemum, tuberose, turf grass
14.	Birsa Agricultural University, Ranchi	2001	Gerbera, rose, foliage plants
15.	Rajendra Agricultural University, Pusa, Samastipur, Bihar	2010	Tuberose, gladiolus and marigold
Institutional centres			
16.	Indian Agricultural Research Institute, New Delhi	1971	Rose, gladiolus, chrysanthemum, turf grass, foliage plants
17.	Indian Agricultural Research Institute, Regional Station, Katrain, Himachal Pradesh	1971	Gladiolus, tulip, daffodils, lilium
18.	Indian Institute of Horticultural Research, Hessaraghatta, Bangalore	1971	Rose, gladiolus, carnation, chrysanthemum, anthurium, tuberose, gerbera, specialty flowers, native ornamentals, landscape plants, turf grass, marigold, crossandra, china aster
19.	ICAR Research Complex for NEH Region, Barapani, Shillong (Meghalaya)	1971	Orchids, gerbera
Voluntary Centres			
20.	University of Agricultural Sciences, Bangalore	1977	Fillers, foliage plants
21.	Horticultural College and Research Institute (TNAU), Periyakulum	2010	Marigold, tuberose, crossandra, native ornamentals

1.1.1. Mandate of AICRP on Floriculture

i Collection, maintenance and evaluation of indigenous and exotic germplasm of ornamental plants, including wild species under different agro-climatic conditions.

ii Development of new and improved varieties.

iii Standardization of agro-techniques for production of cut flowers, bulbs and plants for domestic and export markets.

iv Standardization of propagation techniques, including embryo/ tissue/ meristem culture for quicker multiplication.

v Development of suitable pre and post-harvest technologies for cut flowers. viIdentification and control of major diseases and pest of identified crops.

1.1.2. Mandate crops in AICRP on Floriculture

At present the mandate crops of the AICRP on Floriculture are Rose, gladiolus, chrysanthemum, carnation, tuberose, crossandra, china aster orchids, gerbera, tulip, daffodils, lilium, alstroemeria, specialty flowers (Bird of

paradise, ginger lily, heliconia), foliage & fillers (asparagus, dracaena, gypsophilla, ferns), native ornamentals, landscape plants/ shrubs and turf grass.

1.1.3. Manpower

The strength of personnel working in the project has increased depending on the work load assigned to Coordinated Centres. At present, the sanctioned strength is 74, which includes 40 scientific, 11 technical, 1 administrative and 22 supporting staff (Table 2). The distribution of scientific personnel discipline wise is presented in table 3.

Table 2. Staff Position of AICRP on Floriculture

Plan	Scientific	Technical	Others	Total
IV	*	*	*	*
V	16	2	10	28
VI	29	8	21	58
VII	32	8	21	61
VIII	34	8	26	68
IX	39	11	25	75
X	39	11	25	75
XI	40	11	23	74
XII	40	11	22	73

Table 3. Distribution of Scientific Personnel of AICRP on Floriculture

Plan	Floriculture/ Breeding/ Crop Management	Pathology	Physiology	Total
IV	*	*	*	*
V	13	1	2	16
VI	26	1	2	29
VII	28	2	2	32
VIII	30	2	2	34
IX	34	3	2	39
X	35	3	2	39
35	3	2	40	
XI	35	3	2	40
XII	35	3	2	40

1.1.4. Budget

The coordinated project started with a modest budget of Rs. 7.83 lakhs during IVth Five Year Plan. This has been increased to 2009.72 lakhs during XI Five Year Plan, including state share of Rs. 287.14 lacs. This is distributed under Pay and Allowances (1103.17 lacs), Travelling Allowances (53.80 lacs), Recurring Contingency (343.98 lacs) and Non-Recurring Contingency (488.32 lacs). The sanctioned budget during different Five-Year Plans is presented below in Table 4.

Table 4. Budget details of AICRP on Floriculture

Plan	No. of Centres including P.C. Cell	Amount (Rs. in lakhs) ICAR Share
IV	6	7.83
V	10	21.61
VI	14	68.04
VII	16	73.84
VIII	16	181.39
IX	23	420.00
X	21	627.25
XI	23*	1722.13

* RAU, Bihar and TNAU, Periyakulam were added during XI Five year Plan

1.1.5. Workshops/Group Meetings

The All India Coordinated Research Project on Floriculture conducted group meetings from time to time to review the progress of work done in the coordinated project and for the finalization of research programmes, keeping in view of the changing priorities and thrust areas of rapidly expanding floriculture industry. The first workshop was organized at Indian Agricultural Research Institute, New Delhi in February, 1971. From 1973 to 1977, no workshops were held as there was no Project Coordinator in position. The list of workshops / group meetings held so far under the project is given below.

In the XIX Group Meeting conducted at IARI, New Delhi on 10-12 December 2009, it was decided to hold the meeting annually instead of every biennium (Table 5).

Table 5. The list of Workshops/Group Meetings of the AICRP on Floriculture.

Workshop / Group Meeting	Year	Date	Place
I	1971	18-19 February	IARI, New Delhi
II	1973	29-31 January	AHSI, Calcutta
III	1978	16-18 February	NBRI, Lucknow
IV	1980	17-19 March	PAU, Ludhiana
V	1982	22-24 March	IARI, New Delhi
VI	1983	21-24 September	IIHR, Bangalore
VII	1985	19-22 March	RCA, Udaipur
VIII	1986	29 Sept. - 1st Oct.	MPKV, Pune
IX	1988	18-20 March	Dr. YSPUHF, Solan
X	1990	23-25 April	KAU, Vellanikkara
XI	1992	16-18 November	TNAU, Coimbatore
XII	1994	14-16 December	APAU, Hyderabad

Workshop / Group Meeting	Year	Date	Place
XIII	1996	26-29 December	RPRC, Bhubaneswar
*BSS	1997	16 October	IARI, New Delhi
XIV	1999	6-9 December	MPKV, Pune
XV	2001	22-24 January	RPRC, Bhubaneswar
XVI	2003	17-18 July	UAS, Bangalore
GM-TP$	2004	29-30 April	IARI, New Delhi
XVII	2005	12-14 July	Dr. YSPUHF, Solan
XVIII	2007	15-17 November	MPUA&T, Udaipur
XIX	2009	10-12 December	IARI, New Delhi
XX	2010	13-15 November	BCKV, Kalyani
XXI	2011	04-06 November	CTRI, Rajahmundry
XXII*	2013	29-31 January	MPKV, Pune
XXIII	2014	27-29 February	PAU, Ludhiana
XXIV	2015	17-19 April	SKUAST, Srinagar
XXV	2016	28-30 June & 1 July	CTRI, Rajahmundry
***Brain Storming Session** **$ Group Meting for finalization of Technical Progrmme for 2003-05** **Group Meeting on Crops**			
Orchids	1977	10-11 Oct	ICAR Research Complex for NEH Region, Umiam, Barapani (Meghalaya)
Carnation	1983	10-11 March	PAU, Ludhiana

1.2. Genesis of Directorate of Floricultural Research

Floriculture is becoming important for domestic and export markets and the demand is ever increasing. Opportunities for floriculture and landscape gardening are increasing due to urbanization and enhanced expendable income. In the fast changing global context, managing the change on a time scale, by converting weakness into opportunities to become internationally competitive is considered important. The increasing demand for both cut flowers and potted plants in Western countries will result in the production gain from our country. The scope expands further by increasing the production of exiting product as well as expanding the product range. There has been an appreciable increase in floriculture, but potentialities, which exit in the sector, have not been harnessed. The sector has lot of potential to address social and economic issues including employment generation, private sector investment, entrepreneurship, job for unemployed educated youths and women empowerment. To achieve science and technologically led development in floriculture it is essentially required to have a full-fledge institution.

Floricultural research in the country is scattered and the approach is not focused at present for the overall development of floriculture industry in India. At present, the R&D in floriculture is being taken up by All India

Coordinated Research Project on Floriculture; Floriculture Division of ICAR Institutes like IARI and IIHR; NRC on Orchids; CSIR institutes like NBRI, Lucknow and IHBT, Palampur and some of the SAU's like YSPUHF, PAU, MPKV, TNAU, etc. These institutions have contributed a great deal for the development of Indian floriculture in terms of improved varieties, improved crop production and protection technology, post harvest management and the present trade in India. But the technologies so developed are aimed at improving the flower production under open-field conditions. There is little or no work for boosting flower production under protected conditions, as their requirements are entirely different from that of open cultivation.

Due to various constraints, the avenues like flower drying, essential oil extraction, flower seed production, nursery raising for production of plant material of trees, climbers, shrubs, turf grass, pot plants, etc. were so far never covered under the research programmes. Propagation technology under the programme has been limited to few commercial flower crops only.

In India, there is no separate institute, which is dealing with all these issues exclusively in a comprehensive and collaborative way. All these issues can be well addressed only by a full-fledged institute on floriculture. Keeping in view of the importance of the sector the Department of Agricultural Research and Education (DARE) with the approval of the Planning Commission, Government of India has decided to establish a full-fledged Directorate of Floricultural Research at New Delhi during XI Plan.

The new Directorate shall coordinate research on floriculture on genetic resource utilization, development of cultivars, production technology, productive use of water, plant architecture engineering and management, protection technology, value addition, repository of data bank and to a act as an advanced centre for training on floriculture. It will provide the crucial technological support to the growers and entrepreneurs besides providing employment generation to educated unemployed youth. Therefore the Directorate of Floricultural Research will focus on development of technologies which will be cost effective and suitable for different agroclimatic conditions and more importantly will aim at reducing the dependence on costly and often variable foreign technologies.

The first Quiquennial Review Team (1972-73 to 1985) headed by Prof. P. Das gave a clear-cut recommendation for establishing an Institute on Floricultural Research. In the situation where there are Institutes opened exclusively on specific crops, like NRC for Orchids, which is one component of broader field of floriculture. Since then many experts in floriculture raised their voice in support of an establishment for floriculture, the notable include Prof. K. L. Chadha, Chairman, third and fourth QRT (2000-2006) during various occasions.

The vision of Dr. H. P. Singh, DDG (Hort), ICAR, and the support and momentum offered by him accelerated the process. In fact, Dr. Singh took the initiation to propose the establishment of Directorate of Floricultural Research in XI Five Year Plan. As per his instructions and overall guidance, and also with the necessary help from Dr. R. L. Misra, the then Project Coordinator (Floriculture), Dr. M. T. Patil, the then Head, Division of Floriculture and Landscaping, a three member team consisting of Dr. T. Janakiram, Principal Scientist, IIHR, Bangalore, Dr. K. V. Prasad, Senior Scientist and Dr. P. Naveen Kumar, Scientist, IARI, New Delhi prepared the complete proposal of up-gradation of AICRP on Floriculture in to a Directorate of Floricultural Research. The draft proposal, so prepared, was subjected to several revisions following succession of meetings. Due to voluminous nature of IARI EFC document which includes about 10 schemes, the number of meetings vis-à-vis revisions was quite large. Accordingly, the proposal of Directorate of Floricultural Research was revised and the staff number and the budget outlay were reduced from 120 to 15 and 55 crores to 17.23 crores. All these efforts were materialized with the approval of competent authority for the up-gradation of AICRP on Floriculture in to Directorate of Floricultural Research (vide Lr. No. F. No. 16-16/2007 – I. A. IV dated 23rd July 2009). Dr. Mangala Rai, the then Director General, Indian Council of Agricultural Research in the august presence of Dr. H. P. Singh, DDG (Hort) and Dr. H. S. Gupta, Director, IARI formally launched the Directorate of Floricultural Research on 10th December 2009 at Dr. B. P. Pal Auditorium, IARI, New Delhi.

Since then the Directorate was run on ad-hoc basis. With the timely intervention of Dr. S. Ayyappan, Hon'ble DG, ICAR and Secretary, DARE and Dr. H. P. Singh, DDG (Hort), ICAR, Dr. Ramesh Kumar, who was Professor and Head, Department of Floriculture and Landscaping, PAU, Ludhina, was selected as the founder Director of the Directorate of Floricultural Research on 11th August 2010.

1.2.1. Mandate of ICAR-Directorate of Floricultural Research

- Basic, strategic and applied research to enhance sustainable productivity, quality and utilization of ornamental crops.
- Repository of genetic resources and scientific information on ornamental crops.
- Transfer of technology, capacity building and impact assessment of technologies.
- Coordinate research and validation of technologies through AICRP on Floriculture.

1.3. Salient Achievements in Floricultural Research

During the 11th Plan period the AICRP on Floriculture was upgraded to a full-fledged Directorate of Floricultural Research with its Head Quarter at New Delhi and was relocated to Pune during February 2014.

1.3.1. Germplasm Enrichment

1. A total of 780 accessions of varieties belonging to various classes of roses i.e. Hybrid Tea, Floribunda, Miniature and Climbing groups were collected and maintained at Delhi, Bhubaneswar, Ludhiana, Hessaraghatta, Ranchi, Pantnagar and Udaipur centres.
2. In gladiolus, 637 accessions of varieties were maintained at Ludhiana, Yercaud, Srinagar, Hessaraghatta, Udaipur, Solan, Katrain, Hyderabad, Delhi, Kahikuchi, Lucknow, Ranchi, Pantnagar, Shillong and Kalimpong.
3. In carnation, 121 accessions were collected and maintained at Solan, Yercaud, Srinagar, Ludhiana, Katrain, Kalimpong and UAS Bangalore.
4. In chrysanthemum, a total of 1115 accessions of varieties are maintained at Hessaraghatta, Ludhiana, Pune, Solan, Coimbatore, Bhubaneswar, Hyderabad, Udaipur, Lucknow, Srinagar, UAS Bangalore, Ranchi and Pantnagar centres.
5. The centres namely Vellanikkara, Yercaud, Kalyani, Bhubaneswar, Kahikuchi, Shillong, Kalimpong and UAS Bangalore collected and maintained 165 accessions of various genera, species and hybrids of orchids.
6. In anthurium, 206 varieties were collected, maintained and evaluated at Hessaraghatta Coimbatore, Yercaud, Kalimpong, Kahikuchi, Shillong, Kalyani and Vellanikkara.
7. In tuberose, more than 50 accessions were collected, maintained and evaluated at Hessaraghatta, Coimbatore, Kahikuchi, Kalyani, Hyderabad, Lucknow, Ludhiana, Pune, Delhi and Vellanikkara.
8. A total of 286 accessions of gerbera were collected, maintained and evaluated at Shillong, Pune, Yercud, Hessaraghatta, Kahikuchi, Ranchi, Srinagar, Kalyani, Ludhiana and Vellanikkara.
9. During 2004-05, four new crops were included. About five cultivars of tulip were collected, maintained and evaluated at Srinagar, Solan and Katrain.
10. In daffodils, five cultivars were maintained at Katrain , Srinagar and Solan.
11. 17 varieties of Lilium were collected, maintained and evaluated at Solan, Srinagar and Katrain.
12. In alstroemeria, 15 varieties were maintained at four centres viz., Kalimpong, Srinagar, Katrain and Solan

1.3.2. Crop Improvement

I. Rose

The Division of Floriculture and Landscaping at IARI, New Delhi developed 41 varieties of roses under Hybrid Tea (HT) group (Abhisarika, Anurag, Arjun, Bhim, Charugandha, Chitra, Chitralekha, Chitwan, Dr. B. P. Pal, Dr. Benjamin Pal, Dr. Bharat Ram, Ganga, Gulzar, Hans, Jawahar, Madhosh, Mother Teresa, Mridula, Mohini, Mrinalini, Nehru Centenary, Noorjehan, Preyasi, Priyadarshini, Pusa Bahadur, Pusa Christina, Pusa Garima, Pusa Gaurav, Pusa Manhar, Pusa Mansij, Pusa Priya, Pusa Sonora, Rajkumari, Raktagandha, Raktima, Shreyas, Soma, Sujata, Surabhi, Surekha and Vasant). It is believed that an aneuploid variety Mohini contributed the chocolate brown colour to the present day rose. Four new varieties Pusa Ajay, Pusa Arun, Pusa Shatabdhi, Pusa Komal are ready for release. I.A.R.I is the first to send the trial consignment of roses to Frankfurt and Amsterdam in 1969 with the collaboration of State Trading Corporation. These consignments were well-accepted in global markets.

The Division of Floriculture and Landscaping at IARI also developed 22 Floribunda varieties (Arunima, Banjaran, Chandrama, Deepika, Deepshikha, Delhi Princess, Kavita, Lahar, Manasi, Navneet, Nav Sadabahar, Neelambari, Prema, Pusa Veerangana, Pusa Barahmasi, Pusa Pitamber, Rupali, Shabnam, Shringar, Sindoor, Suchitra and Usha) besides one climbing cultivar namely Clg. Sadabahar.

IIHR, Bangalore developed Dr. G. S. Randhawa and Kiran under HT. recently the Division has also developed one rose varieties Arka Parimala which is highly fragrant. TNAU at Yercaud developed YCD-1, YCD-2 and YCD-3 Floribunda roses. NBRI Lucknow developed 10 HT roses (Kronenberg, Light Pink Prize, Mrinalini Light Pink Mutant, Mrinalini Stripe, Pink Montezuma, Salmon Beauty, Summer Holiday Mutant, Winter Holiday Mutant, Sylvia White and Girija besides 11 Floribunda rosés, *viz*., Angara, Curio, Pink Contempo, Pink Imperator, Salmon Beauty Mutant, Sharada, Sukumari, Tangerine Contempo, Twinkle, Yellow Contempo and Zorina Pink Mutant, one Miniature cv. Windy City Mutant; and one climbing rose cv. Clg. CriCri.

ii. Gladiolus

The Division of Floriculture and Landscaping at IARI released Pusa Red Valentine, Pusa Manmohak and Pusa Kiran recently. The Division has also commercialized these three varieties to private industries. Centres of AICRP on Floriculture, released some 81 gladiolus varieties *viz*., Aarti, Agnirekha, Anjali, Apsara, Archana, Arka Suvarna, Arka Kesar, KKL-1, Arun, Basant Bahar, Bindiya, Chandni, Chaubattia Ankur, Chaubattia Arunima, Chaubattia Shobhit, Chaubattia Tripti, Subhangini, Chirag, Darshan, Dhanvantari, Dhiraj, Gazal, Hans, Indrani, Jwala, Kalima, Kohra, Kum Kum, Manhar, Manisha, Manmohan, Mayur, Meera, Mohini, Mridula, Mukta, Nazrana, Neelam, Phule Ganesh, Phule Neelrekha, Phule Prerna, Phule Tejas, Pitambar, Poonam, Priyadarshini, Punjab Dawn, Pusa Archana, Pusa Suhagin, Pusa Gulaal, Pusa Gunjan, Pusa Jyotsana, Pusa Kamini, Pusa Lohit, Pusa Mohini, Pusa Rangmahal, Pusa Sukanya, Pusa Swapnil, Pusa Urmi, Pusa Urmil, Pusa Urvashi, Pusa Swarnima, Rashmi, Sadabahar, Sagar, Sanyukta, Sapna, Sarang, Shabnam, Shagun, Shakti, Shobha, Shringarika, Shweta, Sindhur, Smita, Suchitra, Sunayna, Suryakiran, Tambri, Triloki and Vandana.

iii. Chrysanthemum

Mutation breeding efforts at IARI resulted in the development of the four mutants Pusa Anmol, Pusa Centenary, Pusa Kesari and TQP06. Out of which Pusa Anmol is a thermo and photo insensitive variety that blooms thrice (October-February-May) in a year. During 2013 the Division has released 3 promising seedlings namely Pusa Chitraksh, Pusa Aditya (which resembles gazania flowers) and Pusa Sona (ideal for mums). All the seven varieties are now commercialized to private organizations.

Research efforts across the country resulted in more than 150 chrysanthemum varieties by various AICRP centres so far. (Lucknow, Ludhiana, Coimbatore, Hessaraghatta and Kalyani) and these are Agnishikha, Ajay, Alankar, Anamika, Appu, Apsara, Apurva singer, Aruna, Arka Ganga, Arka Ravi, Arka Suvarna, Arun Kumar, Arun

Singar, Asha, Ashankit, Basant, Basanti, Basantika, Baggi, Bindiya, Birbal Sahni, Co.1, Co.2, Chandrakant, Chandrika, Colchi Bahar, Cosmonaut, Dhawal, Diana, Flirt, Gairik, Gauri, Gulal, Guldasta, Gul-e-Sahir, Haldighati, Hemant Singar, Hemanti, Himani, Himanshu, Indira, Jaya, Jayanti, Jhalar, Jubilee, Jugnu, Jwala, Jyoti, Jyotsana, Kalima, Kapish, Kanak, Kaumudi, Kansya, Khumani, Kirti, Kiran, Kum Kum, Kunchita, Kundan, KSL-16, Lal Kila, Lalima, Lalpari, Lilith, NBRI Little Darling, NBRI Mini Jessie, NBRI Mini Indiana, NBRI Kusum, Lohita, Maghi Brown, Maghi Pink, Maghi Yellow, Manbhavan, May Day, Mayur, Meghdoot, Mini Queen, Mohini, Mother Teresa, Navneet, Navneet Yellow, Neelima Nirbhaya, Nirbhik, Nirmal, Pancho, Pankaj, Preet Singar, PCO.1, PCO.2, Phuhar Pingal, Pitaka, Pitamber, Priya, Prof. Harris, Puja, Purnima, Ragini, Rakhee, Rangoli, Ravi Kiran, Red Gold, Rimjhim, Rohit, Santi, Shabnum, Sharad Har, Sharad Kranti, Sharad Kumar, Sharad Mala, Sharad Mukta, Sharad Sandhya, Sharad Shobha, Sharad Singar, Sharad Sheela, Shefali, Shveta, Shizuka, Shukla, Shyamal Red, Shymal White, Sonali, Subarna, Suhag Singar, Sujata, Swarna Singar, Swarnim, Sweta Singar, Tamra, Taruni, Tulika, Tushar, Usha, Vandana, Varsha, Vasantika, White Charm, White Prolific, Yellow Charam, Yellow Gold, Yellow Prolific, Yellow Star, etc.

iv. Other Flower Crops

a. *Orchids*

IIHR Bangalore developed 2 promising hybrids, *viz*., IIHR-164 (purple) in *Vanda* and IIHR-38 (purple violet) in *Dendrobium* orchids.

b. *Jasmine*

Coimbatore developed 3 varieties *viz.,* Co.1, Co.2 and Parimullai under *Jasminum auriculatum,* and 2 varieties*, viz.,* Co.1 Pitchi, and Co.2 Pitchi in *J. Grandiflorum.* IIHR Bangalore developed one jasmine var. Arka Surabhi.

c. *Tuberose*

In tuberose, IIHR Bangalore developed 4 varieties, *viz*., Prajwal, Shringar, Suvasini and Vaibhav; NBRI Lucknow 2 varieties, *viz.,* Rajat Rekha and Swarna Rekha; and Pune centre one variety, Phule Rajni.

d. *China Aster*

In China aster, Pune centre developed Phule Ganesh White, Phule Ganesh Pink, Phule Ganesh Purple and Phule Ganesh Violet; and IIHR centre Kamini, Poornima, Shashank and Violet Cushion.

e. *Marigold*

Two improved open-pollinated varieties namely, Pusa Narangi Gainda (deep orange) and Pusa Basanti Gainda (sulphur - yellow) of African marigold and Pusa Arpita of French marigold have been developed and released for commercial cultivation. Pusa Narangi Gainda has caught the attention of the framers especially of Jammu region where the nearly 80% of the cultivated area under marigold is under Pusa Narangi Gainda.

f. *Crossandra*

A very important flower of southern India grown for ages. Farmers used to grown local varieties that were selected over a period of time by the farmers. Research efforts at TNAU and IIHR Bangalore have resulted in development of some improved varieties. IIHR Bangalore has recently released two improved varieties namely Arka Kanak and Arka Ambara

g. *Hollyhock*

Four F_1 hybrids of Hollyhock namely, Pusa Apricot Supreme, Pusa Pastel Pink, Pusa Pink Beauty and Pusa Yellow Beauty were developed. In addition to these hybrids, seven open pollinated varieties namely Dulhan (red), Deepika (light yellow), Gouri (pink), Pusa hollyhock Gulabi (pink), Pusa hollyhock Krishna (maroon), Pusa hollyhock Lalima (red), and Pusa hollyhock Shweta (white) were released.

Apart from these, many hibiscus and bougainvillea varieties were developed by IIHR centre. NBRI centre also developed many bougainvilleas.

1.3.3 Production Technology

i. Rose

Rosa indica var. *odorata* rootstock was found best for Coimbatore, Delhi, Lucknow, Ludhiana and Pune conditions; *R. multiflora* and IIHR - Thornless for Bangalore, Hyderabad and Kalyani conditions; and *R. chinensis* (Titri) for Udaipur conditions.

Depending upon the varieties used, 30 x 20 cm spacing was found best for Super Star and Gladiator under Pune and Udaipur conditions; 30 x 30 cm spacing for Montezuma at Kalyani conditions; and 30 x 40 cm for Super Star under Delhi, and for Sonia Meilland under Udaipur conditions, as quality flower production was maximum there. Per hectare use of 650 kg N, 800 kg P_2O_5, 700 kg K_2O, 10 kg elemental sulphur, 50 kg each of $MgSO_4$ and $CaSO_4$, and November and January spraying of 1% $FeSO_4$, 0.5% $ZnSO_4$ and 0.2% boron at Delhi condition for Super Star roses at 30 x 30 cm spacing, gave maximum yield. At Kalyani with cv. Montezuma, NPK 100:100:75 g/m^2; at Pune with cv. Gladiator, NPK 60:10:20 g/m^2; at Bangalore with cv. Happiness, NPK 50:100:75 g/m^2; and with the same variety at Yercaud, NPK 75:150:50 8/m^2 gave maximum flower yield.

For commercial cultivation of rose, NPK 400:200:200 ppm/plant/week at 'run off' stage is recommended. Coimbatore centre commended NPK [$(NH_4)_2 NO_3$, H_3PO_4 and KNO_3] 150:40:150 for cv. First Red under protected conditions. At Ludhiana, 60:40:40 g/m^2 NPK with cv. Super Star, is recommended.

Delhi centre found 10 cm pruning from Dept. 23 to Oct. 1, in rose cvs. Queen Elizabeth and Happiness, and 45 cm leaving 4 shoots, from Oct. 13 to Nov. 17 in cv. Super Star as the optimum.

Against weeds, Oxyflurofen at 0.5 kg a.i./ha drenching at Kalyani, and 1 kg a.i./ha at Ludhiana; Oxyflurofen (1 kg a.i./ha) or Diuron (2 kg a.i./ha) at Delhi in cvs. Super Star and Raktagandha, and Diuron (2.5 kg a.i/ha) or Simazine (3 kg a.i./ha) or Round Up' (1 kg a.i./ha) at Yercaud and Bangalore conditions, had been found quite effective.

ii. Gladiolus

Pune centre with cv. Sancerre at 25 x 10 cm spacing and Hessaraghatta, Kalyani and Ludhiana centres found 4.5 - 5.0 cm gladiolus corms at 20 x 20 cm spacing and 8 cm depth quite effective. For weed control in gladiolus field, application of Basalin or Stomp @ 1.87 l/ha, followed by hoeing 75 days after planting, proved quite effective. NPK application of 45-50: 10-30: 10-20 g/m^2 along with 10 kg FYM or 300:150:200 kg/ha has been recommended for different regions of the country.

iii. Chrysanthemum

At NBRI Lucknow, technology for year round blooming in chrysanthemum has been standardized. About 150 cultivars have been screened at the Institute for their photo-induction requirement. These have been classified into 7 response groups ranging from 7-13 weeks (Kher, 1994). The miniculture technique standardized at NBRI shows how pot culture of chrysanthemum can be made cheaper, easier, aesthetically rewarding and commercially more profitable (Kher, 1986).

Solan centre developed the technology for year round flower production through staggered planting, pinching, growth retardants, photoperiod regulation and cultural practices, as summarized hereunder:

PRC	Pinching	Retardant	Lighting	Blackout (days)	Blooming period
June 2	June 24	July 28	NLD up to Aug. 4	48-70	Oct. 2-Nov.4
Aug. 5	Aug. 27	Sept. 30	NLD up to Aug. 26 + ALD from Aug. 27 - Oct.6	48-73	Dec. 11-Jan. 1
Oct. 11	Nov. 2	Dec. 5	ALD up to Dec. 12	50-74	Feb. 11-Mar.4
Dec. 1	Dec. 20	Jan. 23	ALD up to Jan. 30	94-115	May 24-June 6

PRC	Pinching	Retardant	Lighting	Blackout (days)	Blooming period
Feb.2	Feb.24	April 1	ALD up to April 8	48-73	June 8-29
April 3	April 22	May 28	ALD up to April 22 + NLD from April 23-June 4	52-72	Aug. 7-29

- Blackout means natural/artificial short days after termination of light to the stage till 60-70% flower buds showed colour.
- NLD = natural long days, and ALD = artificial long days.
- The range under blackout column denotes variation with the treatment.
- PRC = planting of rooted cuttings.

ALD treatments at later stages of growth (1 and 2 months after planting) extends vegetative growth than LD treatments immediately after planting. GA 50ppm advances the flowering while NAA at 50 ppm delays it. At Ludhiana, by providing natural short day conditions from Dec. to Feb. and artificial short days from March, flowering was induced in May in the cv. Punjab Anuradha. Black polythene covering of the plants of cvs Birbal Sahni, Jubilee, Flirt, Sunil, Jayanti and Vijay for 14 h daily at night till 60-70% buds show their colour, induced earlier flowering.

Rooting was more in suckers than the terminal cuttings though reverse was true with respect to flowering and yield. Spacing of 30x30 cm with single pinching at 4^{th} week or 2 pinching at 4^{th} and 7^{th} week of planting provide higher yield. *Azospirillum*, VAM and phosphobacterium along with 200 ppm N, 40 ppm P and 200 ppm K provide better growth, yield and post harvest life in cvs Bronze Spray and Red Spray.

iv. Orchids

A potting medium consisting of charcoal, brick pieces and coconut fiber in equal parts for epiphytic orchids like *Aerides multiflorum* and *Dendrobium moschatum*; loam soil, river sand, leaf mould, charcoal dust and old mortar (1:1:1:0.5:0.5) for terrestrial orchids like *Cymbidium aloifolium and Phaius tankervillae*; and brick pieces, coir dust and charcoal for *Vanda* spp. have been found quite suitable. In epiphytic orchids, *viz., Aerides multiflorum* and *Phalaenopsis amabilis,* hardwood charcoal chunks were found best as compared to tree fern fibers, over burnt brick pieces and coconut husk while *in Cattleya bowringiana and Dendrobium moschatum,* tree fern fiber was found best.

Isabgul as gelling agent and polyprophylene bags as culture vessels gave outstanding response for orchid micropropagation. In *Cattleya bowringiana and C. trianni*, long day treatment suppressed complete flowering while supplementary illumination (16 h day length) induced earlier flowering by 47-59 days in *Dendrobium, Phalaenopsis amabilis* and *P. Schilleriana*. A fertilizer solution containing potassium nitrate (2.63 g), ammonium sulphate (0.44 g), magnesium sulphate (2.04 g), mono-calcium phosphate (1.09g), calcium sulphate (4.86g), ferrous sulphate (0.50g) and manganese sulphate (2ml, of 1% solution) in 4.5 l water at 7 days interval improved growth and flowering in *Dendrobium moschatum, Aerides multiflorum, Vanda* spp. and *Dendrobium* cv. Sonia. For commercial cultivation of *Dendrobium* cv. Sonia-17, 0.2% spraying twice weekly of NPK (20:30:30) is recommended. In *Rhyncostylis gigantea*, 500 ppm each of N. P, K, and in A*erides multiflorum* and *Dendrobium moschatum,* 1000 ppm N and 500 ppm each of P and K at fortnightly interval spraying resulted in better growth and flowering. At Yercaud conditions, in *Epidendrum radicans* and *Coelogyne* spp., VAM applied near root zone at the time of planting and foliar application of NPK (10:5:10) @ 0.2% gave best results.

v. Anthurium

Top cuttings, nodal cuttings and suckers can successfully be propagated on 100% cocopeat. Spadix explant could successfully be established after $HgCl_2$ 0.1% for 10 min surface sterilization and culturing on MS medium supplemented with 2, 4-D (2 mg/l) and kinetin (0.3 mg/l) for organogenesis at Vellanikkara. Shading at 75% level responded best. NPK at 30:10:10 or 30:20:20 at 0.2% + GA_3 200ppm + *Azospirillum* + VAM is recommended for commercial cultivation of anthurium.

vi. Tuberose

The varieties Prajwal and Vaibhav have been recorded best at most of the centres, however, the performance of Single type tuberose is recommended for cultivation at different locations. Planting of medium (2.6-3.0 cm) and large bulbs (3.0-3.5 cm) at 20 x 20 cm has been recorded best. However, for early flowering and more flower yield, 45 days rest period is suggested. NPK (200:200:200 kg/ha) is recommended for commercial cultivation.

vii. Gerbera

Pune centre recorded 2-row planting of gerbera cv. Sangria at 30x20 cm spacing under naturally ventilated or tunnel type polyhouses as best though under open conditions, 30x30 cm spacing with 10g/m^2 NPK is recommended. Srinagar centre recorded 15 g N, 15 g P and 10 g K/m^2 as best at 30x20 cm spacing. Pune centre also recommended 100 ppm N, 40 ppm P_2O_5 and 150 ppm K_2O per day along with 10 kg FYM/m^2/year in gerbera cv. Golden Gate under a naturally ventilated polyhouse. They also recorded highest number of flowers in var. Ornella under polyhouse with 15 g N, 20 g P and 20 g K/m^2.

viii. Jasmine

Terminal nodal cuttings in *Jasminum grandiflorum,* and terminal and semi-hardwood in *J. sambac* and *J. auriculatum* are best suited for mist propagation in the sand medium. Most species rooted well when cuttings contained 4 leaves, treated with 4000 ppm IBA and planted in vermiculite. April-September was the best period for taking the cuttings.

Pinching of new shoots produced after pruning delayed flower bud formation by 14 days in *J. Auriculatum* and 17 days in *J. grandiflorum.* Pruning of *J. grandiflorum* in 3rd week of December at 90 cm height retaining 10 shoots was found best at Hessaraghatta. However, instead of pruning, chemical defoliants, *viz*., PCP (pentachlorophenol) 3000 ppm or potassium iodide 4000 ppm were found best. In *J. grandiflorum*, cycocel at 1000 ppm twice (one in the first week of February and 2nd in 1st week of March) increased flower production *vis-a-vis* essential oil content.

Spacings of 1.5 x 1.5 m for *J. grandiflorum var.* White, 50 x 50 cm for *J. sambac* and 75 x 75 cm for *J. auriculatum* were found optimum. However, 1.8 x 1.8 m spacing (3086 plants/ha) was found most economical in case of *J. grandiflorum.*

Coimbatore recommended NP 120:240:240 g/plant in *J. auriculatum* and 100:120:120 along with 10 kg FYM in two split doses (Jan. and July) for 50:15:20 g/m^2 NPK for *J. auriculatum* and *J. sambac*. Coimbatore centre recommended a basal dose of 10 kg FYM followed by Fe_2SO_4 25g + $ZnSO_4$ 4g + 60:120:120 g NPK in two split doses (Dec. and June) in *J. sambac* cv. Gundumalli. They further recommended *Azospirillum* and phosphobacteria along with 75% recommended N and P doses in *J. sambac* cv. Gundumalli and *J. grandiflorum* cv. Co.2. Hessaraghatta recommended split application of N @ 33.5 g/plant/year each in December, April and August, than single application of 100 g/plant/year. Foliar spray can reduce the consumption to its 50%. Application of magnesium @ 40 kg/ha, Zn 5 kg/ha and molybdenum 2 kg/ha has been recommended by IIHR for *J. grandiflorum*.

ix. Bougainvillea

In order to obtain dwarf, bushy and attractive pot plants, eight varieties of bougainvillea were treated with Cycocel and SADH as foliar sprays once at 4000 and 8000 ppm and twice with 8000 ppm. Soil drench with Cycocal was done at 2000 and 4000 ppm once, and twice with 4000 ppm. Considering the reduction of plant height and improvement in flowering, double application of SADH at 8000 ppm as foliar spray was recommended for dwarfing different varieties of bougainvillea in pots. SADH treated plants also produced larger number of axillary branches and flowering shoots (Bhattacharjee, 1972).

x. Crossandra

It is commercially cultivated for loose flowers. Research conducted under coordinated scheme on floriculture at Coimbatore during 1962-67 revealed that application of K_20 did not show any response. There was marked

response to every successive increase in the dosage of nitrogen, while there was. some response only to the highest level of PPs' Iron deficiency chlorosis is a common problem in crossandra on highly alkaline soils. Application of FYM as basal dose, and foliar spray of 1 per cent FeS04 + 2 per cent urea once in every 30 days increased flower yield significantly (Velu, 1988). For increased growth and flowering in crossandra regular application of N, P and K fertilizer along with FYM and $ZnSo_4$ was recommended (Cezhiyan *et al. 1985).*

xi. Aquatic Ornamentals

Lotus (Nelumbo mucifera) : Delayed and low percentage of lotus seed germination is a well known problem. By means of mechanical abrasion of seeds, 100 per cent germination was reported (Singh and Motial, 1969). The time taken for germination was also greatly reduced by this method.

Nymphaea: Large number of cultivars were grown at NBRI, Lucknow and Indian Botanic Garden, Howrah. Their flowering habit, colour and fragrance, duration of flowering and propagating habit have been studied.

xii. **House Plants**

Influence of light intensity, potting media and frequency of watering on different house plants were investigated at Agri-Horticultural Society of India, Calcutta. Light intensity between 8000-10,000 lux improved the growth of *Dieffenbachia* 'Exotica' and *Peperomia obtusifolia* 'variegata' .In case of *Aglaonema costatum, Philodendron erubescens* and *Chlorophytum comosum* 'Variegata' light intensity between 4000-5000 lux yielded the best performance in respect of height of plants, number and size of leaves. Growth of *Monstera obliqua* and *Peperomia obtusifolia* 'Variegata' was best in a media containing~ equal parts of each of loamy soil, leaf mould and coir-dust. While in case of *Dieffenbachia,* 'Exotica' best vegetative growth was recorded in a media containing equal parts of loam~ soil, leaf mould and cow manure. Application of 100 ml water per pot at 1 day interval showed marked improvement in growth of *Monstera deliciosa, Aglaonema* 'Silver Queen' '*Philodendron erubescens*' and *Dieffenbachia* 'Exotica'. In *Calathea zebrina,* however, daily watering was effective in promoting growth (Sharma *et al., 1994).*

xiii. Other crops

In China aster, 30 x 30 cm spacing and NPK 30:30:30 g/m^2 or 300:200:200 kg/ha has been reported best. In marigold, 40x30 cm (83333 plants/ha) for African and 15 x 15 cm for French marigold with a NPK dose of 30:20:20 g/$m^2$is recommended. Pinching at 40 and 60 days after transplanting is also recommended.

1.3.4 Protected Cultivation

In India, experimental evidences on the cultivation of flowers under protected cover are very meager. At CSIR Complex, Palampur (H.P.) an international standard FRP greenhouse was constructed in 1990 to undertake experimental work on ornamental crops. Research on chrysanthemum (Mukherjee, 1991), gladiolus and Sim Carnation (Mukherjee, 1994) have been reported from this Complex. Gill (1984) at PAU, Ludhiana, observed flowers grown under modified growing environment using plastic cover over rose plants during November-February to be of high quality.

Much water has flown from 1990 to till to date. With the advent of globalization of Indian economy and liberalized seed policy the protected cultivation technology made inroads in to horticulture. Private sector played a crucial role in bringing the technology from Israel, Netherlands, France and Belgium. The private industries entered in to buy back arrangements with the leading companies abroad. A large number of state of the art greenhouses were built across the country with public issues floated almost every week. A majority of the units forayed in to rose cultivation owing to high returns prevailing in the international market. Corporate sector played a major role in investment and import of technology and germplasm. Corporate houses including TATA, Birlas, Essar, RPG, MRF, Cadila, Mahyco etc forayed in to commercial cultivation of flower crops mostly for exports. The euphoria generated remained for about 8-10 years with many companies in the Northern India especially around NCR closed their establishments owing to adverse weather conditions during summer and winter. Though the quality of flowers produced were of high standard during winters the same was not true during summer months in

Northern Plains. The economics of cultivation got skewed and the projects became non viable in the Northern Plains. However, the protected cultivation technology became more successful in the southern, western and eastern part of the country. The proactive policies of the Government of India in terms of support to the sector through National Horticulture Mission, National Mission on Micro Irrigation and the National Rural Employment Guarantee Act have further boosted the investment in floriculture. A large number of small and marginal farmers have set up small polyhouses to grow a wide range of crops like chrysanthemum, carnation, gerbera, lilium, alstroemeria etc., Specialty flowers like lisianthus, limonium, rice flowers, corn flower were introduced in Ooty and Kodaikanak belt of the Western Ghats. A number of small clusters for the cultivation of orchids and anthuriums are established by the women self help groups (SHG's) under the Technology Mission on the North Eastern and Himalayan States (TMNE). The region started exporting the blooms to Middle East and UK in recent times.

With the experience gained the floriculture Industry is now represented by committed and serious players. About 50 corporate and individual companies now operate with direct marketing links bypassing the auction markets. Indian flowers find their way to Europe, USA, Australia, Japan, Russia and the Middle East. The need for the research work on protected cultivation arose due to rapid developments in the industry. A number of research projects were initiated in the ICAR and SAU's besides in some of the CSIR organizations. Salient findings in some of the important crops are summarized hereunder.

i. Rose

The exotic varieties of rose namely 'Skyline', 'Nobelesse' and 'Golden Gate' under Pune conditions performed better than the other exotic varieties. HT rose Pusa Gaurav and Floribunda rose Arunima have been found performing well at most of the centers. For commercial cultivation of rose, 400:200:200 ppm NPK/plant/week was recommended.

Application of 300-400 ppm nitrogen, 200 ppm each of phosphorus and potash per week to the plants of rose cv. 'Montezuma' growing under protected conditions was found to be best with regard to number of flowers per plant (56.80) as well as size of flowers under Bhubaneswar conditions. Application of 400:200 ppm NPK in rose cv. 'First Red' growing under polyhouse recorded maximum plant height, number of flowers per plant (40.55) and stem length (80-50 cm).

ii. Carnation

Under polyhouse conditions in Solan, when cvs Impala, Super Star, Veleta and Fantasia were supplied with 4 h extended lighting, induced early flowering with maximum floral stalk. Also they recommended April planting resulting in earlier flowering (160 days) while October planting delayed it (213 days) but gave better stalk length and floral diameter. Also they recommended 'pinch and a half method' for earlier and regulated flowering. Planting at 15 x 15 cm spacing (444444 plants/ha), twice pinching (40 and 60 days after transplanting) and application of NPK @ 30-40:20:10 g/m^2 gave highest yield with nitrogen in 3 splits (basal, one month after and two months after transplanting).

iii. Orchids

Coconut husk was found as the best suitable medium for *Dendrobium* cv. 'Sonia' at Kalyani. In D*endrobium* orchid Sonia – 17, NPK 20:30:30, 10:30:30 or 10:20:20 at 0.2 % spraying twice weekly were recommended for commercial cultivation. The foliar application of N:P:K (10:5:10) @ 0.2% and VAM applied near root zone at the time of planting resulted in best growth and flowering in *Epidendrum radicans* and *Coelogyne* species under Yercaud conditions. BA 100 ppm and GA3 50 ppm in *Dendrobium* cv. Sonia 17 bring about good spike length. 75 % shadenet for *Dendrobium* cv. Sonia-17, was found to ideal.

iv. Anthurium

The plants of anthurium grown under 80% and 75% shade performed better than other shade levels under Vellanikkara, Yercaud and Hessaraghatta conditions. For commercial cultivation of anthurium, 30:10:10 or 30:20:20 NPK at 0.2 % + GA3 200 ppm + *Azospirillum* + VAM were recommended.

1.3.5. Post Harvest Management

i. Rose

Storage of rose cut flower at 4-8^{0}C for 24h followed by simulated transit has been recommended by Ludhiana centre. Delhi centre recommended pre-cooling at 4^{0}C for 24 h for reduction of respiration rate and increasing of vase life of cut roses. Wet stored cut roses, irrespective of the cultivar and temperature, showed increased fresh and dry weight. Ludhiana centre with Raktagandha cut roses, recommended 3% sucrose + 200 ppm 8-HQC + 200 ppm citric acid. Pune found increased vase life of 6.85 days in Gladiator rose when pulsed with 3% sucrose + 300 ppm aluminum sulphate. Further, Pune centre found increased vase life with pre-transit treatment of 3% sucrose + 300 ppm citric acid + 1mM silver thiosulphate. Pulsing of Raktagandha roses with 3% sucrose for 18 h at 20^{0}C, extended the vase life. Ludhiana, Lucknow and Pune found enhanced vase life in cut roses when pulsed with 300 ppm aluminum sulphate + 3% sucrose, followed by holding solution treatment of 300 ppm aluminum sulphate and 1.5% sucrose.

D-fructose at 3% for cv. Happiness, $Al_2(SO_4)_3$ 300 ppm and $MgSO_4$ 150 ppm over 450 ppm of $FeSO_4$ and $MnSO_4$ for Queen Elizabeth roses, among chlorides, $NiCl_2$ at 300 ppm for Sonia Meilland roses, and $AgNO_3$ 100 ppm, L-ascorbic acid 500 ppm and kinetin 2.5 ppm for Christian Dior roses enhanced the vase life. In Super Star, tight buds developed to commercial maturity in vase solution of 250 ppm 8-HQC, 100 ppm acetyl salicylic acid and 1% D-fructose. Super Star pulsed with 0.2 mM STS for 15 min, followed by 300 ppm 8-HQC + 2% sucrose holding solution improved bud opening and longevity. D-fructose 1%, boric acid 500 ppm and $COCl_2$ 250 ppm for Raktagandha; 4% sucrose, 250 ppm $COCl_2$ and 200 ppm 8+HQC for Eiffel Tower, and 100 ppm aspirin and 4% sucrose for rose var. Dr. B. P. Pal, were helpful as bud opening holding solutions.

ii. Gladiolus

Sucrose 15-20% + 8 HQC 200 ppm as a pulsing treatment for 24 h, and sucrose 4% + $Al_2(SO_4)_3$ 300 ppm or NaOCl 50 ppm or 8-HQC 200 ppm as holding solution has been found quite effective for floret opening and vase life improvement in gladiolus. Gladiolus cut spikes treated with 4% sucrose, 300 ppm $Al_2(SO_4)_3$ and 25 ppm sodium hypochloride, stored at 4^{0}C for 0-3 days and subjected to simulated transit for 48 h either wrapped with polythene or polypropelene or cellophane sleeves recorded the highest post harvest life.

iii. Carnation

Treatment with 4mM STS for 15 min at room temperature before pre-cooling is quite effective for improving vase life of cut carnations.

iv. Chrysanthemum

Cut flowers treated with 1.5% sucrose + 200 ppm 8-HQC and packed in corrugated paper showed significant improvement in vase life. Wrapping the flowers in craft paper for 24 h or in polythene for 24-48 h has been recommended. Citric acid 75 ppm + $AgNO_3$ 25 ppm was recorded as the best holding solution.

v. Anthurium

For pulsing, HQ 500 ppm + sucrose 5% for 6 h or BA 25 ppm + carbendazim 0.2% or $Al_2(SO_4)_3$ 300 ppm for 24 h, and for holding solution, $AgNO_3$ 25 ppm + sucrose 5% or $Al_2(SO_4)_3$ 300 ppm + kinetin or BA 25 ppm + sucrose 5% are quite effective for improving the vase life of cut anthurium.

vi. Tuberose

Citric acid 300 ppm + sucrose 2% at 3.6 pH as pulsing treatment, and NaOCl 100 ppm as holding treatment and packaging in polythene for up to 24 h are recommended for tuberose cut spikes.

vii. Gerbera

$Al_2(SO_4)_3$ 300 ppm + sucrose 2% as pulsing and $AgNO_3$ $(SO_4)_3$ 25 ppm as holding solution increased the vase life in gerbera var. Thalassic and Lyonella.

1.3.6 Crop Protection

i. Rose

Pune centre through epidemiological studies recorded severe powdery mildew in rose during November to March. This centre recorded good control of disease by spraying with 0.02%. Sulfex or 0.5% Karathane or 0.1% Bavistin immediately after pruning and thereafter 2 more sprayings at 10 days interval in cv. Gladiator. However, 0.05% Dinocap/Tridemorphs at 10 days intervals, or 0.05% Difencanozole, Hexaconozole, and Pencanozole were also effective.

Leaf spot at Pune condition was found severe during June to October which was effectively controlled to a tune of 65% with 0.2% Captan or Mancozeb or copper oxychloride or 0.1% Benlate sprayings 6 times at 10-days interval with cv. Mabella. Die-back in rose cv. Mabella at Pune centre was controlled to a tune of 60% with 3 sprayings of 0.2% Captan 50 WP, starting immediately after pruning and then after 10 days. Against *Botrytis* grey mould, 0.2% Kavach was found quite promising.

Hessaraghatta recorded 1.0 kg a.i./ha of carbofuran at 5-10 cm depth of soil quite effective against red scale. Three applications of Monocrotophos and Phosphomidon controlled aphids at Pantnagar. Bangalore found Vertimec or Polo or Mitec at 0.5 ml/l or 1% Jatropha oil promising against mites. For thrips, Dimethoate or Methyl-o-demeton or Chlorpyriphos were effective. Against caterpillars, Hessaraghatta recorded 0.05% methyl parathion or chlorpyriphos very promising. Neem kernel extract (4%), 0.05% methyl parathion, oxydemetonmethyl and 2% neem oil sprayed fortnightly, effectively controlled thrips, caterpillars and beetles of rose at IIHR.

ii. Gladiolus

Captaf 0.03% controlled gladiolus corm rot effectively in the vars Melody and Sancerre. Before planting and after lifting of corms, 10-15 minutes dipping in 0.3% Captan or Thiram or 0.2% Emisan-6, mancozeb or Benomyl, followed by drenching/month in the standing crop, controls *Fuarium* wilt effectively, as well as storage rot. HWT at 50-55^{0}C is also effective. Kavach or Dithane M-45, each at 0.2% controls *Botrytis* grey mould in gladiolus. Bio-agent, *Trichoderma harzianum* is also useful against corm rot disease in gladiolus.

iii. Carnation

Ludhiana centre found spray of 0.3% Blitox or Captan or 0.2% spray of Foltaf or Dithane M-45 quite effective against alternaria leaf spot/blight of carnation, and Kalyani centre obtained promising results with Bordeaux mixture, followed by 0.02% Benomyl or 0.03% Captaf, and Bavistin + Captaf against *Fuarium* wilt in carnation.

iv. Chrysanthemum

Six sprays of 0.02% Chlorothanonil or Mancozeb fortnightly after disease incidence, control the leaf spot diseases of chrysanthemum (*Alternaria, Colletotrichum* and *Septoria*). Sprayings seven times of 0.2% copper oxychloride or mancozeb + 0.1% sticker, at 10 days interval from June to October has been recommended for the control of leaf spot diseases. Bavistin 0.1% or Difoltan 0.3% or Daconil 0.2% spraying monthly controls *Septoria* leaf spot which is a serious disease under Bangalore and Kalyani conditions.

v. Tuberose

Brassicol powder (30%) at 30 kg/ha against stem rot (*Sclerotium rolfsi)*; *Iprodene* (0.025%), followed by Difencanozole (0.05%) sprayings at Pune conditions against leaf blight; and against all the diseases at Kahikuchi conditions, 0.01% Carbendazim + 0.02% captan and 40g/m^2 Basamid G reduced the disease incidence significantly. *Trichoderma viride* 20g/m^2, followed by carbendazim 0.01% + Captan 0.02% had been found reducing *Sclerotium* wilt of tuberose significantly at Pune conditions.

vi. Gerbera

Pune centre controlled gerbera leaf spot/blight with 0.01% Benomyl, followed by 0.02% Kavach and 0.05%

Difencanozole while Kahikuchi centre recorded a good success by spraying the gerbera plants with 0.03% copper oxychloride, followed by 0.02% Mancozeb against gerbera leaf spot/blight. Benomyl 0.01% + Captan 0.02%, followed by Benomyl 0.01% and *Trichoderma viride* 20 g/m^2 has been found effective against gerbera foot/root rot.

1.3.7. Registration of Varieties

The Division of Floriculture and Landscaping, IARI is an International Registration Authority of Bougainvillea. Three hundred and twenty three (323) cultivars of bougainvillea were described and a checklist was published. Among many varieties developed at IARI, a unique cultivar Vishakha (Pink) with variegated leaves became very popular for garden display purpose among the garden lovers.

1.3.8. Value Addition

The demand for value added products in the country has increased enormously. India enjoys a significant position in the global trade of dry flowers. Nearly 60% of the export of floricultural produce comprise of dry flowers. The dry flowers are used in many more value added products like floral gifts, pot pourries, floral crafts, greeting cards, photo frames, book marks etc., The dry flower sector attained the proportion of an Industry in Tamil Nadu (Tuticorin, Thichy) and West Bengal (Kolkotta).

1.4. The AICRP on floriculture has brought out a number of useful publications over the years. Important publication are summarised in Table 6.

Table 6. List of Publications from AICRP on Floriculture

Si. No.	Year	Title
1.	1999	Research Highlights (1971-85)
2.	1999	New Varieties of Flower Crops
3.	2001	Post-harvest Management of Cut Flowers
4.	2001	Chrysanthemum
5.	2001	Vistas in All India Coordinated Research Project on Floriculture
6.	2001	ChinaAster
7.	2002	Gladiolus
8.	2002	Carnation
9.	2002	Agro-techniques for Flower Crop Production
10.	2002	Jasmine
11.	2002	Anthurium
12.	2002	Plant Protection in Ornamental Crops
13.	2002	Collection, Maintenance and Evaluation of Flower Crop Germplasm.
14.	2002	Tuberose
15.	2002	Orchids
16.	2002	Passport Data of Flower Crop Germplasm
17.	2002	Floriculture Directory
18.	2007	Rose
19.	2007	Indian Varieties of Flower Crops

Si. No.	Year	Title
20.	2007	Gerbera
21.	2009	Temperate Orchids
22.	2010	Production Manual on Tuberose
23.	2010	Floriculture in West Bengal: Scope and Opportunities
24.	2010	The Genesis of Directorate of Floricultural Research
25.	2011	Marigold
26.	2011	Prospects of Floriculture in Andhra Pradesh
27.	2013	Post Harvest Technology of Cut Flowers
28.	2013	Quality Rose Production under Protected Condition
29.	2013	Status of Floriculture in Maharashtra
30.	2014	Seed Production of Annual Flowers
31.	2014	Status of Floriculture in Punjab
32.	2014	Dehydration of Flowers and Value Addition
33.	2015	Disease and Pest Management in flower Crops under Polyhouse
34.	2015	Present Status and Prospects of Floriculture in Jammu and Kashmir
35.	2015	Lawn Management
36.	2015	Daffodil
37.	2015	Database on Rose
38.	2015	Database on Tuberose (*Polianthes tuberosa* Linn.)
39.	2015	Lilium
40.	2015	Database on Gladiolus
41.	2015	Present Status and Prospects of Floriculture in Tamil Nadu
42.	2011	Vision 2030
43.	2015	Vision 2050
44.	2016	Phytoplasma Diseases in Horticultural Crops: Current Scenario and Future Challenges

1.5. A number of varieties belonging to different crops were evaluated and released during previous workshops, some of important varieties released through AICRP are summarised in Table 7.

Table 7. Number of varieties released through AICRP on Floriculture

Si. No.	Crop	Variety	Centre
1	Gladiolus	Aka Amar, Arka Kesar, Solan Mangla, Phule Ganesh and Phule Neelrehka	IIHR, Hessaraghatta, Bengaluru
2	Tuberose	Phule Rajani, Prajwal and Vaibhav	MPKV, Pune
3	Chrysanthemum	Anmol, Royal Purple, Yellow Delight, Autumn Joy, Garden Beauty Winter Queen and Solan Shringar	PAU, Ludhiana

Chapter 2
Standard Operating Procedures

2. Standards for Experimental Layout

Layout of an experiment is the basic and foremost important operation in any testing program and it should be implemented with care and precision. It involves field selection, preparation, layout, planting, harvesting, etc. The land should be well prepared and made suitable for planting of flowering plants. The steps in the layout of the field experiments are as below.

1. Establish a base line using Pythagoras theorem, so that the four corners of the trial have right angles, mark the plot and assign different treatments to different plots randomly. Randomization assures the unbiased estimates of treatment means and experimental errors.
2. Replicate the treatment in different blocks. The number of replications is to be decided based on number of treatments, size of the experiment etc. Block is a unit containing the complete set of treatments as per statistical designs of the experiment and it should be ensured that plots within a block are homogenous in all aspects such as fertility, soil type, etc
3. Fertilizers as per requirement should be mixed and placed in rows marked as per spacing for the region/variety
4. Selection of uniform healthy planting material as per standards/ as per objectives of experiments.
5. Seedlings/planting material should be planted at standard planting depth.
6. Complete planting in one replication or block if it is not possible to plant complete planting of the whole experiment in one day.
7. Provide at least two border rows on either side and at least two border plants at the end of the row.
8. Irrigate when ever required as per the nature of experiment and climatic conditions.
9. Weeding and other cultural practices may be followed as per nature of experiments. Information of weedicides used to control weeds in other that weed control experiments may be furnished with reports.
10. While planning experiments in respective crops the DUS guidelines should be taken in to consideration for growing conditions and taking observations.

2.1 Standards for Data Collection

The success of experimental trial is dependent on the type, accuracy and precision of data collection.

1. The time of collecting data depends on the kind of traits. The observations must begin at the earliest and must continue till 50% population of each plot represents the trait to be recorded.
2. Standard botanical nomenclature should be used while taking the observation as per mentioned in technical programme.
3. Data should be collected by the technical expert and in stipulated time.

4. Morphological observations should be taken as per DUS guidelines wherever possible.
5. Morphological observation made too early or too late, may give wrong impression of data and result in wrong conclusion.
6. Data should be collected only on experimental plants and not on border rows and plants after proper labeling.
7. Foliar diseases scoring must be timed accordingly to the epidemiology of the disease.
8. Experimental data should be digitized wherever required.
9. Good quality photographs should be taken as a supporting evidences as per objectives of experiment.
10. Photographs must be taken at the most appropriate stage representing the characters to be documented instead of general views.
11. All the photographs must have proper legends and numbers which should be reflected in the text at appropriate place.
12. The complete details of such as net plot area, dates of sowing and harvesting, production/protection practices carried out etc. should be recorded. Where ever it is possible, record GPS locations of the plots.

Experiments on flower crops under the AICRP trials are broadly categorized under five categories namely

1. Germplasm Conservation and Evaluation
2. Crop Improvement
3. Crop Production
4. Crop Protection
5. Post Harvest Management and Value Addition

The section wise standard operating procedures are presented in the following chapters .

Chapter 3
Germplasm Conservation and Evaluation

3. Germplasm Conservation

Over the years the AICRP centres have collected a large number of germplasm in mandated crops. The newly collected germplasm is regularly evaluated and the passport data is generated. The salient features of maintaining proper germplasm are highlighted in this chapter.

3.1. Collection, Evaluation, Maintenance of Germplasm

i. Germplasm collection must be restricted to named varieties/species only from authentic sources, but in case of promising lines/accession, accession number may be maintained.

ii. Passport data of the existing and new collections must be prepared by the centres and should be sent to the Director, ICAR-DFR, Pune.

iii. The passport data should include name of species/variety, parental details, year of release, country of origin, name of the breeder, form and colour, source and date, salient features, remarks, name of the person who has collected the variety and a photograph at the right stage.

iv. Observations should be recorded on randomly selected ten healthy plants leaving the border plants.

v. Germplasm can be grouped into:

Trait specific flower production- Loose flower, cut flower, garden decoration/display, etc.

Potential for breeding- Good seed set, good seed germination, resistant to powdery mildew, resistant to black spot, resistant to thrips, etc.

vi. Efforts should be made for collection of different species and varieties.

vii. The concerned scientists are advised to maintain passport data of newly collected varieties/lines and obtain the IC / EC number from ICAR-NBPGR, New Delhi (a proforma of application is appended at Annexure I)

viii. The concerned scientists may take the help of ICAR-NBPGR, New Delhi for obtaining/ introducing cut flower varieties from abroad (Annexure I).

ix. The recipient organization has to enter in to a Material Transfer Agreement (MTA) as per the format (Annexure II)

x. The flower's colour should be recorded as per RHS Colour Chart.

Annexure I

Requisition for obtaining of seed/ planting material for research from/ through NBPGR, New Delhi

1. Details of seed/ planting material required for research

S No.	Botanical name	Crop name	No. of accessions (IC/EC)	Seed Quantity (per accession/ per sample)	Purpose (screening/breeding/evaluation augmentation/multiplication)

2. Thesis/ Project title for which request is made: _____

_____

3. Objective / Activity for utilization of indented material: (Please attach sheet if required): _____

_____

_____

4. Material Transfer Agreement (enclosed): Yes/ No

5. Feedback report submitted on germplasm received earlier (if applicable): Yes/No

6. Have you or your Institute developed any variety based on germplasm supplied by NBPGR? Yes/No (If yes, please let us know the details)

7. If required by NBPGR, will you be able to send viable multiplied seed material of the above seed in sufficient quantity for conservation: Yes/No

8. Signature of the indenter:

   Name: _____ Designation: _____

   Address of the Institute _____

   _____

   Phone (with STD code) _____ M _____, Fax _____, E-mail _____,

9. Signature of the Competent Authority with seal: _____

   (PI/ Head of the Department / Director of the Institute)

To be sent on following address
To
The Director
National Bureau of Plant Genetic Resources (NBPGR)
Pusa Campus, New Delhi-110 012
Ph:011-25843697, 25841129 ; Fax: 011-25842495
E mail: : exchange@nbpgr.ernet.in; director@nbpgr.ernet.in

Annexure II

MTA Format
Indian Council of Agricultural Research
Krishi Bhawan, New Delhi – 110001. INDIA

Agreed between

National Bureau of Plant Genetic Resources (NBPGR), New Delhi-110012 of the Indian Council of Agricultural Research, Krishi Bhawan, New Delhi – 110001, the apex agricultural research organization of India, being the first Party (Provider of the Material)

Being the Second Party (Recipient of the Material) For the Supply/Exchange/Transfer of Genetic Resources for Food & Agriculture/ Germplasm / Genetic Material/ Genetic Components for Research2

- Within India, not covering persons as described in Section 3(2) of the Biological Diversity Act, 2002 (18 of 2003) (BDA).
- Within India, wholly or partly covering persons as described in Sec. 3(2) of BDA.
- Outside India, with Members of the International Treaty for Food and Agriculture (ITPGRFA), and wholly or partly covering persons as described in Sec. 3(2) of BDA.
- Outside India, with Non-Members of ITPGRFA, and wholly or partly covering persons as described in Sec. 3(2) of BDA.

AS follows:

Recipient Name	
Recipient Institution/	
Organization/ Agency/	
Centre	
Recipient Full Address with	
PIN Code	
Phone number	
Fax	
Email	
Nature of activities	
Germplasm material (specify)3	Crop and varieties
Supply made through	NBPGR
For Official Use of Supplier	1. Germplasm Identity (Species name, common name, etc.) 2. Accession Number 3. Short Description of the Material 4. Passport Data

1 Mention Name and address of the Second Party
2 Tick mark the appropriate box
3 Specify the type of material involved for supply/transfer e.g seed, tissue culture, DNA etc.

I/We agree to abide by the following terms of the MTA and certify that:

i. The germplasm MATERIAL (S) transferred herein as above shall be used only for the purpose of research under my/our direct/close supervision and will not be used for commercial purposes or profit making whatsoever, without prior written approval of the BA4/MoEF5/DARE6/ICAR7, Government of India as the case may be. The importer/recipient (Second party) agrees to provide a concept note of research project in which the MATERIAL (S) will be used, including the manner in which to be used. The importer/recipient (Second party) agrees to cease any use of the material in case of suspension of research project at the instance of either party or due to factors beyond the control of either party. Upon such suspension of further research work, both parties will mutually agree for adopting a suitable provision for their preservation. In case of failure of the parties to arrive at an agreement, the materials including derivatives will be destroyed upon 90 days notice from NBPGR.

ii. All information and material supplied by NBPGR shall be deemed to have been disclosed or provided to the recipient in confidence. The recipient agrees to preserve the confidential status of the material and information.

iii. The germplasm MATERIAL (S) or its (their) part(s), components or derivatives (including live or dead tissue/DNA) that can be used to retrieve whole DNA/fragment or sequence or any other genetic information shall not be distributed or transferred to any third country/party, except those directly engaged in research under direct supervision of the recipient (second party), without prior written approval of the NBA/MoEF/ICAR/DARE, Government of India as the case may be.

iv. Any development of commercial product based on research on gene manipulation/selective breeding programme for genetic improvement shall not be undertaken without written consent of NBA/MoEF/ICAR/DARE, Government of India as the case may be. Modalities of undertaking any such work will be worked out before its conduct.

v. If any third country/party is to be associated with any commercial development arising out of the germplasm accessed, permission from NBA shall be sought.

vi. The recipient agrees to acknowledge explicitly the name, original identity and source of the material, if used directly or indirectly, in all research publication(s) or other publications, such as, monographs, bulletins, books, etc. and shall send a copy of each of the publications to the NBPGR.

vii. The recipient agrees to supply the feedback information on the performance/utilization/ research outcome of the material(s) to the NBPGR.

viii. The recipient agrees not to claim any intellectual property right over the MATERIAL (S) received including its related information and knowledge without prior written approval of the NBA/MoEF/ICAR/DARE, Government of India as the case may be.

ix. The intellectual property protection or benefit sharing in respect of derivatives of the material(s) received/accessed, where applicable, shall be as per the Indian IPR/Biodiversity laws.

x. The recipient agrees to hold the entire responsibility for the quarantine/SPS clearance of the material accessed as specified herein above. The recipient shall abide by the biosafety guidelines of ---------- ---------- (Name of the importing country/ organization) and shall not hold NBPGR/ICAR/DARE, Government of India responsible for any identity/ quality/ viability/ purity/ quarantine/ biosafety related or any other related matter/hazard that may be attributable to the release of genetic material/ resource accessed as specified in this Agreement. The recipient agrees to hold entire responsibility for the importer/ indenting country's biosafety and other related hazards due to release of genetic material. The recipient agrees waive all claims against NBPGR/ICAR/DARE, Government of India and to defend and indemnify them from all claims and damages/recoveries arising from the use, storage or handling of the material.

xi. The recipient also agrees that the material is for experimental use and is being supplied without any warranties, whatsoever.

xii. The MTA is non-assignable. The recipient agrees to abide by any other conditions that may be set in and conveyed to them from NBPGR in respect of this germplasm access/exchange or any Law, Rules, Regulations, etc. enacted by Government of India from time to time.

xiii. In case of any dispute between the parties to this MTA, the dispute shall be referred to the Sole Arbitrator to be appointed by the Secretary, DARE, Government of India. The Decision of the Sole Arbitrator shall be final and binding on the Parties. The Arbitration proceedings shall be governed by the Arbitration and Conciliation Act, 1996. The Arbitration proceedings shall be in New Delhi.

Agreed Recipient	**Provider**
Authorised Officer's Name:	Authorised Officer's Name:
Designation:	Designation:
Organization/Institute/University Address:	Organization/Institute/University Address:
Signature: Date:	Signature: Date:
Recipient Scientist/Person's Name:	Provider Scientist/Person's Name:
Designation:	Designation:
Organization/Institute/University Address	Organization/Institute/University Address:
Signature: Date:	Signature: Date:

Definitions

Extract from Section 3(2) of BDA-2002-

a) a person who is not a citizen of India;

b) a citizen of India, who is a non-resident as defined in clause (30) of Section 2 of the Income-Tax Act, 1961 (43 of 1961);

c) a body corporate, association or organization-

(i) not incorporated or registered in India; or

(ii) incorporated or registered in India under any law for the time being in force which has any non-Indian participation in its share capital or management.

4 National Biodiversity Authority

5 Ministry of Environment and Forests

6 Department of Agricultural Research and Education

7 Indian Council of Agricultural Research

Chapter 4

Crop Improvement

4. Crop Breeding

Ever since its inception in 1971-72 the AICRP on Floriculture contributed a large number of varieties which are well accepted by the farmers. Research work on breeding of ornamental crops at present is restricted to the evaluation of new promising varieties/lines/genotype that are developed in the national agriculture research system. This chapter dwells about the procedures to be adopted for breeding as well as evaluation of new genotypes.

4.1. Varietal Development and Selection of Varieties/Hybrids for Proposing in AICRP (F)

4.1.1. Selection of Parents

The novelty is the most important criteria in the breeding programme of ornamentals. Therefore, breeder has to take lot of care while selecting the parents in breeding programme. The choice of parents in hybridization depends on the objectives of the breeding programme. Breeders prefer to work with parents having wider adaptability, good agronomic attributes, tolerant/resistant to various biotic/abiotic stresses, high multiplication rate, etc. Since most of commercial ornamental can be propagated vegetatively there is lot of scope to harvest the heterozygocity obtained in F1 generation itself. Therefore, selection of parents in breeding of ornamentals is foremost important criteria for successful breeding programme.

Important points for consideration

1. Presence of trait of interest in at least one of the parent.
2. Genetic divergence among parents to produce heterotic effects using genetic distance for planning crosses with ideal parent.
3. Agronomically adapted with wider coverage with novel colour and flower from can be the better parents for breeding of varieties.
4. Good general combining ability of parents for trait of interest, biotic and abiotic stress resistance characters should be identified.
5. Seed and pollen parents should be identified based on the trait of interest, flowering and seed setting
6. Planting of parents should be done as per the objective of experiment.
7. All the cultural practices should be followed as per the objective of experiment.
8. Hybrid seeds should be harvested, processed, packed and stored properly.

Annexure III

Proposal for Multi-Location Testing of Technology under AICRP (Floriculture)

The technologies/varieties developed at various AICRP centres need to be validated across the centre for its viability/performance. The centre should send the technology for testing through The Director, ICAR-DFR with complete proposal in following form.

Proposal for Multi-Location Testing of technology under AICRP (Floriculture)

1.	Name of the crop with botanical name	
2.	Name of technology proposed	
2.	Name of the technology proposed	
3.	Name of the leader proposing the technology	
4.	Name of the scientist(s) responsible for the development of the technology	
5.	Name of the project in which the technology was generated	
6.	Objectives	
7.	Duration for testing of technology	
8.	Brief description of the technology/ product/ process (indicating background information namely existing technology and alternatives and the highlights of the present technology).	
9.	Methodology for testing of new technology	Annexure
10.	Specific/ practical utility of the new technology (support with experimental results/data)	Annexure
11.	Novelty of the technology	
12.	Benefit Cost Ratio of the technology	
13.	Likely impact of the technology	
14.	Likely beneficiaries of the technology (end users)	
15.	Any other pertinent information	
16.	Was the proposal discussed in IRC or other reviewing authority? If yes what was the decision?	

Signatures of the scientist	:	
Signature of the Divisional Head	:	
Signature of the Director (ICAR based Institutes) Director Research (SAUs)	:	

Remarks of Project Coordinator

Experimental details*

1.	Name of the technology to be demonstrated	:	
2.	Objectives	:	
3.	Zones/regions of the country where it can be tested	:	
4.	Experimental material (as per objective of testing)	:	
5.	Number of treatments	:	
6.	Treatment details (treatments indicated should be justified with published reference)	:	
7.	Design	:	
8.	Replications	:	
9.	Plants /treatment	:	
10.	Varieties to be used (any specific varieties or leading local variety)	:	
11.	Observations to be recorded (Parameters with SI units)	:	
12.	Any other information	:	

***The scientist is requested to propose experimental details for testing of the particular technology. The experiment will be finalized in the annual group meeting of AICRP on Floriculture in accordance with the suggestions.**

Letter of Undertaking

Name of the Scientist…….(Designation)…….....working in the organization…….authorized.....by the organization to give entry name…….. in trial.....under MLT.

It is assured to supply the planting material of above entry as per the schedule for evaluation purpose.

Name of the Scientist	
Designation	
Organization & full address	
Email	
Mobile	

Name of the Head of the organization	
Centre (Authorized person)	
Designation	
Organization & full address	
Email	
Mobile	

Annexure IV

Proposal for identification of varieties during the annual group meeting by the committee Introduction (Brief note on the new proposal)

- Importance of the crop, present problem and status
- Objectives for development of new variety/ hybrid
- Brief note on the methodology followed for development.

Proforma for submission of proposal for identification of varieties/hybrids of flower crops

1	Name of the crop with Latin name	:	
2	a) Name/code/designation under which tested b) Proposed name of the variety		
3	Proposed by a) Centre/Department/Division responsible for developing variety (with address)	:	
	b) Name of Scientist (s) responsible for the development of variety	:	1 2 3 4
	c) Names of Collaborator(s)	:	1 2 3 4
	d) Year of submission		
4	Project in which variety developed		
	a. Breeding Objective	:	
	b. Breeding Method	:	
	c. Parentage with details of its pedigree	:	
	d. Source of Material in case of introduction	:	
5	State the varieties which most closely resemble the proposed variety in general characteristics	:	
6	Description of variety		
	a. Plant height	:	
	b. Distinguishing morphological characteristics	:	
	c. Characteristics different from those of the parents	:	
	d. Maturity (range in number of days from sowing to green harvest.	:	
	e. Maturity group (early medium and late) wherever such classification exists	:	
	f. Reaction to major diseases under field and controlled conditions	:	
	g. Reaction to major pests (Under field and controlled including store pests)	:	
	h. Agronomic features (e.g. resistance to lodging, shattering, fertilizer responsiveness, suitability for early or late sown conditions, seed rate, etc.)	:	

	I. Growing environment i. export (under protected conditions) ii. domestic (under protected conditions/low cost poly house) iii. domestic (under open field conditions)	:	
	j. Quality attributes/purpose for which recommended i. Cut flower ii. Loose flower iii . Pot culture iv. Garden decoration		
	k. Reaction to environmental stresses	:	
	l. Kind of root stock to be used, if applicable	:	
7	Description of parents of variety	:	
8	Yield data in experimental station trials (levels of fertilizer application, density of plant population and superiority over local control/standard variety to be indicated)		
9	Premium attributes of new variety	:	
10	Scientist/ Division responsible for maintaining breeder seed/planting material		
11	Quantity of breeder seed/bulbs/cuttings, etc in stock.		
12	Information on the acceptability of the variety by farmers / consumers / industry attach data generated on these aspects		
13	Specific recommendations, if any, for seed/planting material production		
14	Any other pertinent information	:	
15	Vivid presentation with the help of photographs of the variety to be submitted by the Breeder:		
16	Likely beneficiaries of the new variety	:	
17	Likely impact of the new variety	:	
18	Whether the new variety/ hybrid can be protected under PPV and FRA, if so pl indicate DUS characters		
19	Signature of Scientist (s) who developed the new variety/ hybrid	1 2 3 4 5	
20	Recommendations by the Head/Officer-in-Charge of the centre of AICRP on Floriculture		
21	Recommendations by VIC Directorate of Floricultural Research College of Agriculture Campus Shivajinagar, Pune		
22	Approval by VIC Member Secretary (VIC)		
23	Approval by Director Director, ICAR-Directorate of Floricultural Research College of Agriculture Campus Shivajinagar, Pune		

Chapter 5
Crop Management

5. Crop Production

Experiments on crop management involve evaluation in terms of their productivity, resource use efficiency, complementary use of resource, benefit cost ratio etc. The data on yield, nutrient uptake by the different crops and the cost of input and output are used to calculate various efficiencies some of which are listed below. The research work at AICRP centres resulted in a number of useful recommendations in mandated crops. This chapter highlights the producers to be adopted for conducting experiments on production technologies.

5.1. Nutrient Management

Studies on nutrient management aim at determining the dose of nutrient to be applied to ensure a given uptake of the nutrient for a proportionate increase in yield and quality of flowers. This would involve determining the nutrient present in the soil, the proportion of nutrient taken up from the present in the soil, the dose of nutrient added and the proportion taken up from that applied. Therefore, nutrient management studies would require proper sampling of the soil as well as plant so that their chemical analysis would give reliable result.

5.2. Collection and Preparation of Soil Samples for Analysis

- ✓ Only a minute fraction of huge soil mass of the field is used for the analysis in the laboratory to find out the relevant physical and chemical characteristics. Therefore, for collecting soil samples the following aspects should be considered carefully.
- ✓ The soil sample collected should be representative of the area sampled.
- ✓ Variation in slope, colour texture, crop growth and management should be taken into account and separate sets of composite sample should be collected from each of such area.
- ✓ Recently fertilized plots, bunds, channels, marshy tracts and spots near tress, wells, compost or FYM/piles or other non representation location must be carefully avoided during sampling.
- ✓ Soil sampling should be done well in advance and not just before planting.
- ✓ Ten to fifteen sub samples of approximately equal weight should be drawn in a zig zag pattern from an apparently homogenous plot. However, where the area within the field looks different in appearance or topography, divide the field into parts and take a sample of each portion (Constituting a sample unit) separately.

5.2.1. Sampling Procedure

- ✓ To obtain a composite sample, small portion of soil are to be collected up to a desired depth. Generally the samples may be drawn to plough depth (0-15 cm) by means of suitable sampling tools from at least 10-15 spots after scrapping of the surface litter, if any.
- ✓ For sampling soil, the tube auger, spade or khurpi is quite satisfactory. If a spade or khurpi is used, a V shape cut may be made up to plough layer and a uniform 1.5 cm thick slice is taken out.

- ✓ The soil collected in this manner should be thoroughly powdered and mixed by hand on a clean piece of cloth or polythene sheet or thick paper. The bulk is reduced by quartering and about 500 g of the composite sample is retained. The soil must be quickly dried in shade at room temperature and put in cloth or polythene bags with suitable description and identification marks.

5.2.2. Preparation of Sample for Analysis

Drying: Samples are generally air dried (25-35°C), at low relative humidity and stored. Results of soil analysis are expressed on oven dry weight basis. This necessitates determination of moisture percentage by drying a small quantity in an oven at 105°C for 2 hours.

Sieving: Field moist samples prior to drying can be made to pass through a 6 mm sieve (about 4 mesh per inch) by rubbing with fingers. Soils in the right moistures condition can even be passed through a 2 mm sieve (about10 meshes per inch)

Mixing: Samples should be thoroughly mixed by rolling procedure. Placed the dried and sieved sample on a piece of cloth. Grasp the opposite corners and then holding one corner down pull the other corner across the sample. Now the process is repeated in the reverse direction. Use the other two corners and roll the soil from one corner to another repeatedly. Continue this until through mixing is assured.

Storing: Store the soil in paper carton (soil sample box) using a polythene bag as an inner lining

5.3. Plant Sampling and Sample Preparation

5.3.1. Sampling Technique

- ✓ In plant sampling every alternate row should be sampled in small plots and in big plots every 5^{th} to 50^{th} row (depending upon the size of field) should be sampled. For small experimental plots (100sq m) about 10 plants would serve the purpose but for bigger field about 25-50plants should be collected. It is always advisable to collect a larger sample in the field and reduce it in the laboratory as it helps in getting a representative sample. For working out the plant nutrient uptake by crop, entire plants are to be sampled. Different tissue should then be separated (their dry weight must be recorded) and analysed separately.

5.3.2. Sample Preparation

- ✓ After sample collection, the fresh tissue should be decontaminated from dust and other foreign material.
- ✓ The fresh tissue should be washed in sequence in detergent solution (0.2% teepol), and then in dilute HCL (0.1N) and finally with demonized water. The liquid detergent will remove waxy coating on leaf surface and soil particles. N/10 HCL will remove metallic contaminants and demonized water will wash the previous two solutions. The extra moisture is wiped out; the sample is placed in new paper bags and dried in oven at 60+5°C.

5.3.3. Nutrient Uptake

- ✓ Stems sections should be cut into small piece (5mm size), mixed and a 100g sample is drawn and dried at 60+5°C for approximately 48 hours for working out the water content and nutrient analysis.

5.4. Water Management and Irrigation Scheduling

Experiments on water management aim at determining the water content of soil, the amount of water taken up by the plants, water use efficiency etc. Therefore, such studies involve periodic soil sampling and estimation of soil water content.

5.4.1. Soil Moisture Content Estimation Procedure

Soil samples are collected by tube or auger from a number of points (0 – 15 cm) within the experimental site and mixed thoroughly. The composite sub samples of about 50 g to 100 g of soil are placed in moisture cans and closed with tight fitting lids. The moist samples are weighted immediately after bringing to the laboratory and dried to constant weight in an oven at 105 to 110°C (for about 24 hrs) and reweighed after colon in desiccators. The calculation of the soil moisture content is done by determining the loss in weight on drying and the weight of the oven dry soil as follows.

Soil moisture content by weight (%) =Weight of wet soil+tare)-(Weight of dry soil+ tare)/(Weight of dry soil +tare)-(tare)*100

MW(%)=Loss in weight on drying /Weight of oven dry soil*100

The soil moisture content is estimated before each irrigation in case of irrigated crop.

Water Use Efficiency

- ✓ The water use efficiency is computed by dividing yield with total water applied (cm)
- ✓ In water management studies the water content in the plants is also is estimated as below.

Relative Water Content (RWC)

- ✓ The relative water content of leaf should be estimated using physiologically active leaves.
- ✓ 25 leaf discs of one cm diameter is cut using punching machine and their fresh weight is recorded.
- ✓ The leaf discs then immersed in water at constant temperature for 4 hours. Then, the turgid weight of the discs is recorded.
- ✓ The leaf discs should be oven-dried in hot air oven for 8 hours at 80^0 C, and the dry weight of the discs is finally taken
- ✓ Using the formula proposed by Barrs and Weatherley (1962), the RWC is estimated and the values are expressed in percentage.

  RWC = {(fresh weight – dry weight)/ (turgid weight – dry weight)} × 100

5.5. Weed Management

Weeds compete with the crop for space, nutrient and water. Therefore, it is necessary to estimate the competition offered by weeds in weed management trails. In such studies weed number and dry weight of the weeds is recorded and those samples can then be analyzed for their nutrient content to compute the competition for nutrients by the weeds.

5.5.1. Weed Number and Dry Matter Estimation

Weed population is estimated by using a quadrate of 50 × 50 cm^2 or 25 × 25 cm^2. The quadrate is thrown randomly at different number of places in a plot (depends upon size of field and weed incidence). Weeds of different species are counted and uprooted. For nutrient uptake estimation, preparation of sample is done in the similar way as for the leaf tissues detailed elsewhere in the manual.

5.6. Standardization of Potting Media Components for Potted Plants

- Treatments should be fixed by considering all possible combinations of different potting media components with appropriate control.

- Media components should be mixed in bulk. Weighed, recommended dose of fertilizers of N, P and K should be added and well mixed into the potting media. Then seedlings of plants under test should be transplanted to pots.
- Potting media components should be analyzed for physical parameters such as bulk density and maximum water holding capacity and for chemical parameters pH, EC, OC, Total N, P, K, Ca, S, Fe, Cu, Zn and Mn.
- Plant observations *viz*., plant height (cm), number of branches per plant, plant spread (cm) (North-South) and (East-West), days taken for flowering, duration of flowering (days), number of flowers per plant should be recorded from the onset of reproductive phase until 50% withering of flowers.
- pH and EC of potting media should be recorded fortnightly starting from one month after the plant establishment.
- At the end of experiment, fresh and dry weight of plant at harvest (g), root length (cm) and root weight (g) at harvest should be measured.
- After harvest, plant samples and media will be analyzed for total N, P, K, Ca, S, Fe, Cu, Zn and Mn contents.
- Differences among the treatments should be analyzed using ANOVA.

5.7 Nutrient Omission Trials

Soil and plant analyses are commonly performed to assess the fertility status of a soil. However, the analytical results do not indicate the most limiting nutrient according to Liebig's law of the minimum "the minimum nutrient is the factor that governs and controls growth and potential yield of crop". An omission pot trial provides a visible order of crop response to nutrient availability.

5.7.1 Pot Experiments

- A representative soil sample has to be collected from the field in which crop response to applied fertilizer was not observed. Soil sample should be analyzed for all physical and chemical parameters including lime.
- The common treatments for a nutrient omission trial are All, control, -N, -P, -K, -Mg, -S, -Zn, -Cu, -Fe, -Mn, -B and –Lime.
- Soil pH should be adjusted to 6 using $Ca(OH)_2$, except the –Lime treatment sample and then filled into the pots and incubated for two weeks.
- Test crop has to be sown in the pots. According to the test crop, sufficient amount of all test nutrients should be applied into the pot containing complete treatment (All) and each nutrient has to be omitted in the corresponding minus treatments.
- Watering and weeding has to be done as and when required.
- Visual nutrient deficiency symptoms have to be recorded for each of the treatments at the 2, 4, 8 and 12 weeks after emergence.
- After 30, 45, 60 and 90 days of emergence (sampling interval has to be decided based on crop duration) the plant height, number of leaves and leaf length have to be measured. After harvest, above and below ground plant parts have to be weighed fresh, dried at 85±5°C and weighed again.
- After harvest, soil and plant samples should be analyzed for all nutrients.
- The effects of nutrient omissions should be determined by comparing the relative growth with that of the All treatment.

- Nutrient deficiency symptoms should be co-related with plant analysis results.
- Differences among the treatments should be analyzed using ANOVA. Means which are significantly different should be separated using Duncan's multiple range test.
- Pot experiment data has to be verified by conducting a field experiment.

5.7.2 Field Experiments

- A field experiment should be conducted in a field in which crop response to applied fertilizer was not observed.
- A composite soil sample has to be collected and analyzed for all physical and chemical parameters including lime.
- Nutrient omission plots (5 x 5-m size) should be installed at the long side of the field, not in a corner.
- Soil pH (0-15cm) should be adjusted to 6 using Ca(OH)2 except the –Lime treatment sample. After pH adjustment, three weeks incubation time has to be given.
- The common treatments for a nutrient omission trial are All, control, -N, -P, -K, -Mg, -S, -Zn, -Cu, -Fe, -Mn, -B and –Lime.
- Test crop has to be sown in the field. According to the test crop, sufficient amounts of all test nutrients should be applied into the pot containing complete treatment (All) and each nutrient has to be omitted in the corresponding minus treatments.
- Double bunds of minimum 25 cm height should be constructed to effectively reduce fertilizer contamination and bunds need to be well maintained throughout the season.
- Irrigation and intercultural operations should be done as and when needed.
- Irrigation should be ideally performed for individual plots, avoiding water running through all plots, which may cause fertilizer contamination.
- Sufficient and well-timed N top dressing using the leaf color chart should be done in all plots except – N plots to make sure that N is not limiting growth.
- Visual nutrient deficiency symptoms should be recorded for each of the treatments at 2, 4, 8 and 12 weeks after emergence.
- After 30, 45, 60 and 90 days of emergence (sampling interval has to be decided based on crop duration) the plant height, number of leaves and leaf length should be measured. After harvest, above and below ground plant parts have to be weighed fresh, dried overnight in oven at 85±5°C and weighed again.
- At full maturity, harvest all plants from a central 5-m2 area and should avoid plants from border rows. After harvest, soil and plant samples should be analyzed for all nutrients.
- The effects of nutrient omissions should be determined by comparing the relative growth with that of the All treatment.
- Nutrient deficiency symptoms should be co-related with plant analysis results.
- Differences among the treatments should be analyzed using ANOVA. Means which are significantly different should be separated using Duncan's multiple range test.

5.8. Nutrient Uptake Studies for a Particular Element/Heavy Metal Contamination

5.8.1 Selection of Test Plants

Plant species with large biomass production and robust rooting nature should be selected. Planting material should be uniform in size and free of disease symptoms.

5.8.2. Treatment Imposition

- Soil sample has to be tested for all essential nutrients including the element or heavy metal under study.
- Standard solution of test element should be prepared from stock solution containing a known concentration of test element. Working solutions of required concentrations according to the decided treatments should be prepared and applied to soil at intervals.

5.8.3. Plant and Soil Sampling

- After 20, 40, 60 and 90 days of treatment imposition (sampling interval should be decided based on crop duration), plant samples from each pot will be collected and washed thoroughly with tap water followed by distilled water so that no soil particles are remained.
- Above soil plant portion and roots should be separated and fresh weight has to be taken separately. Samples should be dried in an oven overnight at 80 ± 5^{0} C and weighed.
- Oven dried samples have to be powdered, digested in nitric acid and perchloric acid and analyzed for all the nutrient elements including element of study.
- Soil samples should be analyzed for all essential nutrients including the element or heavy metal under study
- Nutrient uptake should be calculated by using plant biomass and element concentration.

5.9. Nutrient Deficiencies

Sixteen nutrient elements are considered to be essential for plant growth. These elements are Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S), Zinc (Zn), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Boron (B) and Chlorine (Cl). Plants take carbon, hydrogen and oxygen largely from air and water and the rest of the thirteen elements are taken from soil. Whenever there is deficiency of any nutrient element(s) in the soil plant growth suffers and characteristic deficiency symptoms of the element generally show up on the plants. Besides plant nutrient stress due to less availability of essential nutrients, ornamental plants may also show nutrient toxicity symptoms due to excessive application of fertilizers either in the nursery beds or in the field after transplanting. At times toxicity may also result from foliar sprays of nutrients if applied in higher concentration than recommended dose. Soil conditions may also cause toxicity e.g. aluminum toxicity in higher acidic soils. Such soils may need corrective measure to mitigate adverse soil conditions to prevent nutrient toxicity before taking up flower production on large scale.

Nutritional disorder in plants can be easily recognised and symptoms caused due to the deficiency or toxicity of each nutrient element are definite and characteristic. Although these may at times are modified by factors like light, temperature and water supply, yet the characteristics symptoms have been found to be essentially similar. Nutritional stress in plants to which ornamental crops are no exception results from nutrient imbalances in soil. The nutrient disorders could arise from inadequacy of one or more plant nutrients. It may also be caused by the presence of an excessive amount of a plant nutrient that hinders proper functioning of another element. It is therefore, imperative that a balanced supply of each plant nutrient element is maintained for getting quality produce. This becomes more significant in the case of flowers where the quality becomes critical for getting higher price of the produce. A number of factors are responsible for nutrient disorders are discussed in this chapter along with the remedial measures to mitigate them.

5.9.1. Nitrogen

Nitrogen is most important nutrient element affecting plant growth. The most easily observed symptom of nitrogen deficiency is the yellowing (chlorosis) of leaves. This symptom is usually noticed first in the older leaves and last in the upper more actively growing leaves. In young plants in the nursery nitrogen deficiency is characterized by stunted growth and yellowing of foliage. It appears last in the younger leaves because of the high mobility of nitrogen in the plant, younger leaves retain their nitrogen and in addition, obtain nitrogen translocated from older leaves. Excessive application of nitrogen results in the marginal scorch of the leaves and tip burning. Apical buds also dry off. Newly emerging shoots after pruning in roses also dry up.

Remedies: Nitrogen deficiency can be corrected by applying nitrogenous fertilizers such as urea (46%N), DAP etc. The dose of nitrogen should be based on soil test and applied in the equal splits. Half of this quantity should be applied at sowing and the remaining half at first irrigation. In light textured soils nitrogenous fertilizers should be applied in three split doses. All sources of nitrogen are equally efficient. Organic manures in the form of composts, FYM, etc. sludge may be applied judiciously @ 20 tonnes per hectare.

5.9.2. Phosphorus

Phosphorus is necessary for cell division in growing root and shoot tissues. Its deficiency results in stunted growth. It is particularly needed for development of root system. Like nitrogen, the older leaves are usually the first to exhibit deficiency symptoms. Plants develop purple or dark to blue-green coloration with necrotic areas on leaves and petioles. Plants have a general overall stunted appearance. The symptoms are most obvious in young plants in nursery beds. Phosphorus toxicity shows as mottled chlorosis just behind the tip of the oldest leaf and along with the margin of leaves. In case of severe P toxicity similar symptoms will progress to all leaves.

Remedies: Phosphorus deficiency can be corrected by drilling phosphatic fertilizers before transplanting @ 30-60 kg P_2O_5 in form of single superphosphate, triple super phosphate, diammonium phosphate, etc.

5.9.3. Potassium

The external symptoms of potassium deficiency are easily recognized on the older leaves of the plant. A mottled chlorosis first occurs, followed by the development of necrotic areas at the tip and margin of the leaf. Like nitrogen, these symptoms generally appear on the more mature leaves. Generally, a plant deficient in potassium is stunted in growth with a pronounced shortening of the internodes. The leaf tips become dry and scorched. There is in general loss of dark green colour of the leaves.

Remedies: Application of 60 kg K_2O per hectare at the time of sowing is recommended.

5.9.4. Magnesium

The most common symptom of magnesium deficiency in plant is extensive interveinal chlorosis of the leaves. Like nitrogen, yellowing is apparent first in the basal leaves, and as the deficiency becomes more acute, eventually reaches the younger leaves. Under acute deficiency necrotic spots may be observed.

Remedies: Soil application of light amounts of dolomite limestone or fertilizer mixture containing 15-20 kg magnesium oxide per ton. The foliar application of 2 to 3 per cent solution of magnesium sulphate is a quick acting remedy but soil application produce a more lasting effect.

5.9.5. Sulphur

Symptoms of sulphur deficiency resemble somewhat those of nitrogen deficiency. Plants have stunted growth with yellowing of foliage and delayed maturity. Unlike nitrogen, sulphur deficient plants show chlorosis of younger leaves first. Under severe deficiency conditions, however, all leaves may undergo some loss of green colour.

Remedies: Use of sulphur containing fertilizers such as single superphosphate (12-14% S) ammonium sulphate (24% S) and gypsum (15% S) is recommended in areas of sulphur deficiency. Gypsum is the cheapest source of sulphur. Application of 18 kg S/ha (120 kg gypsum/ha) will correct the S deficiency.

5.9.6. Zinc

Generally, the first sign of zinc deficiency is interveinal chlorosis of older or middle leaves. Yellowish-brown and white necrotic spotting soon follows. Smaller leaves and shortened internodes, resulting in stunted growth, are characteristic of more severe deficiency. There is distorted appearance of the plant leaves. They are generally smaller in size, distorted in shape, and twisted in appearance and may be clustered on short branches known as rosettes. The effect of zinc deficiency on leaves is sometimes referred to as "little leaf" disease.

Remedies: Apply 50 kg of zinc sulphate per hectare if zinc deficiency has been noticed. This would be sufficient for 4 to 5 crops. Zinc can also be sprayed as 1% neutralized zinc sulphate solution. Two to three sprays at an interval of 7-10 days would be enough. To prepare zinc sulphate solution for one hectare, the following ingredients are required:

Zinc sulphate: 2.0 kg

Water : 200 litres

5.9.7. Iron

Unlike zinc, the iron deficiency does not result in stunted growth of the plants but it causes complete failure of chlorophyll production in the young leaves. Young leaves show interveinal chlorosis or chlorotic striping because the veins and areas close to them remain green. The chlorosis appears first at the basal part and spreads systematically towards the interior margins of the leaf. The points and margin remains green for a longer time.

Chlorosis due to mild deficiency recovers after some time. In severe deficiency, chlorosis of larger veins is followed by the loss of green colour in the liner veins.

Chlorosis spreads to the older leaves and the entire foliage becomes chlorotic within 3-4 weeks. The tips of chlorotic leaves become necrotic and wither, which may hang down. Total bleaching of the emerging leaves occurs.

5.9.8. Maganese

The plants are stunted with restricted foliage and root system. Visual symptoms appear in the patches on middle leaves a few days after the first irrigation. Chlorotic spots ranging in colour from very light greyish and whitish yellow to yellowish green appear between the veins at the middle regions of the leaves. The veins remain green. The chlorosis later spreads and results in the tissue necrosis. The necrotic areas often develop buff coloration or greyish yellow to pinkish brown colours. The chloritic spots increase in number and size and coalesces to form a streak or band in between the veins resulting in chlorotic striping. These symptoms then spread to the apex and base of the affected leaves and from the middle to young leaves. Young leaves emerging after 6-7 weeks of crop growth show interveinal chlorosis. Symptoms of Mn toxicity appear first on the oldest leaf and progress to younger leaves. Characteristic symptom is chlorosis with little necrosis which appear in the oldest leaf tips which gradually progress along the leaf margins.

Remedies: On soils slightly acidic to neutral, apply 50-100 kg $MnSO_4$/ha. One soils neutral to slightly alkaline, apply 100-200 kg $MnSO_4$/ha. Another method is to apply 0.5% manganese sulphate neutralized solution as foliar spray.

5.9.9. Copper

In nursery beds, plants develop bluish green appearance. The apical growth ceases and numerous bud tillers

develop. The plants remain dwarf and give a bushy look. Symptoms appear when the plants have 4 or 5 leaves i.e. at about 4 week of crop growth. The tips of young leaves develop chlorosis. Soon after the symptoms appear, the growth is depressed. Tillers are poorly formed and exhibit the symptoms as in the main shoot. Chlorosis later spreads alongside the margins towards the base of the leaves but the basal one-third part remains green. The severely chlorotic leaf tips become papery, withered and often twisted. The emerging leaves fail to unroll, appear needle-like and become severely coiled. The older leaves are not severely affected but they may develop small buff or pale-yellow spots.

5.9.10. Boron

The first visible symptoms of boron deficiency is the death of the shoot tip. This usually causes the growth of lateral shoots, the tips of which also dies. The leaves may have a thick texture, sometimes curling and becoming quite brittle. Generally, flowers do not form and root growth is stunted. A general disintegration of internal tissues results in abnormalities in the internal tissues. Symptoms of B toxicity are similar to that of P toxicity. However in the case of B toxicity mottled chlorotic areas have dehydrated appearance and necrosis of the leads down the margin.

Remedies: Broadcast 1-2 kg boron/ha as borax or borated fertilizer or spray 0.25% solution of borax to correct this deficiency.

5.9.11. Molybdenum

Molybdenum deficiency symptoms start with chlorotic interveinal mottling of the lower leaves, followed by marginal necrosis and infolding of the leaves. Under more severe conditions mottled areas may become necrotic, causing the leaf to wilt.

Remedies: The most commonly recommended compound used for this purpose is sodium molybdate, applied at a rate varying from 50-250 g/ha. (mixed with fertilizer depending upon the established need. Spray 0.5% solution of ammonium molybdate.

Chapter 6

Crop Protection

6. Crop Care

Diseases and insects pests are the major challenges faced by the commercial flower growers. With infestation of any diseases or insects, the quality of flowers is reduced significantly which directly affects the market price. Therefore, experiments as well as plant protection measures have the major role in commercial cultivation of flowers. Since majority of cost of cultivation is incurred on the plant protection measures, there is need to plan the experiments as per standards so that effective management techniques can be recommended for different flower crops.

6.1. General Guidelines for Undertaking Plant Pathology Experiments

- The recording of observations on diseases in the selected fields should be initiated with the sowing of the crop and continued till the end of the crop season.
- Fill in the details like location along with the field, date of observation, stage of crop, climatic condition, minimum and maximum temperature, rainfall and crop health in the field book/field register.
- For crop stage tick mark appropriate stage of crop at the time of surveillance *viz*., vegetative, reproductive and maturity or number of days after planting or number of days after inoculation etc.
- For crop health, tick mark appropriate term as to excellent or good or poor based on the status of crop stand in the field relating to crop growth and development.
- Crop stage wise record of package of practices followed to be noted.
- In field, select spots randomly such that the entire field has been covered. Five feet (if possible) distance alongside of boundary in all directions of the field should be left out as buffer space to avoid border effects during disease observations.
- The spot selection for observations during each weekly visit should be random and it is not the fixed spots in a field that would be sampled continuously.
- While recording the incidence, try to record even the minor diseases observed and note if anything unusual is observed.
- Take photograph of the disease symptoms on different plant parts and properly document the same.
- Always try to maintain control for every experiment.
- The disease scoring scale used for a particular disease has to be uniform across the centres to evaluate the germplasm or varieties.
- In the field the information on surrounding crops, weeds and insects to be recorded along with the disease record.
- In the case of artificial inoculation through injury to plant, remember to maintain two controls one un-inoculated and another one inoculated with sterile water to minimize the errors.
- In case of evaluation of chemicals, the concentration, method of application and the plant variety used has to be uniform.

- All data analysis has to be validated statistically.
- The risks and benefits of chemical application need to be weighed in each situation. In addition to the cost of chemical treatment, there are sometimes negative side effects of pesticide use: stress, resistance problems, interference with biocontrol, or an increase in diseases normally held in check by naturally occurring antagonistic microflora.
- Certain fungicide treatments on healthy plants may have a negative effect on plant growth, and possibly increase the length of time to bring the crop into flower.
- The residue effect of fungicides in soil and on beneficial microbes need to be recorded during bio-efficacy evaluation.
- In case of viral diseases symptoms, it should not be confused with nutrient deficiency. Always record the nutrient application status of the crop to avoid misinterpretations.

6.2. Procedure for Recording Disease Observations

The intensity of the disease should be recorded based on the ratings given alongside of data recording table. The severity rating for individual plants randomly selected in the field should be recorded.

6.2.1. Alternaria Leaf Blight

The severity rating scale can be followed for Alternaria leaf blight (Bal and Kumar, 2014)

Scale	Description
0	No symptoms
1	1-10% of plants infected
2	11-25% of plants infected
3	26-50% of plants infected
4	51-75% of plants infected
5	75-100% of plants infected

PDI = Sum of individual disease rating x 100 / Number of observations x Maximum disease grade

6.2.2. Gladiolus Wilt

Disease severity can be assessed with a 0–3 visual scale (Riaz *et al,* 2008)

Scale	Description
0	No symptoms,
1	Yellowing of leaves,
2	drying of leaves and
3	Dead or almost dead plants.

Disease incidence (%) = No. of diseased plants × 100/ Total no. of plants
Mortality (%) = No. of plants died due to disease × 100/Total no. of plants

6.2.3. Carnation Wilt

The wilt disease scoring of carnation wilt caused by *F. oxysporum* f. sp. *dianthi* can be done on 0-5 scale as proposed by Schoffel meer *et al.,* (1992), which is as follows

Wilt index	Visible signs
0	No wilt disease symptoms
1	Questionable wilting symptoms only
2	Limited local wilting symptoms
3	Well-developed wilting symptoms on otherwise healthy looking plant
4	Severe wilting
5	Complete wilting and death

6.2.4. Foliar Diseases

Percent Disease Index (McKinney's Index)

- For visual estimation of severity, 0-9 point scale (No infection -0; 0-10% leaf area infected -1; 10-20% leaf area infected -2; 20-30% leaf area infected -3; 30 -40%leaf area infected-4; 40-50% leaf area infected -5; 50-60% leaf area infected-6; 60-70% leaf area infected-7; 70-80% leaf area infected -8; 80-90% or more leaf area infected -9) can be used for rating of all foliar diseases.
- In the case of die back of rose, a whole plant is considered a unit of infection.
- In calculating severity, lesion lengths or any part of the plant can be summated as infected area (Ghosh *et al,* 2009).

6.2.5. Bioassay *in vitro*

- The per cent increase in the colony diameter has to be calculated using the following formula:
- % increase = (colony diameter in treated - colony diameter in control) X 100 / colony diameter in control
- The per cent inhibition in the colony diameter has to be calculated using the following formula:
- % inhibition = (colony diameter in control - colony diameter in treated) X 100 / colony diameter in control

6.2.6. Estimation of Occurrence, Incidence, Intensity and Severity

- Occurrence/Incidence = Sample Plants Infected × 100/ Total No. of Samples
- Intensity = No. of Leaves or Units Infected × 100/ Total No. of Leaves or Units of Infection
- Severity = Sum of all Ratings × 100/ No. of Observation × Highest Rating

6.3. Model 1: Powdery Mildew in the Greenhouse

Powdery mildew is probably one of the most common and widely distributed disease of plants in greenhouse production. This disease is responsible for significant economic losses in many greenhouse floricultural (e.g., roses, violas, African daisy, zinnias) crops.

6.3.1. Causal Organisms and Disease Development

Although the symptoms of disease are similar, the fungi responsible for powdery mildew fall into a number of different genera. The genera of primary importance to greenhouse production include *Erysiphe, Leveillula, Microsphaera, Sphaerotheca,* and *Oidium.* These fungi are all obligate parasites that require living hosts in order to complete their life cycles so they readily infect healthy, vigorous plants.

Development of powdery mildew in the greenhouse is influenced by many environmental factors including temperature, RH, light level, and air circulation. Greenhouses usually provide optimum levels for all of these conditions. Optimum conditions include moderate temperatures (68-86° F), high humidity (>95% RH), and fairly low light intensities or shade. However, these requirements vary with the specific powdery mildew fungus. There is an inverse relationship between temperature and RH which influences both the production and spread of powdery mildew conidia. As temperatures fall at night, RH increases. High RH stimulates conidia to germinate and also encourages the production of chains of conidia in existing infections. In the morning after sunrise, the temperatures warm and RH levels fall. These conditions help to dry the chains of conidia. Since conidia function as the primary means for new infections in the greenhouse, air movement and circulation in the house are very important for development and spread of disease. Dry "powdery" conidia are easily dislodged and disseminated by air movement from grower activities in the house as well as by opening and closing doors. The time from when conidia land to the production of new conidia can be as short as 72 hrs but is more commonly 5-7 days. Powdery mildew conidia are unique since unlike most fungal spores, they do not require free moisture (e.g., guttation, dew, water from overhead irrigation) on plant surfaces in order to infect (Douglas, 2001 and Magarey, 2010). Take these points into consideration while recording observations.

6.3.2. Guidelines for Disease Management Experiments

- Maintain adequate plant spacing to reduce RH levels in the plant canopy. This also helps to obtain good coverage with fungicide sprays.
- Maintain RH levels below ~ 93% by properly timed venting and heating.
- Identify the particular powdery mildew fungus in order to anticipate the potential for spread to other plants in the house.
- Syringing or applying water directly to leaves of some greenhouse crops discourages germination of conidia and helps to wash conidia off leaf surfaces. This procedure works for some crops provided other types of foliar diseases favoured by leaf wetness are not common problems for that crop.
- Control with chemicals is targeted at eradication of existing infections and protection of healthy tissues. Once disease is detected, the first sprays should be aimed at eradication. These are usually followed by sprays for protection. The efficacy of specific compounds can vary significantly with the particular powdery mildew fungus and host, so knowledge of the host pathogen combination is helpful. Attention to spray delivery and coverage is also very important.
- Eradication sprays should be applied as soon as symptoms are first observed since early control is critical.
- Monitor and rotate the types of compounds used to avoid development of fungicide resistance in the powdery mildew population. The diversity of products currently registered and effective for greenhouse use makes fungicide resistance management much easier than in the past. Since pesticide registrations vary with state, check with the appropriate agency and consult the label before applying any pesticide.

6.3.3. Guidelines for Disease Monitoring and Sanitation

- Carefully examine and inspect new cuttings, seedlings, and plugs upon arrival. Never use diseased plant material.
- Scout for disease on a regular schedule to identify outbreaks before they become widespread. This typically involves examining one out of 30 plants each week. It is helpful to concentrate on the middle and lower leaves since infections often start in these leaves. Once disease is detected, examine one out of 10 plants every week. Continue with this schedule until plants are free of disease for at least three weeks. Thereafter, resume weekly scouting of one plant out of 30.

- All diseased tissues should be removed as soon as they are detected and immediately placed in a plastic bag to avoid carrying infected material through the house.
- All production areas should be thoroughly cleaned and plant debris removed between crops and production cycles. This includes removing all weeds in and around the greenhouse.

6.3.4. Germplasm Screening for Disease Resistance

To develop disease resistant material, screening of germplasm and breeding material need to be undertaken effectively. Field techniques for large-scale screenings and glasshouse/net house/laboratory techniques are used to confirm resistances identified in the field screening as well as to carry out inheritance and race identification studies.

6.4. Model 2: Wilt of Gladiolus (*Fusarium oxysporum* f. sp. *gladioli*)

Fusarium wilt of gladiolus is considered a serious and highly devastating disease. The soil borne fungus *Fusarium oxysporum* f. sp. *gladioli* is a major causal organism of yellowing and corm rot in gladiolus.

6.4.1. Sick Plot for Fusarium Wilt of Gladiolus (*Fusarium oxysporum* f. sp. *gladioli*)

1. Select a plot of adequate size and ensure that it is isolated from other fields to avoid spread of the fungus inoculum from one plot to another. The plot should have been grown with *Fusarium* infected plants of the same crop and at least traces of wilt incidence should have been observed during preceding year.
2. Collect as many wilted plants from other fields as possible, chop them into small pieces and incorporate these uniformly on the soil surface of plot.
3. Plant a sole crop of a highly susceptible cultivar in this plot. Ensure a good plant population and carry out normal agronomic operations.
4. By the end of the season, at least 20% of the plants should show wilt symptoms. After harvesting and threshing, scatter the debris uniformly all over the plot and incorporate it by disking. Also add the infected plant parts from other fields, this will help to increase the level of the inoculum and to make the soil more "sick."
5. Repeat steps 3 and 4 in the next season. By the end of this season, we should see more than 90% wilt incidence. If the incidence is less than 70%, repeat steps 3 and 4 once more.
6. Initiate screening in the next season. Plant a susceptible cultivar after every two test rows in the whole field. These rows will serve as checks, and will help in monitoring and maintaining the wilt sickness of the plot. The susceptible check rows should show more than 90% wilt.
7. From the 4^{th} or 5^{th} year onwards, plant every fifth row as a susceptible check. This will provide for more breeding material and at the same time maintain the level of sickness.
8. Planting any other crop in this plot is not recommended. It must be emphasized that by following all these steps a sick plot in which *F. oxysporum* f. sp. *gladioli* will be the most predominant pathogen can be developed. However, the presence of other soil borne pathogens cannot be avoided.

6.4.2. Pot Screening

1. Take pure culture of *F. oxysporum* f. sp. *gladioli* from infected gladiolus by following standard isolation procedures.
2. Prepare a sand-maize meal medium by placing 90 g riverbed sand, 10 g maize meal, and 20 ml distilled water in each 250 ml Erlenmeyer flask. Autoclave the medium in the flasks at 15 lb for 20 min. Inoculate each flask with a bit of fungus growth from tubes and incubate at 25°C for 15 days.

3. Prepare a fungus-soil mixture by hand mixing contents of each flask with 2 kg of non autoclaved field soil. The soil must come from a gladiolus field where wilt normally occurs.
4. Fill large (30-cm diameter) earthen pots with the inoculated soil. Approximately 10 kg of soil will be required to fill each pot. Water the pots and wait for 4 days before proceeding to the next step.
5. Sow corms of a highly susceptible cultivar in each pot. Water adequately and regularly. Most plants should show wilting after 10 days. Remove healthy plants after 30 days. Chop and incorporate all the wilted plants into the soil.
6. Repeat steps 5 and 6 until over 90% wilt is observed. These pots are then ready for screening.
7. Divide a pot into two sections. Plant corms of a test line in one section and corms of a susceptible check in the other.
8. These pots can be used for several successive screenings.

6.5. Guidelines for the Diagnostics of Plant Pathogens (Adopted from International Standards for Phytosanitary measures ISPM 36)

Proper pest detection and pest identification are crucial for the appropriate application of disease management measures. The following points to be taken into consideration while doing plant disease diagnostics.

- The sample collected for diagnostics should be representative of the whole lot of plants or planting material or whichever it may be.
- Depending on the diagnostic method and nature of occurrence of pathogen, the tissue to be sampled also varies. A few examples are given below;

Pathogen	Sample
Fungus	Symptomatic portion of the plant or fungal mycelium/spores if visible
Bacteria	Symptomatic portion of the plant/bacterial ooze
Virus	Depending on the cells which they reside. Use of younger part of plant will enable the easy lysis of cells and release of viruses
DNA viruses	DNA
RNA viruses	RNA
Viroids	RNA
Phloem inhabiting pathogens like Phytoplasma	Midrib, petiole, stem, bark etc
Xylem inhabitants like Xylella sp.	Xylem tissues, veins, midribs, stem, etc.

- Diagnostic protocols must have the description of procedures and methods for the detection and identification of the pathogen.
- Diagnostic protocols are to be selected on the basis of sensitivity, specificity and reproducibility as well as the availability of equipment, the expertise required for these methods and their practicability.

- In case of routine diagnostics for a common well studied pathogen, low cost speedy methods amiable to high throu-putting has to be used like ELISA – Enzyme Linked Immunosorbent Assay in the case of virus indexing and certification.
- In case of identification of an unknown pathogen all the systematic steps from symptomatology, morphology and specific diagnostic method; molecular or serological techniques to be followed.
- In case of nucleic acid based protocols, care should be taken to avoid degradation and contamination of the nucleic acid while performing the protocols.
- The final report generated should have
  a. Scientific name of pathogen identified
  b. Code or reference number of samples
  c. Nature of infected material including scientific name of host wherever applicable
  d. Origin (including the geographic location if known) of the infected material, and location of interception or detection
  e. Description of symptoms (including photographs wherever relevant), even the absence of symptoms as the case may be
  f. Different methods used, including controls, used in the diagnosis and the results obtained with each method
  g. For morphological methods, measurements, drawings or photographs of the diagnostic features (where relevant)
  h. For biochemical and molecular methods, documentation of test results such as gel photographs or ELISA results printouts
  i. Wherever appropriate, the magnitude of any infestation (severity and extent of damage)
  j. The name of the laboratory and if required, the name of the person(s) responsible for and/or who performed the diagnosis
  k. Dates of collection of sample, date of detection and identification of pathogen
- Evidence such as the pathogen culture, nucleic acid, preserved specimens or test materials (e.g. gel images, ELISA plate reading printout, etc.) should be retained at least one year for future reference as well.

6.6. General Symptoms of Diseases in Plants

6.6.1. Spot

Well defined, self limiting lesion on arial plant parts are called spot. They are often named after the plant part on which they are present, for instance on the leaves are called Leaf spot. These maybe of various shapes such as round , circular ,angular, etc. and are often light to dark brown or black in colour. It is worthy to note that in angular leaf spots, veins and vein lets normally restrict the spread of infection.

6.6.2. Blotch

Large areas of discoloration on leaves, fruits etc. are called blotches. There spread on the leaves is not restricted by veins.

6.6.3. Anthracnose

Black or charcoal like, slightly sunken lesion on leaves, stems or fruits result in a disease.

6.6.4. Canker

A necrotic, often sunken lesion, on a stem, branch or twigs of plants is called a canker.

6.6.5. Scab

A rough, crust like lesion on a plant part, showing surface layer thickening ; or the disease condition in which such areas form is termed scab.

6.6.6. Rot

Softening, discoloration and decay of succulent plant tissue as a result of infection is called rotting. Root rot, foot rot, crown rot, bulb rot, collar rot, soft rot, rhizome rot, sett rot, stem rot etc. are some common types of rots.

6.6.7. Damping off

Death and collapse of seedling at or near the soil line is normally referred to as damping off. However, in the strict sense of the term, decay of seeds in the soil or of seedlings before or after their emergence from the soil is called damping off. It is very common in the nursery and they often result in heavy seedlings mortality. If the seedlings are vary mildly infected they may withstand attack but carry infection to the field and at a later stage succumb if weather turns favourable.

6.6.8. Gummosis

External or internal production of an exudates or gum by the plants tissue is referred to as gummosis.

6.6.9. Dieback

Death, decay or drying of twigs or branches from tip downwards is called dieback. Discolouration or darkening of the bark is a very common features in such diseases.

6.6.10. Wilt

A diseased condition that result in dropping of plant parts generally caused by insufficient transport of water in the plants is called wilting. It may occurs due to pathological or a physiological cause.

6.6.11. Shot hole

A disease symptoms in which leaf lesion becomes cicatrized and fall away drop off and leave small holes in their place, is called shot hole.

6.6.12. Mould

A disease in which the mycelium or spores of the fungus are seen as a blackish, brownish, bluish or grayish growth on the host surface. The term also refers to fungal growth, which may be present on the non living substrate, too. Sooty mould is common disease affecting plants and is caused by saprophytic fungi . It is appears as a sooty or black coating on plants and is commonly associated with honeydew secreted by insect such as aphids, mealy bugs, scales and white flies.

6.6.13. Mildews

A disease in which mycelium and spores of the fungus are seen as a whitish or grayish growth on the host surface is called mildew. The leaves are most commonly infected, whereas the other arial plant parts are not exception. If growth develops mainly on the lower surface of the leaves named downy mildew. On the contrary, growth develop on upper surface named powdery mildew.

6.6.14. Rust

A disease representing a “rusty “look to a plants is called rust. It is caused by fungi belonging to the order Uredinales.

6.6.15. Smut

A disease characterized by masses of dark, powdery and sometimes odorous spores and caused by one of the members of fungi belonging to the order ustilaginales.

6.6.16. Gall

A swelling or overgrowth produced on plant due to infection by certain pathogen to called a gall. The galls are commonly noticed on leaves and roots.

6.6.17. Tumor

An uncontrolled overgrowth of tissue due to infection by a pathogen is called tumor.

6.6.18. Mosaic

Presence of dark and light – green or yellow areas on leaves of virus – affected plants, is known by the name mosaic. Associated with them may be thickening, puckering or distortion as well as ring, line and streak patterns may also be encountered in mosaic – types f disease. Vein clearing or vein – banding is also a common symptoms of infection with mosaic diseases.

6.6.19. Colour - break

Narrow elongated streaks r stripes of indefinite or restricted length on flower petals often result in variegation in flower colour and the symptoms are known as colour – break.

6.6.20. Witches Broom

Broom- like growth or massed proliferation is caused by dens clustering of branches of woody plants. In such diseases the internodes gate shortened and the numbers of stems is greatly increased.

6.6.21. Chlorosis

Yellowing of normal green tissue due to destruction or failure of chlorophyll to form is called chlorosis. It is called general chlorosis when uniformly present white interveinal when present between the veins.

6.6.22. Necrosis

Death and discoloration of tissue is called necrosis.

6.6.23. Scorching

Appears as burning of margin or nearly whole leaves as a result of infection or unfavourable environmental conditions.

6.6.24. Stunting or Dwarfing

It is reduction in the size of plant. It generally result from fungal, bacterial viral or nematode infections.

6.7. Diseases of Rose

6.7.1. Fungal Diseases

I) Black Leaf Spot

Circular black spots ranging from 1/16 inch to 1/2 inch in diameter appear generally on upper sides of leaves. The spots are frequently surrounded by a yellow halo. Infected leaves characteristically turn yellow. They fall prematurely. This leaf spot can be distinguished from others by the fringed margin and consistently black color. Cane infection produces a reddish-purple spot. It produces a weakened bush on which cane dieback, stem canker, and winter injury can become severe.

ii) Powdery Mildew

Leaves, buds, and stems are covered with a white powdery coating. This disease can cause young leaves to curl and turn purple. Young canes may be distorted and dwarfed. Badly infected buds do not open.

iii) Botrytis Blight

A smooth, slightly sunken, grayish-black lesion may develop just below the flower head. The bud is destroyed and frequently hangs over at or near the lesion. The disease causes flower buds to droop and remain closed. Buds turn brown and decay. Sometimes partially opened buds are attacked and an entire flower may be covered by gray fungus.

iv) Downy Mildew

Downey mildew is characterized by purple-red to dark-brown spots on the leaves with irregular margins, however, often angular. Stems, petioles and flower stalks can split and spotted with purple marks. Buds, sepals, petals and calyces can be affected and will present purple spots. New growth affected will be deformed.

6.7.2. Bacterial Diseases

Crown Gall

This disease is characterized by large lumps at the base of the plant stem or on roots. Galls may appear higher on stems as the disease progresses. Galls are soft compared to surrounding plant tissues. If the disease affects the plant whilst it is young the plant may be affected to the degree where it will not produce blooms.

6.7.3. Virus Diseases

i) Rose Rosette

Symptoms caused by Rose rosette virus may vary according to climatic conditions and type of roses but they can include the development of witches' brooms, excessive thorn production, excessive lateral shoot growth, rapid stem elongation, thickened, succulent stems, leaf proliferation and malformation, mosaic, bright red pigmentation, deformed buds and flowers, and lack of winter hardiness. Infected plants lose their aesthetic value and gradually display a general decline leading to plant death. It is reported that infected plants usually die within 1 to 5years.

ii) Rose Mosaic

The symptoms caused by Rose mosaic virus are highly variable. The most common symptoms include; chlorotic bands or ring spots, wavy lines, yellow vein banding, oak-leaf pattern, and general mosaic (splotches of yellow and green on leaves). Colour-breaking (mottled flower colour) is also observed. Symptom development on only a portion of a plant is common.

iii) Rose Leaf Curl

Roses infected by begomovirus show leaf curling, leaf distortion and dwarfing.

6.8. Diseases of Gerbera

6.8.1. Fungal Diseases

I) *Alternaria* Leaf Spot:

Brown specks form on florets and the leaves. Centers become white on the leaf spots

ii) Bacterial Leaf Spot

Small to large spots are circular at first, then become irregular and dark brown to black and may have a concentric ring pattern.

iii) Botrytis Blight

Petioles have long brown spots. Leaves yellow and die. Petals have tan spots. Stems at soil level are killed. Infected tissues become covered with gray fungal growth

iv) ***Phytophthora* Crown Rot**

Plants wilt suddenly. Leaves turn brown. Roots are rotted and a crown rot develops

v) ***Pithyum* Root Rot**: Plants wilt and die as roots rot

vi) ***Rhizoctonia* crown rot**: Stems at the soil level have a brown lesion. Plants wilt and die.

vii) **Powdery Mildew**

Powdery mildew is easy to identify since noticeable white spots or white patches appear on the upper and lower surfaces of the leaves. These spots gradually enlarge to form a white, powder-like mat that can spread to healthy plants.

6.8.2. Virus Diseases

Cucumber mosaic virus causes yellowing and mottling in Gerbera leaves. The CMV infection is characterized by severe chlorotic mosaic, greening of veins on leaves, color breaking in florets accomplished with flower deformations, and poor growth of the bloom. The Common symptoms of Tobacco rattle Virus infection include mottling, cholortic or necrotic local lesion, ringspots or line patterns, and systemic necrosis.

6.9. Diseases of Carnation

6.9.1. Virus Diseases

i) **Carnation Mottle Virus (CarMV)**

The infection is characterized by mild symptoms including split calyces and reduced vigour, lesser lateral shoots, flowers and fresh weight.

ii) **Necrotic Fleck**

The Carnation necrotic fleck virus causes greyish-white or reddish-purple necrotic flecks, streaks or spots on leaves and stems, with yellowing and complete necrosis on older leaves. Symptoms are milder on younger leaves. Flowers generally do not show symptoms, but owing to the severity of symptoms on leaves and stems, flowers from infected plants are of poor quality and mostly unmarketable.

6.9.2. Fungal Diseases

i) ***Fusarium* Stem Rot/Wilt**

Plants wilt, turn yellow, and die. Symptoms on rooted cuttings range from wilted cuttings with a severely reddish-brown crown rot to apparently healthy cuttings with small internal, amber colored crown lesions. Young plants with basal stem rot become ash green, wilt, and die. Upon closer inspection of diseased cuttings, reddish-brown lesions with pink or orange spore masses are found in association with the disease.

ii) ***Alternaria* Blight**

Initial leaf symptoms of *Alternaria* blight of carnation, caused by the fungus *Alternaria dianthi,* are tiny purple dots (1/ 16 to 1/8 inch).When moist weather prevails, the spots enlarge, developing into large lesions with a purple margin and a yellow-green border surrounding a gray-brown center covered with black spores. Several lesions may expand and coalesce to form large, irregular necrotic areas that eventually kill the entire leaf. The branches are most frequently infected at the nodes and branch base. These infection centers enlarge to form cankers, which eventually girdle the stem, causing the branch to wilt and the girdled portion to turn yellow and die.

iii) ***Septoria* Leaf Spot**

Septoria leaf spot is caused by the fungus *Septoria dianthi.* Symptoms on leaves and stems appear as light brown

spots with purple margins. Small black specks are present at the center of the spots. These are the spore producing structures of the fungus. Individual lesions may enlarge and coalesce with adjacent lesions to cause death of the leaf.

6.10. Diseases of Tuberose

6.10.1. Fungal Diseases

i) Foot and Tuber Rot

The disease appears on patches and causes wilt and stem rot. Fan shaped mycelia strand of the fungus appear at the base of infected plants. The fungus initially attack on roots and later spread to the tubers and petioles, which induce rotting.

ii) Blossom Blight

With the infection of fungus light brown lesions develop on petals, which soon darken and result in the drying of the tissue. The blightened blossoms drops off from the plants.

iii) Bacterial- Flower Bud Rot

The young flower buds are affected initially by the fungus causing dry rotting buds with brown scorched necrotic discoloration of peduncles.

iv) Alternaria Leaf Spot

It is characterized by faint concentric ring on midrib and rarely on the margin of leaves. It is prevalent in the rainy season. Affected peduncle and leaves show circular to oval spots. The leaves and peduncles become necrotic and dry up with the infection.

6.10.2. Virus Diseases

i) Tuberose Mild Mottle Virus:

The infection .causes symptoms of mosaic, mottling and in severe cases reduced tillering and stunted growth

6.11. Diseases of Gladiolus

6.11.1. Fungal Diseases

i) Fusarium Wilt, Yellow or Corm Rot

The characteristic symptoms is interveinal leaf tip yellowing, which extend down the leaf and whole leaf gradually turns brown and become narrow. The other common symptoms include stunting, curving, arching and bending of leaves. On advancement of infection of plant suddenly wilt or turn yellow and die prematurely. The leaf infection is usually basal and associated with corm rot. Roots arising from corm show brown lesions. The centers of bulb turn black and rot completely. Lesions on corms are reddish-brown with well defined margins, round to oval, somewhat depressed leading to hard shrunken mummified corms.

ii) Storage Rots

The disease mostly appears in the form of black, brown, greenish or yellowish mould growth on the corms during storage. Under poor air circulation the corms may rot or emit foul smell.

iii) Dry or Neck Rot

It is also known as root rot. The disease is seen on the stored corms as small dark more or less superficial spot or lesion on which can also produce collar rot, killing the plants or its delay attack may only harm the new

corms for carrying the disease to the next season. Dry rot is wide spread disease attacking gladioli plants in the field . It is more severe during humid condition. The leaves turn brown from the tips downward . Diseased corms show round black and small lesions.

iv) Botrytis Blight and Flower Rot

It is destructive to leaves and flower . Disease epidemic erupt during the cool , wet weather condition. The little brown black spot observed on the top of corms. The symptoms on the leaves consist initially of light afterward dark brown spot . Later in the season large and dead gray brown patches appear on the tissue. Germinating spores may colorless watery spot on the flower.

6.11.2. Virus disease

i) Cucumber Mosaic Virus and Bean Yellow Mosaic Virus:

These are most prevalent in gladiolus and their infection results in mosaic, leaf stripe, pale-yellow mottling of the leaves, flower distortion colour-breaking, overall stunting, reduced flower and cormel production.

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6.12. Insect and Non-insect Pests and their Management

Insects like whitefly, thrips, aphids, bud borers, tobacco caterpillars etc., and non-insect pests like two spotted spider mites pose a serious threat to commercial flower production, due to congenial microclimate prevailing inside the polyhouse and in open field crops. For effective management of such pests multi-location trial has to be conducted to test the effectiveness of pest management options either biological control agents or synthetic insecticides. Here are some guidelines for conducting entomological trials under AICRP on Floriculture.

6.12.1 Insect and Non-insect Pests and their Scouting Methods

Insect and non-insect pests need to be scouted carefully and kept under check for attaining better marketable yield of commercial flower crops. The standard scouting procedure for insects and non-insect pests on commercial flower crops is given here under. These procedures have to be followed while recording the population density or damage percentage caused by a pest. The population density has to be calculated before imposing any given treatment to assess their effectiveness against a given pest.

i. Whitefly

The cotton whitefly, *Bemisia tabaci* is the major whitefly noticed in most of the commercial floriculture crops. Adults of *B. tabaci* are 1.0 mm long and powdery white in appearance. Both adults and nymphs are found on the undersurface of broad leaved plants like gerbera. Adults mostly appear on the upper leaves and nymphs are on older leaves. The population of whitefly can be recorded by either leaf-count method or yellow sticky trap method.

Leaf Count Method: In this method, counting should be undertaken either during early morning or in the

evening hours, as active under day light condition. Observations on number of whiteflies should be counted on upper most, middle and lower leaves in at least 15 randomly selected plants in a replication.

Yellow Sticky Trap Method: Yellow sticky traps have to be installed @ 60 traps/ha. The traps have to be installed just 10.0 cm above the plant canopy to attract most of the active flying adults. The conservation on number of adults trapped can be counted once in 15 days interval.

ii. Red Spider Mite

Two spotted spider mite, *Tetranychus urticae* is serious problem in most of the commercial flower crops like rose, gerbera, carnation, chrysanthemum, China aster, marigold, *etc*. Sampling of two spotted spider mites can be done by two methods either by direct counting of mites on plant parts or assessing the damage done by these mites on plants.

For direct counting of mites, three leaves from top, middle and lower parts of the plant are selected. The newest expanded leaves and those at the very bottom of the plant should not be sampled. The number of mites on these leaves can be counted by using hand held lens (preferably 10X). Mites have to be counted on 25-30 randomly selected plants per replication.

Per cent damage by mites can be calculated by assessing the damage done by mites due to feeding which appears as yellowing, browning of leaves and at sever infestation withering of leaves. Damage percentage has to be counted on 25-30 randomly selected plants per replication.

iii. Thrips

Thrips post special sampling problems as they will be cryptic in nature and will be always hidden in the growing parts or flower buds. Sampling of thrips can be done in two ways, directly counting of thrips in plant parts or indirectly by counting the damage percentage on a plant.

Direct Method: Population of thrips can be counted either on leaves, flower buds, flowers and blue sticky traps, depending on the stage of the crop and plant parts available at the time of planting.

For counting thrips on leaves, thrips on top, middle and lower plant canopy have to be counted on three leaves each from each strata of the plant. In general 50 randomly selected leaves per 2000 m^2 area have to be counted for assessing the population density.

For counting thrips on flower buds or flowers, 10 flower buds from each plant have to be tapped gently on a white sheet and the number of thrips emerging from each flower bud can be noted for population analysis.

Blue sticky traps can be installed @ 60 traps/ha. The traps have to be installed just 10.0 cm above the plant canopy to attract most of the active flying adults. The conservation on number of adults trapped can be counted once in 15 days interval.

Indirect Method: The damage due to thrips feeding on foliage and flower buds can be counted on 15-20 randomly selected plants. On each plant, observation has to be recorded on top, middle and lower parts of the plant.

iv. Aphids

Aphids occur in both wingless and winged forms. They will be congregated in the terminal shoots or flower buds. Aphid population can be counted by number of aphids per unit length (preferably 10.0 cm). Observations on number of aphids should be counted on upper most, middle and lower parts of at least 15 randomly selected plants in a replication.

v. Bud Borer

Bud borer, *Helicoverpa armigera* infestation can be noticed in commercial flower crops like rose, gerbera, carnation, chrysanthemum, China aster, marigold, *etc*. This insect generally feed on flower buds, however

during initial plant growth stages it feeds on leaves. Adult female lays eggs in single on new flush or flower bud. Eggs or number of larvae can be recorded on new flush or flower bud on 15-20 randomly selected plants per replication. Damage percentage can also be calculated by counting number of flower buds damaged and total number of flower buds in a given plant. Observation has to be recorded on 15-20 randomly selected plants per replication.

vi. Tobacco Cutworm

Tobacco cutworm, *Spodoptera litura* infestation can be noticed in commercial flower crops like rose and gerbera. The adult moth lays eggs in groups of 100-150 eggs and covers such egg mass with tuft of hairs. The egg mass can generally be seen on the under surface of the young leaves. After hatching, initial stage larvae will be gregarious in nature and feed on the plant foliage by scraping the chlorophyll content leaving behind skeleton of leaf. The later stage larvae feed voraciously on leaves and flower buds.

Direct Method: As the egg and early instar larval stages are gregarious in nature, they can be counted as number of egg masses or larvae per plant. Observation has to be recorded on 15-20 randomly selected plants per replication. The later stage larvae are nocturnal in habit, will be active during dusk and dawn hours. Number of larvae on 1.0 meter row can be counted for analyzing the pest population level.

Indirect Method: Damage percentage can also be calculated by counting the number of plants or flower buds damaged to the total number of plants or flower buds in 1.0 meter row. Observation has to be recorded on 5-10 places per replication.

6.12.2 Typical Symptoms of Insect Pest Damage : Irrespective of the crop the typical symptoms alive to different insect pests are summerised in Table 8.

Table 8. Manifestations of Insect Pests on different crops

Pest	Damage
Aphids	Aphids damage the plants by sucking the leaf sap in young stage, cotyledonary leaves crinkle and in severe cases the plants withers off.
Cutworms	The tender plants are found damped at ground level during the night Young larvae feed gregariously on foliage but later segregate and enter into soil.
Jassids/ leafhoppers	Both nymphs and adults suck the sap from the lower surface of the leaves. The infested leaf curl upward along the margins, which may turn yellowish and show, burnt up patches.
Defoliator/ Leaf eating caterpillar	Larvae feed on lower surface of leaves by scraping while greenish-brown mature larvae feed voraciously during nights on these leaves.
Leaf Roller	Caterpillars roll leaves and feed on chlorophyll while remaining inside the folds. The folded leaves wither and dry up.
Mealybug	Nymphs and adults of mealy bugs suck sap from the leaves, tender shoots and the fruits. A heavy black sooty mould may develop on the honeydew like droplets secreted by mealy bugs.
Red pumpkin beetle	They make holes in cotyledonary leaves of cucurbits. As a result the seedlings die in the younger stage
Red spider mite/ two spotted spider mite	Different stages of mites are found in colonies covered by white-silky webs on lower surface of leaves. Nymphs and adults suck cell sap and white patches appear on leaves. Affected leaves become mottled, turn brown and fall.
Thrips	Nymphs and black adults feed on tender leaves causing silvering, mottling and distortion of leaves.
Whitefly	The damage by whitefly also leads to yellowing of leaves and stunted growth, in severe cases leading to shedding of leaves.

6.12.2 Model 1: Evaluation of Entomopathogen Formulations against Whitefly, *Bemisia tabaci* on gerbera under polyhouse conditions

Duration : Three years
Centres : Hessaraghatta, Pune, Kahikuchiand Ludhiana
Technical Programme
Design : RBD
Number of treatments : 9
Number of replications : Three (30 plants/replication)
Variety : Any susceptible
Treatment details

1. *Metarhizium anisopliae* water formulation, 1 X 10^7 spores/ml
2. *Metarhizium anisopliae* oil formulation, 1 X 10^7 spores/ml
3. *Metarhizium anisopliae* talc formulation, 1 X 10^7 spores/ml
4. *Beauveria bassiana* water formulation, 1 x 10^7 spores/ml
5. *Beauveria bassiana* oil formulation, 1 x 10^7 spores/ml
6. *Beauveria bassiana* talc formulation, 1 x 10^7 spores/ml
7. Spiromesifen @ 0.005 %
8. Imidacloprid @ 0.005 %
9. Untreated control

Note: All treatment sprays are to be initiated when 2-4 whiteflies are noticed per yellow sticky trap. Treatments 1-6 to be applied at weekly intervals and 7-8 at 2 weeks interval

Observations to be recorded:

1. No. of nymphs/adults per plant (pre-count) and after each spray 3, 7 and 14 days after treatment.
2. Floral parameters and healthy flower yield
3. Any phytotoxic effect

6.12.3. Model 2: Management of two Spotted Spider Mite on Gerbera under Greenhouse Condition.

Duration : Three years
Centres : Hessaraghatta, Pune, Kahikuchi and Ludhiana
Technical Programme
Design : RBD
Number of treatments : Twelve
Replications : Three (Thirty plants/replication)
Variety : Any susceptible variety
Treatment details

1. Fenazaquin 0.01%
2. Diafenthiuron 0.05%
3. Propargite 0.057%
4. Flufenoxuron 0.01%
5. Milbemectin 0.001%
6. Pongamia oil 10.0 ml/l
7. Neem oil 10.0 ml/l.
8. *Paecilomyces fumosoroseus* 4.0 ml/l
9. *Lecanicillium lecanii* 3.0 g/l.
10. Dicofol 0.046% (standard check)
11. Abamectin 0.009% (standard check)
12. Untreated control

Note: First spray to be taken immediately at initial incidence of the pest, subsequent sprays for botanicals and bioagents (treatment 6 to 9) at weekly intervals and synthetic pesticides at two weeks interval.

Observations to be recorded:

1. Pre-count mites per 5 leaves (per replication)
2. Mite counts at 3, 7 and 14 days after spray
3. Floral parameters and healthy flower yield
4. Assessment of cost-benefit ratio.

6.13. Pant Parasitic Nematodes and their Management

Plant parasitic nematodes are considered as one of the limiting factors for crop production. Nematode infection can reduce plant vigor, flower size, no. of flowers/plant, and the productive life of the plant. Root-knot nematodes (*Meloidogyne* spp.), root-lesion nematodes (*Pratylenchus* spp.), reniform nematodes (*Rotylenchulus* spp.), foliar nematodes (*Aphelenchoides* spp.) and other ectoparasitic nematodes can limit quality and quantity of floricultural crops both under open field conditions also under protected cultivation. Therefore, proper sampling of fields and reliable determination of nematode population density for diagnostic purpose, and proper planning of experiments for conducting nematode management trials at multi-location is crucial for recommendation and implementation of nematode management strategies to growers. The standard operating procedures are given below.

6.13.1 Sampling for Plant Parasitic Nematodes for Diagnostic Purpose

Due to lack of distinct symptoms on crop plants due to nematodes, the damage often been confused with nutrition problem and occasionally has been attributed to fungi or bacteria. The accurate way to detect nematode is through soil assay. However, characteristic foliage (above-ground) symptoms in the field are clues that plants are diseased with nematodes. So look for the areas in the field where the plant exhibits above-ground symptoms. Carefully uproot such plants with root intact and observe the below-ground symptoms. The above and below-ground symptoms are given below.

i) Above-ground Symptoms

A. Root-parasitic Nematodes

- ✓ Infested plant shows various degrees of stunting and chlorosis (yellowing) and failure to respond normally to fertilizers.
- ✓ Infected rows appear thinner compared to healthy rows and give the patchy appearance
- ✓ Reduced number of spikes (tuberose)
- ✓ Reduced length of flower stalk, flower size, no. of flowers/plant, and also the productive life of the plant
- ✓ Infected plant tends to wilt more readily than healthy plants and slower recovery from wilting.

B. Foliar Nematodes (*Aphelenchoides* spp. in tuberose)

- ✓ Nematode parasites on young foliage and flower stalk
- ✓ The infected flower stack initially appears rough, stalk become crinkled, stunted and finally distorted and in severe cases flower buds failed to bloom
- ✓ Brown streaks appear on the leaf bracts and petals and subsequently develop rusty brown spots
- ✓ Severely infected flower stalk becomes rotten and brittle over drying
- ✓ Reduced number of flower stalk

ii) Below-ground Symptoms

A. Root-knot Nematodes (*Meloidogyne* spp)

- ✓ Formation of distinctive swelling called root galls (root-knots) on the roots of affected plants

- ✓ Root-knot galls may be vary in size and shape
- ✓ On heavy infected plants, galls tend to fuse together so that large areas or entire root may be swollen.

B. Root Lesion/Reniform/Ectoparasitic Nematodes

- ✓ Lesions of necrotic tissue on the roots of infected plant
- ✓ Root necrosis resulting in severe root pruning and subsequent dwarfing of plants and plants may be easily pulled from the ground
- ✓ Fibrous or feeder roots are mostly attacked which may reduce the absorption ability of plants and other physiological functions of the plant
- ✓ Other microorganisms may colonize the necrotic area and may damage the root system

Diagnosing the damage due to nematodes on flower crops can best be done by periodic field observations and examinations of roots in conjunction with testing the soil and plant sample for nematode. Take the soil sample from the rhizosphere (where the roots are abundant) of the plants that exhibits symptoms of nematode damage. Collect several cores of soil and put into bucket and mix the soil gently and place 500 cc composite soil samples into the plastic bag. At least minimum four composite soil samples should be taken for diagnostic purpose. It is also useful to collect the equal number and size of the soil sample from nearby healthy plant for comparison. Diagnostic sample can be taken at any time when plants exhibit possible symptoms of nematode damage. Isolation and extraction of nematodes can be done by following the standard extraction procedure like Cobb's decanting and sieving technique (Cobb, 1918) followed by modified Baermann funnel technique (Schindler, 1961). Result should be reported up to genus level and number of nematodes in 200cc soil.

6.13.2. Guidelines for Root-Knot Nematode Management Experiments.

- Centre should maintain the culture of root-knot nematode population and it should be identified up to species level for the development of sick plots.
- If it is already root-knot nematode infested field, select the field with uniformly infested with nematodes for preparation of plots.
- Draw a composite sample from individual plot and estimate initial nematode population density per 200 cc soil. Undertake the trial only when the initial population density exceeds 200J2 per 200 cc soil.
- Always use the susceptible cultivar recommended for that area.
- Raise the crop as per the recommended agronomic practices

Model 1: Management of Root-Knot Nematodes in Tuberose.

Duration	:	Three Years
Centres	:	Minimum three centres for multi-location trials

Technical Programme

Number of treatments	:	Six
Number of replication	:	Three
Variety	:	Susceptible cultivar recommended for that area
Design	:	RBD
Plot size	:	1.5m × 1.2m
Spacing	:	30 cm × 30 cm

Treatment details:

T1: Bulb treatment with Bacillus subtilis – 1% W.P. @10g/lit.

T2: T1 + Application of 2.5 tons of FYM/ 1 tons of vermicompost enriched with 2.5 kg of *Bacillus subtilis*/ha

T3: T1 + Application of 5 tons of FYM/2 tons of vermicompost enriched with 5 kg of *Bacillus subtilis*/ha

T4: Application of 5 tons of FYM/2 tons of vermicompost enriched with 5 kg of *Bacillus subtilis*/ha

T5: Chemical treatment (Carbofuran @ 2 kg a.i./ha)

T6: Untreated control

Observations

i. Root-knot nematode population density at initial, 60, 90, 120, 150 and 180 days after planting and final nematode population density (per 200cc soil) at the time of termination of experiment.

ii. CFUs of biocontrol agents / g soil at initial, 60, 90, 120, 150 and 180 days after planting and at the time of termination of experiment.

iii. Root-Knot Index on 1- 5* scale at 90 days after planting of bulbs

iv. Flower stalk length (cm) (measure at least 10 stalks from each plot)

v. Rachis length (cm) (measure at least 10 rachis from each plot)

vi. Root-Knot Index on 1-5* scale after the termination of experiment

vii. Yield per plots

viii. ICBR (Incremental Cost Benefit Ratio)

* Root Knot Index (1-5 Scale)

1=Healthy

2=1-10 galls

3=11-30 galls

4=31-100 galls and

5=>100 galls in a root system

Chapter 7
Post Harvest Management

7. Post Harvest Management

Experiments on post harvest management involve evaluation in terms of flower quality, vase life longivity, grading, packaging, storage and transportation, etc. Therefore, meticulous planning and executing of these experiments is very important to get the desired results. The research work on post harvest management of loose flowers and cut flowers over the years resulted in some of the useful recommendations for extending the shelf life/ vase life of loose flowers of cut/ loose flowers.

7.1. Experimental Layout

With the emerging challenges and also withdrawal of some of the important post harvest compounds in the cut flower trade the research for new molecules has to be intensified to offer the solutions. Some of the important points are mentioned below.

1. Material (flowers) selected for experiment should be uniform and equally distributed to all the replications and treatments.
2. Material selected for the experiment should have been cultivated in healthy and diseases free conditions with following all standard packages of practices for cultivation.
3. Experiment should be planned and executed under uniform laboratory conditions.
4. Experimental area should be under uniform light, temperature and humidity conditions or as per the objectives of the experiment.
5. Flowers or experimental material should be collected at its standard harvesting stage or as per the objectives of experiment.
6. Distilled water and other standard preservative chemicals should be used as per the nature and objectives of experiment.
7. pH and EC of preservative solutions should be monitored time to time.
8. Stock solutions and its efficacy should be tested as per nature and objectives of experiment.
9. The carcinogenic, heavy metals and other harmful chemical generated during experiments should be disposed off as per the standard procedures.

Some of the general observation in post harvest experiments.

1. Physiological loss in weight (%) after storage
2. Change in fresh weight (during longevity period)
3. Percent of fresh flowers
4. Retention of colour (using colour chart-mini RHS)
5. Acceptability on visual basis (1-9 hedonic scale)

6. Rotting percentage (or any other disease)
7. Xanthophyll content in flower (if available)
8. Flower opening index (0-closed flower, 3- Fully opened flower)

7.2 General Observations in Post Harvest Experiments

I. Physiological loss in weight (%) after storage

To determine physiological loss of weight of flowers after storage, the initial and final weight (after storage) of the flowers should be measured accurately and then total loss of physiological weight should be calculated by subtracting the final weight of the flowers from the initial weight. The results expressed in percentage using following formula:

$$\% \ PLW = \frac{Initial\ weight - final\ weight}{Initial\ weight} \ x\ 100$$

ii. Change in Fresh Weight

The original fresh weight of flowers should be measured immediately after cutting and before the immersing in keeping solutions. After immersing flowers in keeping solution, the change in fresh weight of flowers should be calculated by subtracting the total weight of flask + solution + flowers by total weight of flask + solution. This process should be repeated everyday till the flowers remains fresh. The flower weight will expresses in grams. Fresh weight of stored or packed flowers mainly depends on condition of flower (wet or dry), storage temperature, storage duration and the packing system. Change in fresh weight (%) should be calculated according to the proportional relationship described by the following (Setyadjit *et al.*, 2004)

$$Change\ in\ fresh\ weight(\%) = \frac{Fresh\ weight\ at\ the\ end\ of\ vase\ life}{Fresh\ weight\ at\ the\ beginning\ of\ experiment} \ x\ 100$$

iii. Flower longevity

Flower longevity should be recorded as the number of days on vase until the flowers showed symptoms of bent neck or advanced signs of fading on all petals (Liao *et al*., 2000).

iv. Floret diameter

Diameter of the floret should be measured in two perpendicular directions. The averages of these two measurements should be given as results of floret diameter.

v. Vase life

Vase life of flower should be determined from the time of harvest to petal drop (abscission), separately for the primary and secondary florets. Days to the second floret opening should also be recorded.

vi. Pedicel length

On the day of the diameter measurements three pedicels should be measured from each inflorescence, on all stems/isolated inflorescences. The length should be measured from the base of the umbel till the base of the last (tertiary) bud.

vii. Water Quality Parameters

Before starting the experiment, it's important to record the pH (It is a measure of how acidic or basic your water is on a scale of 0 to 14.), Hardness (It is the amount of calcium and magnesium ions in the water and measured in ppm, or parts per million), Alkalinity (It is the capability of water to neutralize acid.) and Total Dissolved Solids (TDS) (It is a measure of the total salt content in your water and expressed as ppm) of the preserving solution.

viii. Pre-cooling

It is a step that rapidly brings the temperature of the flowers down from the field temperature to a proper storage temperature. A low temperature slows the respiration rate of the flowers which in turn helps them last longer.

ix. Forced-air cooling

It is the best method for flowers. Cool air is actively forced with fans through the bunched flower. This can be done when the flowers are in a bucket or when they are packed dry into boxes.

The heat to be removed from a material (Q) can be estimated using following equation

$$Q = m\ Cp\ dT$$

Where, m = weight of the material (kg),
Cp = specific heat (kJ/kg/K), and
dT = change in temperature (^{0}C).

Chapter 8

Reporting

8. Reporting

The success of the experiments depends on the effective reporting some important tips for reporting are summarised here under

8.1. Guidelines for Research Report

The report has to be divided in to seven different parts and the sequence is as follows. It is requested to submit the report in this order only. This can be the content of the report

Part-A	:	Check list
Part-B	:	Experimental results (It has to be in separate folder of word files equals to the number of trials allotted to each centre)
Part-C	:	Results fit for adoption
Part-D	:	Concluded project report
Part-E	:	Background report
Part-F	:	Action taken report
Part-G	:	New research programmes

Part-A (Check list)

Reports should cover the progress of the projects strictly as per technical programme approved during group meeting and distributed in the form of proceedings. Avoid deviation from that list as it creates lot of difficulties in compilation.

Part-B (Experimental results)

B.1 Experimental results should be as per the following guidelines (format has been enclosed as part-1**) and concluded projects may also be presented here.**

i. Project number and title (should be as per technical programme approved during group meeting and as per proceedings)

ii. Technical programme with details of treatment (the treatment sequence should be strictly as per the order indicated in technical programme. If any treatments of in between order was not imposed, it can be stated as not imposed and additional treatments if any tried must be indicated in reports. The approval, date of start, etc should be included in the text while giving the results.

iii. Methodology (other relevant details like input viz., fertilizers dose, irrigation method, climatic conditions, etc).

iv. The data should be statistically analyzed. Presenting the data without statistical analysis is not having any scientific relevance. Indicating the highest and lowest value for statistically non significant should be avoided. Some common do's and don'ts in statistical analysis is provided in B3.

v. The results must be in abstract form only. Need to answer only the point which are given below: (as per the listed questions for each trial)

   a. Effective treatment/variety.

   b. Its yield and favorable yield characters.

   c. Crop cycle/age of plant

d. Variety used
e. Benefit cost ratio (if relevant)
f. Any other significant points to be considered in highlighting the results of the experiment in question

vi. Table should contain treatments average value for traits, P-Value, SEm,LSD (5%), CD (5%) and CV (%) and it should be self explanatory.

vii. Wherever applicable, pictorial or graphical (line drawing histogram) form should be given

viii. Conclusion (it must be part of abstract only, also indicate whether proposed for conclusion or continuation

Table: title should be brief and self-explanatory

Treatment*	Traits (specify standard units wherever applicable)			
1				
P-Value				
Sem±				
LSD (5%)				
CV (%)				
*Treatment order should be as per technical programme				
Use superscripts for treatment comparison whenever P value is less than 0.05 with same superscript in a column should be statistically non-significant				

B.2 The reports should be made in MS word for each experiment separately. Hence the number of files are equals to the number of experiments for each centre. The file name has to be experimental number with centre name at the end (e.g. for 1.2.1 b Effect of Weed Management in Gladiolus for Pune centre, the file name is 1.2.1 b_Pune)

B3. Dos and Don'ts in Data Analysis

Use standard software for data analysis. Examples of how to analyze various statistical designs are available at Design Resources Server of ICAR-Indian Agricultural Statistics Research Institute (www.iasri.res.in/design). The details of the pages which are useful are provided in References.

Randomization should be done for each experiment. An online tool is available for randomization in IASRI Design Resources Server.

The mean results should be based on the scale of the analyzed data. Do not convert the results to standard unit area after the analysis.

Whenever, there is a missing value, do not include 0 or any other value for the purpose of analysis. Most of the statistical software can analyze data with missing value. In case of missing values, do not report SEm, CD and indicate the treatment(s) which ha(ve)s missing values.

Some of the observations such as number of leaves, larvae, germination rate etc. may not satisfy one or more assumptions of Analysis of Variance. In such cases, standard transformations such as square root, logarithmic, arc-sine transformation could be used before analysis. Details of are available in Design Resources Server of IASRI about commonly used transformations in data analysis. While reporting, report means in original scales and transformed means in parenthesis. Other measures such as CD, CV etc. should be reported only for transformed values. Do not back transform CD, CV, SEm etc.

Part-C (Results fit for adoption)

Relevant technology or cultivar developed which has feasibility for adaptation based on economic analysis should be given. Kindly avoid mentioning the technology based on insufficient data and also presenting the already recommended technology. The technology developed for implementation need to be looked further for the extent of adoption.

Part-D (Concluded project report)

The project being concluded may be submitted to the Director ICAR-DFR with copy to the lead presenter. In this part the results have to be compiled since inception of the trial and pooled data may also be given. However, for the results have to be given in part-B for the period under review.

The conclusion report should include title, location, objectives, experimental details viz., treatment/design, date of start, date of completion, observations recorded, results and conclusion, technology/package ready for adoption (clearly indicate the superiority of the new technology over the existing technology if any) the lead presenter to collect the technology for all the coordinating centres finalize the technology of AICRP.

Part-E (Background Report)

The report should also include up to date list of staff members, both scientific and establishment (with names), papers published and seeds and planting material multiplied and supplied (Provide the details as per the enlisted format)

Staff position
Name of the centre:

Sr no	Designation	No. of post	Present position as on closing date	Name of the personnel holding the post*
a) Scientific				
1				
2				
b) Technical				
1				
2				
c) Administrative				
1				
2				
d) Supporting				
1				
2				

List of publications:

The publications should be mentioned in the following format and arranged alphabetically for each category

a) Research papers:
   - Tiwari, A K., Kumar, R., Kumar, G., Kadam, G. B. and Saha, T. N., (2015) Comparing digital image analysis and visual rating of gamma ray induced Kentucky bluegrass (*Poa pratensis*) mutants. *Indian Journal of Agricultural Sciences*, **85**(8) 93-96.

b) Popular articles:
   - Prasad, K. V. and Patil, T. V. (2016) Open filed cultivation of roses. *Indian Horticulture*, **12**(2):25-30

c) Bulletins/reports:
   - Kumar R, Saha, T. N., Kadam, G. B., Gunjeet Kumar, Jayoti Majumder and Girish, K. S. (2013) Annual Reports 2012-13 of All Coordinated Research Project on Floriculture, Published by Director, ICAR-Directorate of Floricultural Research, Shivajinagar Pune-411005.

PART-F (Action Taken Report)

Kindly report according to the points indicated in the proceedings of Group Meeting. Action taken on each point of respective session should be indicated wherever relevant. Avoid mentioning noted for compliance or being followed or accepted; rather indicate the specific action taken.

Recommendations	Action taken

Part-G (New Research Programmes)

The research planning is one of the objectives of the group discussion, the center interested to initiate new research programmes/activities, either or coordinated nature or location specific, (based on QRT/University recommendations and problems faced by the farmers in the region) may propose new projects. It should include: 1) Project title, 2) Location,3) Objectives,4) Background / Importance of the problem, 5) Previous work done/ review of literature, 6) Probable date of start, 7) Experimental details *viz*., Number of treatments/Design, 8) Treatment details (treatments indicated should be justified with published reference), 9) Area required, 10) Observation to be recorded/ plan of work, 11) Duration of the project and 12) Practical/ scientific utility. The entire proposed research programme would be discussed during the group discussion for finalization.

PART-I (Points to be considered while presenting results)

An experiment and its results are given for the purpose of example only just to make clear understanding while presenting the data.

Standardization of media composition for pot mum production under open conditions.

Duration : Three years (Ongoing)

Centres : Hessaraghatta, Ludhiana, Pantnagar and Coimbatore.

Objectives :

Methodology: the trial was laid out with seven treatments in CRD replicated three times. The treatment derails are:

T_1	:	Soil + Sand + FYM (2:1:1)
T_2	:	Soil + Sand + Vermicompost (2:1:1)
T_3	:	Soil + Sand + FYM + Vermicompost (2:1:0:5.0.5)
T_4	:	Cocopeat only
T_5	:	Cocopeat + Sand + FYM (2:1:1)
T_6	:	Cocopeat + Sand + Vermicompost (2:1:1)
T_7	:	Cocopeat + Sand + FYM + Vermicompost (2:1:0.5:0.5)

Number of treatment	:	Seven
Pot size	:	15 cm plastic pots
Variety/planting material	:	Var. Sadhbhavana
No. of replications:	:	3
No. of pots/treatment	:	10
Design of experiment	:	CRD
Inputs	:	Basacote (19:19:19) -5g / pot every 6 months
Irrigation method	:	Manual (required as per soil moisture content) or drip irrigation

Cultural practices	:	Pinching-3; first pinching two weeks after planting; second and third pinching at three weeks after first and second pinching, respectively
Additional information	:	Planting should be done in such a way that flowering coincides with the short days of the winter

Observations to be recorded:

1. Plant height at the time of first flower bud appearance
2. No. of branches per plant
3. Days taken for flowering
4. Diameter of flower (cm)
5. Duration of flowering (day)
6. No. of flowers per plant
7. Plant spread (cm)

Results (representative table)

Treatment	Plant height (cm)	No. of primary branches/ plant	Days taken to flowering	Flower diameter (cm)	Duration of flowering (days)	No. of flowers/ plant	Plant spread (cm)
T_1	27.00						
T_2	29.67						
T_3	32.10						
T_4	31.67						
T_5	31.33						
T_6	35.60						
T_7	22.56						
SEm±							
LSD at 5%							
CV%							

T_1- Soil + Sand + FYM (2:1:1), T_2- Soil + Sand + Vermicompost (2:1:1),T_3- Soil + Sand + FYM + Vermicompost (2:1:0:5.0.5), T_4- Cocopeat only, T_5- Cocopeat + Sand + FYM (2:1:1), T_6- Cocopeat + Sand + Vermicompost (2:1:1)

T_7- Cocopeat + Sand + FYM + Vermicompost (2:1:0.5:0.5).

It is requested to look for the figures highlighted to draw meaningful conclusion whenever the differences are statistically significant.

Routine method of presenting results

Results of the first season's crop are presented in Tables 1, 2 and 3. Growth characters of pot mum variety…….as influenced by media composition are presented in Table1. Plant height at flowering was maximum for T_6 (Cocopeat + Sand + Vermicompost (2:1:1)) and T_4 (Cocopeat only). Number of primary branches and flower diameter were not significantly influenced by media composition. Days to flowering was minimum for T_5 (Cocopeat + Sand + FYM @ 2:1:1). Among the yield characters, number of flowers per plant was highest for T_7 (Cocopeat + Sand + FYM + Vermicompost @ 2:1:0.5:0.5) (Table 2)…….

Comments

- Results are presented without considering the objectives in question (which is the best treatment combination?)
- Results were explained without following any guidelines (crop cycle not indicated i.e., plant crop, first season and second season. First season crop means?)

- No conclusion can be drawn by the above paragraph.
- Name of variety?

Results expected (as per the guidelines)

Steps to be followed before writing results

- Look for the data of all parameters.
- Identify the best treatment(s) based on the objectives set for the experiment.
- Also add any specific comment, if required (like flower quality and crop duration) to support the data.

Results of the plant crop (cv. sadbhavana) indicated that application of Cocopeat + Sand + FYM + Vermicompost (2:1:0.5:0.5) was found to be effective in improving the plant growth and number of flowers (110). However, minimum days for flowering (120.25) and plant spread (50.23 cm) was observed with application of Cocopeat + Sand + Vermicompost (2:1:1) as against the high yielding treatment recording 138.16 days for flowering and plant spread of 61.23 days .....

Conclusion: Proposed for conclusion and the technology is ready for recommendation.

Technology: It should be self-explanatory, semi technical and end user should be able to follow. The information has to be translated to the enclosed format **(format 1a. & 1b.)**.

In all experiments, it is suggested to enlist the set of questions to be answered so as to convey the results in the meaningful way. Accordingly, following guidelines are made.

Guidelines for model set of questions for AICRP on Floriculture trials

Model-1 Project No. 1.1.1: Collection, Evaluation and Maintenance of Rose Germplasm.

The questions to be made are as follows (as per envisaged objectives)

1) What are the areas explored/ sources of collection?
2) How many collections were made and what for?
3) What is the performance of genotype at given location?

   E.g. Ten cultivars were collected during 2016 from IARI, New Delhi centre. Six polyhouse varieties (First Red, Grand Gala, Gold Strike, Hollywood, Bordo and Shakira) were collected for use in breeding programme for development of cut flower varieties under protected conditions. For growth, flowering and tolerance to extremes of temperatures the varieties First Red and Grand Gala performed significantly better.

Model-2 Project No. 3.5.1: Studies on Nutrient-Growth Regulator Combinations in Orchids

The questions to be made are as follows (as per envisaged objectives)

1) Is there any best treatment compared to control?
2) If not, is it on par with any other treatment?
3) If so, why and was it consistent? (If repeated)

Model-3 For the trial 5.1.3: Evaluation of Insecticides Against White Fly in Gerbera

The questions to be made are as follows (as per envisaged objectives)

1) Which is the best chemical/ treatment for the management of targeted insect-pest in relation to standard check?
2) What is the extent of damage by the targeted insect-pest in best treatment as compared to standard check? Also, whether this effectiveness was consistent in different sprays? (3,7 & 14 DAS)
3) Which are the factors responsible for higher B: C ratio and for which treatment?

Use the following Unit symbol in all places

Unit name	Unit symbol	Quantity name
centimeter	cm	length
centimeter square	cm^2	Area
degree celsius	^0c	temperature relative to 273.15 k
gram	g	mass
gray	Gy	absorbed dose (of ionizing radiation)
hectare	ha	Area
hour(s)	h	time
kelvin	K	thermodynamic temperature
kilogram	kg	mass
liter	l	Volume
meter	m	length
meter square	m2	Area
milligram	mg	mass
milliliter	ml	volume
millimeter	mm	length
mole	mol	amount of substance
second(s)	s	time

For uniformity of the document, it is suggested to follow the below mentioned points

- All chemical name of any molecule has to start with lower case letter if it is mentioned in the text or in the sentence.
- Use of trade name is not recommended unless essential and if mentioned use caps for the first letter.
- Use the standard abbreviations
- Months need not be abbreviated

8.2. Language and Expression of Reporting

In order to bring in uniformity of reporting, the center are required to present their report in the following format adhering to the observations as prescribed in the technical programme.

1. Background Information.
2. Staff Position (Name and addresses with E-mail, approved scale, present scale, research projects with which associated, etc.).
3. Budget Details (Opening balance, receipts and expenditure during the reporting year with full details and head wise).
4. Salient Achievements during 2015-16. (Not more than 1-2 page)
5. Experiment wise results as per the technical programme of XXIV Group Meeting held at SKUAST, Srinagar. The pooled data along with Summary / Conclusion of the concluded experiments (if any).
6. Recommended varieties (crop wise along with photographs), technologies developed (section wise along with photographs), recommendations to flower growers, planting materials produced & supplied, training/ extension programme organized.
7. The details of new lines/ hybrids developed for considering their inclusion in the technical program of the

Coordinated Project in the forthcoming Group Meeting. (Along with high quality digital colour photographs (in jpeg format).)

8. Kindly do not mention that observation recording is in progress/ the experiment is in progress, etc. and also do not give inconclusive data.
9. Meteorological Data.
10. Research Publications of the project staff related to AICRP on Floriculture.
11. Training/ symposium/ seminar attended by the project staff.
12. Any other useful information, like commercialization, state release, success stories, etc.

Over a period of time our technical writing got fossilized and we tend to follow a particular type of expression which is inappropriate. At times our expression conveys the opposite of what we actually want to convey. Suggested way of expression in some of the examples is furnished.

Suggested Modifications in Reporting

- Response of different bulb size of tuberose as planting materials on growth and flowering characteristics We all know that bulb size does not respond but tuberose does.

***Suggested*: Effect of or influence of different bulb sizes on growth and flowering of tuberose.**

- At _____ centre, following cvs. recommended for commercial cultivation. For cut flower: Abba, Apledoorn, Ballerian, Cassini, Golden Melody, Inzell Lucky Stricke, Parade and Purrisima. For garden decoration: Cassini, Beethoven's Memory, Cantala, and Golden Melody.

Suggested: At _____ centre, cultivars that are recommended for commercial cultivation for cut flower purpose include Abba, Apledoorn, Ballerian, Cassini, Golden Melody, Inzell Lucky Stricke, Parade and Purrisima. Whereas for garden decoration cvs.Cassini, Beethoven's Memory, Cantala, and Golden Melody were found to be suitable.

- At _____ centre, following Daffodil genotypes recommended for cultivation. For cut flower: Vansion, Wrestler,N-23, White Well, Golden Pedestal and Tunis. For pot culture: Scilly White, N-25, N-30 and Texas.

Suggested: At _____ centre, Daffodil genotypes Vansion, Wrestler,N-23, White Well, Golden Pedestal and Tunis were found ideal for cut flower cultivation. While cultivars Scilly White, N-25, N-30 and Texas were found ideal for pot cultivation.

- At _____ centre, following Alstroemeria genotypes Allaha Din and No. 14. For pot culture: Pluto, Serina and Rina.

Suggested: At_____centre, Alstroemeria genotypes Allaha Din and NO 14 are ideal for commercial cultivation of cut flowers, while Pluto, Serina and Rina are ideal for pot culture.

- At Pune centre, survey was conducted during *kharif* season. In kharif season at Markal, Dist: Pune the tuberose showed 7.50% incidence of stem rot with 10.15.0 % leaf blight intensity., while in marigold showed 8.75% leaf blight intensity and golden rod showed 21.50% rust intensity. At Induri Tal. Rajgurunagar in Pune district the marigold showed 9.75% leaf blight intensity gladiolus showed 10.50% wilt incidence. At Dehu Tal. Haveli, Dist. Pune tuberose showed 8.75% stem rot incidence and 9.75 % leaf blight intensity.

Suggested: Stem rot incidence to a tune of 7.5% was recorded in tuberose at, _____ district of _____ ___besides 10.15 % of leaf blight. In case of marigold leaf blight incidence was recorded to a tune of 8.75 %. Rust incidence to a tune of 21.5 % was observed in golden rod.

- At _____ centre, spraying with Azoxystrobin (Amister) (0.1%) or Difenoconazole (Score) (0.1%) or Iprodione + carbendazim (Quintal) (0.1%) were found effective in managing the leaf spot disease of

tuberose, which recorded significantly lowest disease incidence of 8.21, 9.43 and 10.37 per cent with highest per cent disease control of 75.49, 71.32 and 69.83, respectively.

Suggested: At _____ centre, spraying with Azoxystrobin (0.1%) or Difenoconazole (0.1%) or Iprodione + Carbendazim (0.1%) were found effective in managing the leaf spot disease of tuberose, which recorded significantly lowest disease incidence of 8.21, 9.43 and 10.37 per cent with highest per cent disease control of 75.49 , 71.32 and 69.83, respectively. (Do not use the trade names)

- In chrysanthemum treatment T_7 (Cocopeat + Sand + FYM + Vermicompost (2:1:0.5:0.5)) gave maximum number of branches per plant (40.26), flower diameter (3.68 cm), number of flowers per plant (213.55), plant spread (21.63cm) and took minimum number of days for flowering (124.63).

We all know that treatment does not give maximum number of branches but the plant does

- Suggested: In chrysanthemum treatment T_7 (Cocopeat + Sand + FYM + Vermicompost (2:1:0.5:0.5)) gave maximum number of branches per plant (40.26), flower diameter (3.68 cm), number of flowers per plant (213.55), plant spread (21.63cm) and took minimum number of days for flowering (124.63).

- At _____centre, severity of leaf blight of tuberose was significantly reduced by four fungicidal treatments, namely difenconazole (Score, 0.1%), chlorothalonil (Kavach, 0.2%), azoxystrobin (Amistar, 0.1%) and mancozeb (Dithane M-45, 0.2%) over the control.

Suggested: At _____ centre, severity of leaf blight of tuberose was significantly reduced by four fungicidal treatments, namely Difenconazole (0.1%), Chlorothalonil (0.2%), Azoxystrobin(0.1%) and Mancozeb(0.2%) over the control.(Do not use the trade names)

- At _____centre, packaging materials: Considering the shelf life and other flower qualities of tuberose, CFB boxes with 100 gauge Polyethylene lining is the best. Storage temperature: Cold storage at 4°C registered the highest number of 9.42 days shelf life in CFB boxes.

  (cold storage does not register vase life but the flowers)

Suggested: At _____ _____ centre, considering the shelf life and other flower qualities of tuberose, CFB boxes with 100 gauge Polyethylene lining are the best. **Flowers stored at 4^0C cold storage in CFC boxes exhibited the highest shelf life of 9.42 days when compared to control (days).**

- At _____ centre, maximum shelf life of 5.1 days with highest freshness score of 4 were obtained for garland tuberose var. Local Single flower buds transported in no perforated polyethylene (PE) package without perforation followed by 4.5 days of shelf life of flower buds transported in perforated PE and non-perforated PP, whereas, higher per cent bud opening was obtained with flower buds transported in perforated PE and PP packages.

Suggested: At ____ _____ centre, maximum shelf life of 5.1 days with highest freshness score of 4 were obtained for garland tuberose var. Local Single flower buds transported in polyethylene (PE) package without perforation followed by 4.5 days of shelf life of flower buds when transported in perforated PE and non-perforated PP, whereas, higher per cent bud opening was recorded in flower buds transported in perforated PE and PP packages.

8.3. Format for UC & AUC

As per the financial norms, submission of UC for the preceding year in respect of AICRP on Floriculture centres is mandatory for the release of allocated funds during succeeding year. The UC has to be made as per the allocated budget sub-heads vide above ref.

Submission of authenticated AUC in original is necessary for sanctioning the earmarked budget to the centre. It has to be authenticated by the local fund auditor besides the competent authorities of respective university/Institute (signature with seal of the Director of Research, Comptroller, Officer In-charge and Chartered Accountant as per the format attached).

Form of Utilization Certificate & Audit Utilization Certificate

Sr no.	Letter No. and Date	Amount

1. Certified that the out of Rs._____sanctioned during the year ____in favour of under this Ministry /Department Letter No. given in the margin and Rs. _on account of unspent balance of the previous year, a sum of Rs. _____ _____ has been utilised for the of remaining unutilized at the end of the year has been surrendered (vide No _____ _____ _____dated) will be adjusted (to be payable the next year).
2. Certified that, I have satisfied myself that the condition on which the expenditure was made have duly fulfilled/are being fulfilled and that I have exercised the following check to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of checks exercised

1.
2.
3.

Table 1: Showing the details of receipt and expenditure

Figure (in Rupees)

Opening balance as on 1st April	Remittance received	ICAR share of Expenditure during the year	Closing balance as on 31st March
1	2	3	4

The remittance as indicated in Column No. 2 are as per ICAR/ Project Coordinator letter

No _____dated, _____

Table 2: Showing the head wise details of expenditure

Figure (in Rupees)

Head	Allocation for the year	ICAR share of Expenditure (100%)	State share (0%)	Total expenditure
1	2	3	4	5
A Recurring				
1. Pay & allowances				
2. TA				

Head	Allocation for the year	ICAR share of Expenditure (100%)	State share (0%)	Total expenditure
1	2	3	4	5
3. Recurring contingencies				
4. HRD				
B Non-Recurring				
1. Equipment				
2. Works				
3. Vehicle				

The figures in col. No. 2 may be shown as communicated by project coordinator under annual plan for the year

In-charge/PI of the scheme Director of research/Director Comptroller/account officer

Duly audited and signed by the chartered accountant

8.4 Format for Reporting of Significant Achievements

As per the instructions from the ICAR, the progress made in the trials under AICRP on Floriculture has to be updated yearly basis. It is suggested to submit only quantifiable and achieved results in bullet form only. The words like in progress, will be done, with a view of etc., are to be avoided.

The achievements may be indicated under the following heads in the enclosed format:

1. Number of germplasm explorations takes up/surveys conducted/ germplasm collected, germplasm characterized, important accessions identified for different traits (provide range, mention good ones with quantified data)
2. Germplasm identified/ breeding material identified (quantified data)
3. Production/ Protection technology developed/ treatment effects assessed etc., with quantified information.
4. Number of training conducted, number of participants benefitted, Radio/TV programs organized topics etc.,
5. Number of demonstrations conducted, title and impact (quantified improvements)

ICAR-AICRP on Floriculture
For Half Yearly Report
(Apr. 20 ..... - Sep. 20 ....)/(Apr. 20 ... - Sep. 20 ...) /(Oct. 20 to Mar. 20--)

Lead Centre Name:

Activity (Title of the AICRP trial)	Targets*(Apr.20..- Sep.20..) (Oct.20 to Mar. 20 --)	Achievements (Apr.20..- Sep.20..) (Oct.20 to Mar. 20 --)	Targets (as per the technical programme of the Group Meeting Proceeding) (Apr.20..- Sep.20..) (Oct.20 to Mar. 20 --)
# It is requested to indicate the significant achievements only. Kindly differentiate the status and achievements, hence not to indicate the status. In view of this, though some of the targets would have been completed, but may not lead to final achievements. Such information may not appear in the achievement column.			

8.5 Format for Annual Group Meeting Presentation

In view of the time constrains and huge number of trials, a standard template has been made for the presenting the experimental results. It shall bring uniformity in presentation. It also helps presenters stick to important aspects of the results, without diverting to irrelevant areas of the experiment and to restrict to the stipulated time allotted. However; font size/colour/ background can be as per the presenters' choice. At the end of each presentation, all the concerned have to make scoring of the experiments at each centre as per the identified indicators, which has been furnished in the enclosed

Format:

Slide 1:

Expt. No:	Title:
Centres Enlisted:	
Centres Not reported	
Lead Presenter	Name: Address

Slide 2:

Introduction

Objective:

-
-

Category:

I = MLT of variety
II = MLT of technology
III = Strengthening information
IV = Service oriented support to NARS

Slide 3:

Methodology

- Treatment details
- Date of start
- Etc.

Slide 4:

Results

Answer for objective-1

e.g. For the trial on weed control, what is the weed control noticed. The measurable parameters are

- Weed count
- Dry weight of weeds
- Weed control efficiency

Answer for objective- 2

e.g. To what level it has influenced the yield and quality parameters

- What attributes contributed for its yield increase
- Additional slides can be used for tables, graphs, pictures photos

Slide 5:

Conclusion

Clearly indicate the status

Centres involved	Centre-1	Centre-2	Centre-3	Centre-4
Category	A1	B	B	C

Category A1	:	The trial has been implemented as per the envisaged Programme, but no conclusion/trend can be drawn.
Category A1	:	The trial has been implemented as per the envisaged programme, but no conclusion can be drawn. Further, it needs mid-term correction.
Category B	:	Initial results have given some leads and needs to be observed for years for its consistency.
Category C	:	Results have the consistency over the period and fit for recommending as technology /fit for publication in referred journals.

The results for the category C, it should clearly define the technology.

8.6 Format for Group Meeting Proceedings

In order to facilitate proper recording of the proceedings, format for recording group meeting proceedings have been prepared. It enlists general guidelines for carrying out the work, recording observations and other aspects connected with the implementation of the programme. Brief description of work done and salient achievements reported are to be noted. Number of reports presented in the GM as well as recommendations ready for transfer to extension agency also to be recorded.

Review of technical programme during group meeting Session Title:

Session No :

Chairman :

Co-Chairman :

Reporters :

Convener :

1. Number of reports presented

Crop	:	
Centres where work has been done	:	

2. Centres where work has been done

Crop	Rose	Gladiolus	Chrysanthemum	Tuberose	Gerbera	Etc.
Number of centres						
Co-opting centre						
ICAR ad-hoc schemes						

3. Non reporting centres:

4. Brief description of work done an salient achievements reported:

5. Recommendation ready for transfer to extension agency if any:

6. Programme proposed for coming years

Crops	Ongoing experiments	Revised experiments	New experiments

7. General guidelines for carrying out the work, recording observations and other aspects connected with the implementation of the programme

8. Recommendations

i.

ii.

iii.

9. Technical prorgamme (project wise)

8.7 Format for proceedings of the centre visit by the Director/Project Coordinator/Crop-Coordinator to review the programmes of AICRP on Floriculture at centre (dd/mm/yyyy)

Proper monitoring is essential for proper conduct of experimental trials. The project coordinator has to ensure that the trials in the centres are according to the technical programme. It is to be ensured that the centres are representing the problems of the region and caters for the needs of the region they are working under. Director/PC's centre visit has main agenda items like monitoring of technical programme, field layout, data management book and reporting pattern and schedule. The result sent from centre has to be compared with those published by PC. Project coordinator also monitors the fund utilization and revenue generation from the centre. The status of human resource in the centre is also monitored.

A. General observations

Al. Human Resources/Administrative matters

- Briefly indicate the details of positions and vacancies.

A.2 Financial matters

- How it is being utilized

- Is the utilization as per ICAR guidelines or not
- Status of AUC, ME

A.3 General Recommendations

- Specific suggestions for improvement

Bl. Recommendations for the allotted programmes

No.	Trial Name (As per latest technical programme)	Code No.	Comments	Status (Scientist at the centre has to furnish)	Recommendations/ Action plan (To be made by PC/ CC)
1	2	3	4	5	6
1.					
2.					
3.					

Note:

The list along with its code as approved in the latest proceedings has to be indicated. It is suggested to review with a brief presentation at the centre by the scientists associated. The copy of the same has to be submitted to the Director of Research for an effective implementation. It is suggested that the best performing centre will the less comments in column 6 or the remarks column 6 is an indication of the centre performance.

8.8. Publications (2015-16)

8.8.1.Technical/Extension bulletins:

1. Singh, Prem Jit., D. S. Kakade, N. Majumder, V. Sridhar, Girish, K. S., Prabha, K., K. P. Singh and Prasanna Holajjer (2015). Disease and Pest Management in Flower Crops under Polyhouse. ICAR-Directorate of Floricultural Research, College of Agriculture Campus, Shivajinagar, Pune-411005 (Maharashtra), India. 1-57.

2. Sheikh, M.Q., Z. A. Bhat, M. A. A. Siddique, K. P. Singh and T. N. Saha (2015). Present Status and Prospects of Floriculture in Jammu and Kashmir. Published by Director, ICAR-Directorate of Floricultural Research, Pune-411005 (Maharashtra), India. 1-40.

3. Sheikh, M.Q., Z. A. Bhat, M. A. A. Siddique, Tarak Nath Saha, K. P. Singh, Mast Ram Dhiman and Sita Ram Dhiman (2015). Daffodil. Published by Director, ICAR-Directorate of Floricultural Research, Pune-411005 (Maharashtra), India. 1-19.

4. Sheikh, M.Q., Z. A. Bhat, M. A. A. Siddique, Tarak Nath Saha, K. P. Singh and Mast Ram Dhiman (2015). Lilium. Published by Director, ICAR-Directorate of Floricultural Research, Pune-411005 (Maharashtra), India. 1-28

5. Tiwari, A.K., K. P. Singh, Shephalika Amrapali, Girish, K. S. and Prem Jit Singh (2015). Lawn Management. Published by Director, ICAR-Directorate of Floricultural Research, Pune-411005 (Maharashtra), India 1-48.

6. Kannan, M., M. Jawaharlal, M. Ganga, K. P. Singh, Tarak Nath Saha, S. P. Thamaraiselvi and P. Ranchana (2015). Present Status and Prospects of Floriculture in Tamil Nadu. Published by Director, ICAR-Directorate of Floricultural Research, Pune-411005 (Maharashtra), India.1-54.

7. Ganesh B. Kadam, Tarak Nath Saha and K. P. Singh (2015). AICRP on Floriculture, ICAR. Database on Gladiolus (2010-11 to 2013-14). Published by Director, ICAR-Directorate of Floricultural Research, Shivajinagar, Pune-411005 (Maharashtra), India.1-276.

8. Tiwari, A. K. And K. P. Singh (2015). AICRP on Floriculture, ICAR. Database on Rose (2010-11 to 2013-14). Published by Director, ICAR-Directorate of Floricultural Research, Shivajinagar, Pune-411005 (Maharashtra), India.1-96.

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Other Varieties Developed and Evaluated in AICRP

Chrysanthemum

Bidhan Gold

Bidhan Joyanti

Bidhan Pradayat

Bidhan Rupanjali

Bidhan Swapna

Bidhan Sweeta

Himanshu

Vijay Kiran

Vijay

Pusa Aditya

Pusa Anmol

Pusa Centenary

Pusa Chitraksha

Pusa Kesari

Pusa Sona

TPQ-06-01

TPQ-06-01c

China Aster

Phule Ganesh Pink

Phule Ganesh Purple

Phule Ganesh Violet

Phule Ganesh White

Crossandra

Arka Ambara

Arka Kanaka

Arka Shravya

Arka Shreeya

Marigold

Bidhan Marigold-1

Bidhan Marigold-2

Bidhan Marigold-3

Pusa Narangi Gainda

Pansy

Punajb Purple Wave

Punjab Choco Gold

Gladiolus


Arka Gold


Arka Naveen


Dahanvantari


Gulal


Jyotsna


Neelum


Punjab Dawn


Punjab Elegance


Punjab Lemon Delight


Punjan Beauty


Pusa Manmohak


Pusa Red Valentine


Pusa Srijana


Pusa Suhagin


Pusa Unnati


Pusa Vidushi


Shagun


Sringarika


Rangmahal


Urmil

Rose

Bhim

Jawahar

Priya

Pusa Abhishek

Pusa Pitamber

Raktagandha

Raktima

Tuberose

Arka Nirantara

Hyderabad Single

Phule Rajani

Prajwal

Rajat Rekha

Shringar

Vaibhav

AICRP-Floriculture Released Varieties

Chrysanthemum

Anmol

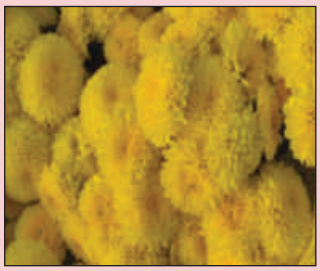
Autumn Joy

Garden Beauty

Winter Queen

Royal Purple

Solan Shringar



Yellow Delight

Gladiolus

Arka Amar

Phule Neelrekha

Phule Ganesh

Arka Kesar

Solan Mangla

Tuberose

Prajwal

Phule Rajani

Vaibhav

AICRP-Floriculture Network

Budgetary Centres


UBKV, Kalimpong


KAU, Vellanikkara


MPUAT, Udaipur


OUAT, Bhubaneswar

TNAU, Ooty


BAU, Ranchi


BCKV Kalyani


TNAU, Coimbatore


SKLTSHU, Hyderabad


GBPUAT, Pantnagar


MPKV, Pune


RAU, Pusa


DrYSPUHF, Solan


PAU, Ludhiana


AAU, Kahikuchi


SKUAST, Srinagar

Institutional Centres

ICAR-RC NEH, Barapani

ICAR-IIHR, Bengaluru


ICAR-NRC Orchids, Pakyong


ICAR-IARI Regional Station, Katrain


ICAR-IARI, New Delhi

Voluntary Centres


TNAU, Periyakulam

UAS, Bengaluru

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